Abstract

This paper is in engineering account of what life is how it began. There are two main threads; the limits of natural causes and the difference between naturally caused entities and designed entities.

The most fundamental difference between life and machines vs. all other entities is embedded intelligence; life and machines have it and natural entities do not. Machines require logical functionality, a form of intelligence, to move and maintain matter/energy away from equilibrium to perform logic driven, as opposed to naturally driven work. Natural causes, driven by the laws of physics and initial conditions, move towards equilibrium or a more probable state. Machines designed and fabricated to perform specified work require configurations of matter/energy that natural causes are incapable of creating due to the logical constraints that result from limited initial conditions and available free energy.

Each step of natural processes is the result of free energy, initial conditions resulting from previous steps and the laws of physics. The outcomes of such processes are atoms, molecules, suns, planets, solar systems, galaxies, black holes, weather, plate tectonics, etc. All these entities can be explained without the addition of intelligence after a point in the big bang where the laws of physics were solidified.

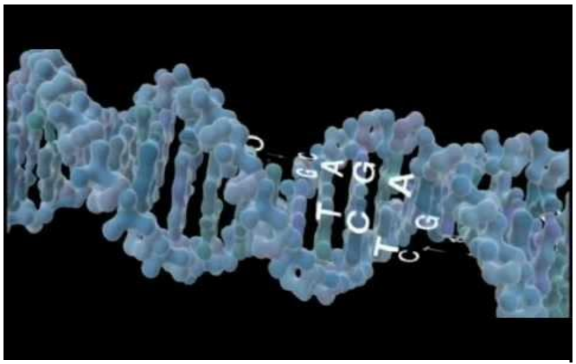
Intelligent processes involve steps that are the result of specified work being performed to achieve a predetermined end. Such work is performed by machines. Experience shows that intelligent processes must be designed, the machinery must be created, specified conditions established, intelligent action performed to start the process, and consumption of energy is required while the process is functioning to perform the logical functionality. Such processes can achieve results that are impossible by natural causes even though both are constrained by the laws of physics.

Because life is a process enabled by molecular machines, it is matter/energy embedded with logical functionality and therefore not a result of natural causes alone.

This paper develops the concepts that lead to these conclusions and provides testable means to falsify the claims made herein.

Background

In college, I learned that all life evolved from a single cell, and later learned that first life occurred from natural causes. This view continued until attending Steve Meyer's *Signature in the Cell* book launch party. [1] He gave a presentation that included this video which he narrated. I was shocked because this shattered my understanding that life was chemistry, never imagining that machines were involved, particularly molecular machines.



VIDEO 1. PROTEIN SYNTHESIS ANIMATION

That seemed impossible. Machines are something I understand as I spent my life designing them. But there was a concern as well. The movie seemed to be oversimplified. Piece parts that were being placed just "floated" into position which does not happen naturally. How did the RNA know where to go? How did the membrane gate know to "open the door" for the RNA? How was the membrane sealed as it went through and afterward? Many questions such as these lingered because my experience dictated that every detail of such an intelligent process must have a mechanism that controls the outcome of each step to ensure success. It seemed that the process had to involve much more than was shown in the movie.

My experience and intuition both told me that there is no possibility that such an intelligent process could start by natural causes. Not only would the first cell need the information to make it work, it would have to be constructed and the process started. How could this occur?

This was the beginning of my interest in the ID debate.

[1] Here is a link to Steve Meyer's talk; the video starts at the 15 minute mark. Here is link to Video 1.

Terminology and Definitions

The concepts presented herein posit some different ideas that make fine distinctions between things that often use imprecise terminology or require new terms that will be defined in this section. The terminology used is a convenience for the author and not meant to become a standard. This section will include definitions as well as background and context.

Free Energy

Definition from the textbook *Biochemistry*[2]: The energy in a system available to do useful work.

The author's definition: the energy in a system to do work that is not controlled by intelligence.

The distinction between the two definitions is one of causation, whether the cause is physics alone, or specified arrangements of matter/energy that control the expenditure of energy to be the right form, place and time to achieve a desired end. This distinction will not be detectable at the micro level, only at the macro level where the surrounding logic functionality, signaling means and energy control means can be detected and measured. At the micro level, there can be no means to determine if a given state change is the result of embedded intelligence or natural causes because embedded intelligence is contained within a machine, a structure larger than a few atoms[3].

At the macro level, an example would be to compare a lighting bolt providing the free energy to start a fire compared to the intelligently controlled ignition spark that causes the intelligently controlled fuel/air mixture in the combustion chamber of an engine to explode. A micro comparison is four molecules of iron and six molecules of water "rusting" the iron ($4Fe + 6H2O \rightarrow 2Fe2O3 + 6H2$) from natural, "free" thermal energy from the sun compared to the specified work done by the

[2] McKee, Trudy and James R. *Biochemistry, The Molecular Basis of Life,* Oxford University Press, 2017, p.G-6.
[3] However, in life, if a state change involves a large protein molecule and the "firing" of an ATP molecule, it is probably an intelligent action.

hexokinase enzyme with energy provided by ATP[4] molecules to convert glucose that enters a cell to glucose-6-phosphate.[5]

From a "scientific" point of view, the energy released by the conversion of ATP to ADP is "free energy" and therefore no distinction is required. However, from a logical or engineering point of view, the work done by the Hexokinase enzyme could never occur "on demand" by natural causes; the cause is due to a different paradigm: intelligent work by a machine as part of the life process.

Intelligent Work (iWork)/Intelligent Causes (iCauses) vs. Natural Work (nWork)/Natural Causes (nCauses)

Author's Definition, Intelligent Work (iWork):

1. work accomplished by a machine.
2. work not solely the result of natural causes (nCauses).

The author has taken the liberty of using a shorthand notation to distinguish between "natural work," (nWork) and "intelligent work," (iWork). Similarly, natural causes (nCauses) are distinguished from intelligent causes (iCauses) and natural processes (nProcesses) are distinguished from intelligent processes (iProcesses).

iWork is work accomplished by a machine. A machine's functionality is the result of intelligent manipulation of matter and energy that imbeds intelligence in the machine.

The technical definition of work (W) is a force (F) applied over a distance (d), in vector algebra:

$$\boldsymbol{W} = \boldsymbol{F} \cdot \boldsymbol{d} \quad \textbf{Eq. 1}$$

The term "work" also has many non-technical meanings. A Webster definition is: sustained physical or mental effort to overcome obstacles and achieve an objective or result. Another Webster definition: energy expended by natural phenomena. The definitions of interest here involve the expenditure of energy to cause

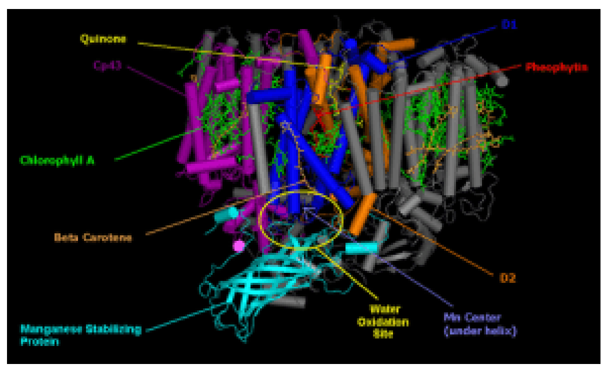
[4] Ibid 2, p 108-111, "ATP is the energy currency for living systems", p 110.

[5] Ibid 2, p 252. This reaction is called "phosphorylation" which "prevents transport of glucose out of the cell and increases the reactivity of the oxygen in the resulting phosphate ester."

something to happen. In the natural word it can mean the energy of the sun to heat the earth, or the energy of wind and rain to cause erosion or the energy released by burning or metal rusting. For humans it might mean to build a fence or clean the house. All these examples involve the release or consumption of energy. The first list of examples involves nWork, and the human examples involve iWork where the human is performing the function of a machine.

nWork has no intelligence involved. iWork is a different paradigm as it can only be performed by a machine. A machine requires embedded (logical) intelligence because it must gather information, process the information to determine the action required, and have embedded means to control the expenditure of energy to perform the specified work.

An example that is commonly thought of as nWork, but is iWork, is the sun's energy using a process called photosynthesis that converts energy from the sun into chemical energy. Photosynthesis is a result of both molecular machines and natural chemical reactions – this process cannot occur by natural chemical reactions alone. This is Wikipedia's description of the area in a plant cell that performs this process: "A photosynthetic reaction center is a complex of several proteins, pigments and other co-factors that together execute the primary energy conversion reactions of photosynthesis. Molecular excitation, either originating directly from sunlight or transferred as excitation energy via light-harvesting antenna systems, give rise to electron transfer reactions along the path of a series of protein-bound co-factors. These co-factors are light-absorbing molecules (also named chromophores or pigments) such as chlorophyll and pheophytin, as well as quinones. The energy of the photon is used to excite an electron of a pigment. The free energy created is then used to reduce a chain of nearby electron acceptors, which have subsequently higher redox-potentials. These electron transfer steps are the initial phase of a series of energy conversion reactions, ultimately resulting in the conversion of the energy of photons to the storage of that energy by the



production of chemical bonds." This is a description of iWork being performed by molecular machines in conjunction with some normal (natural) chemical reactions.

There are two (maybe three?) levels of iWork that we regularly experience. The first is logic level iWork, work that has at least logic level functionality. This includes all man-made objects plus objects made by other living things such as bird nests and bee hives. It also includes the work done by each molecular machine in every living cell.

Humans can perform a higher level of work: abstract iWork. We can think, conceptualize, design, build machines and processes that logic level intelligent entities cannot.

The logical extension is to conclude that there must be an even higher level intelligent entity that designed humans. This assumes that man cannot design an entity that has abstract intelligent functionality because we do not and cannot understand the mechanism.[6]

iWork, performed by machines, requires the continual expenditure of energy to power the logical functionality of the machine. nWork does not have this requirement as there is no intelligence involved. Eq. **1** is the physics defined relationship between the work performed and the energy required to perform nWork. Such a relationship does not exist with intelligent work because the energy involved in performance of a task involves variable, logical factors in addition to the physical work required for the task.

Understanding the difference between iWork and nWork is key to understanding the conclusions presented herein. Life depends upon the iWork that takes place in every cell. Everything we (humans) make and do is the result of the iWork we do as an organism acting as a machine, plus the internal energy consumption required to perform the intelligent functionality within our organism.

[6] Kurzweil, Raymond, *How to Create a Mind,* 2012, is typical of futurists predictions regarding humans creating "minds" that have abstract intelligent functionality. Kurzweil feels that reverse engineering the neocortex of our brain will achieve that end. But as far as I can tell, the brain's functionality is based on neural networks, and my understanding of how they work would not encompass abstraction, but I could be wrong.

There is a need to explain the use of the term "intelligence" as engineers tend to use the term differently than many others.

Intelligence is defined as the ability to acquire and apply knowledge and skills.[7] From an engineering point of view, intelligence is in the realm of philosophy and has a hierarchy of levels: information, logic and abstract. An analogous hierarchy in the realm of science regarding space/time is distance, speed, and acceleration. Most people think of intelligence in terms of a combination of the logic and abstract forms. Engineers use all three levels; abstract intelligence for design and other forms of conceptual "thinking", logic for processing information, and information for specifications, design documentation, data, etc.

Intelligence, at all levels, has no meaning in science in the sense that in the natural world, there is no measuring of states, there is only the direct interaction of matter and energy according to the laws of physics. Measuring and processing state variable information is intelligent activity and only occurs in matter/energy that has been manipulated by iWork to embed intelligence.

The fact that logic processing and abstract thinking are the results of "activity" or work and not a static thing like information is the center of the arguments presented in this paper.

Strictly speaking, engineering and biology are not totally science by these definitions because both fields involve embedded intelligence. nCauses have no analog to logic and no mechanism to perform logical functionality.

iWork differs from naturally caused work because iWork can:

1. perform the work on demand determined by specified state variables and/or logical signal(s), e.g., the temperature is a specified value, a mouse is present, the crankshaft is at a specified angle, the switch is "ON", or some computed algorithm is a specified result, and
2. control the use of energy, i.e., the form, time and profile, location, direction and amount are all specified[8].

[7] Oxford Dictionary
[8] Note that a specified value can be "do not care."

The "on-demand" requirement is a logical operation that requires an output which has at least two states based upon the states of the input(s). Natural causes cannot meet this requirement for two reasons:

1. The only inputs available are the state variables resulting from a previous naturally caused event with no intelligence involved, and
2. The only output is the unitary most stable equilibrium of the system.[9]

In other words, nCauses have no mechanism for logical functionality and therefore cannot perform iWork.

Machines

Merriam-Webster Definition

1. a archaic: a construction thing whether material or immaterial;
   b: conveyance, vehicle;
   e: an assemblage of parts that transmit forces, motion, and energy one to another in a predetermined manner or an instrument designed to transmit or modify the application of power, force, or motion;
   f: a mechanically, electrically or electronically operated device for performing a task.
2. a: a living organism or one of its functional systems
3. a: a literary device or contrivance introduced for dramatic effect.

A.C. McIntosh Definition[10]

1. a functional device which uses energy.

[9] A "most stable equilibrium" may not be a singular state. For example, molecules in a solution may be jumping between two or more states to maintain a concentration equilibrium when there is more than one product. However, this is the nature of this "state", and it does not meet the requirement of providing a singular outcome for a given set of input conditions.

[10] From "*Functional Information and Entropy in Living Systems*," pp 115-126, Design and Nature III: Comparing Design in Nature and Science and Engineering, Vol 87 of WIT Transactions on Ecology and the Enviornment, Editor Brebbie, CA, WIT press, 2006, ISBN 1-84564-166-3

Author's Definition

1. An assemblage of parts that performs intelligent work.

The author's definition is inclusive of all Webster's definitions.

All living things are machines because they are entities that perform intelligent work within every cell just to maintain life. Biologists have discovered that most proteins molecules have a limited lifetime (half-life).[11] This is true from a physics point of view (2nd Law) because they are in a marginally stable state in their environment. If the protein becomes dysfunctional, the cell may die.[12] The "off-equilibrium" status of the cell is maintained by machinery within the cell that detects conditions and performs iWork as needed to keep the cell alive.

This example illustrates an important characteristics of machines, stated as this theorem:

All machines require off-equilibrium matter/energy to function.

One reason is that machines require complex specified configurations of matter/energy which nCauses tend to destroy per the 2nd law of thermodynamics. Another reason is that logical functionality requires the temporary storage of information, which requires states that are "read" by the logic processor. Due to energy constraints, the "reading" and "writing" of the stored information must have relatively small activation energies, which equates to being off-equilibrium.

These are logical, not scientific arguments. The second law of thermodynamics is not a scientific law, it is a law based on observation, not scientific law.[13]

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[11] Ibid 2, p.514

[12] The knowledge that protein machines have a half life is used as regulatory mechanism for some proteins such as aconitase, Ibid 2, p 304 and 311.

[13] Resnick, Robert; Halliday, David, *Physics,* Part 1, John Wiley & Sons, Inc., 2nd edition, 1960, "The second law of thermodynamics is a broad generalization from experience," p 540; "Although the ideas are sometimes subtle and the theory may at times seem abstract, in application this is one of the most practical and fruitful areas of physics," p. 532. This fact means that any action that is the result of the 2nd Law is a constraint that is not scientific, rather logical.

Machines must have embedded intelligence as logical actions that require the intelligent use of energy[14] are required to determine the specified work that must be performed. Machines, to manipulate matter and energy in a specified manner, must themselves be the result of intelligent work by a machine. In other words, it takes a machine to create another machine. This is another form of the classical "chicken and egg" conundrum, but with one big difference. The chicken and egg both have the same level of intelligence. But the machine designing and building the other must have a higher level of intelligence. This answers this ancient mystery: the most supreme intelligence comes first.

The claim that machines perform logic functions or have embedded intelligence may be an unconvincing argument to some. However, inspect any machine and one can find the logic function. Take for example combustion engine. The "logic" is the coordination of the pistons, valves, fuel, ignition sparks, etc., to make the engine work as explained in this video. Without the intelligent coordination of these parts, the engine will not work.

All Machines must have several functionalities:

1. Sensing means. All machines perform an action based upon state variables and/or logical inputs that are used to determine work to be performed. Therefore, the parameters that are involved in the decision-making process must be sensed and signaled to the processing means. This can mean any combination of:
    a. Passive sensor, a device that has no embedded intelligent functionality, e.g., thermistor, photosensor, strain gage or throttle potentiometer sensor,
    b. Active sensor, a device that does have embedded intelligent functionality, e.g., servo accelerometer, a radar sensor, infrared temperature sensor, logic output from another machine, and
    c. Signal inputs from another source.

[14] There may be a distinction between the energy used to implement the logical functionality between the molecular level vs. the macro level. At the micro level, there are machines, i.e. the enzyme aconitase, Ibid 2, p. 304, that act as an enzyme in both directions, therefore absorb some energy in one direction and give off energy in the other direction using free energy for the logical functionality. All macro machines the author can think of use specified energy sources to power the logical functionality.

2. Sensor-Processor Signaling means. The signals, or information, must be conveyed to the processing means in a way that the processor can “understand” the information.
3. Logical Processing means. Logical processing is performed on the input signals to determine the action required.
4. Processor-Actuator Signaling means. The “action required” message must be conveyed in a form understandable to the actuator.
5. Actuator. The actuator is a device, controlled by the signal from the processor, that performs the commanded work.

All machines, when working, are running an iProcess, so the characteristics of an iProcess, explained in detail in the iProcess section that follows, apply: they require specified initial conditions and they must be started by intelligent action. The concept of iProcesses and machines is confusing because iProcesses use machines and machines use iProcesses. An iProcess step is the specification of the required task and a machine is the matter/energy entity that performs the iWork to accomplish the specified task.

The concepts described here are hard to visualize by verbal descriptions, so specific examples of machines are used as examples to identify the various attributes; initial conditions, start action, the sensor(s), signaling means, processor, actuator and power source.

Machine Examples

Mousetrap

A mouse trap is a very simple device, but it is a machine and has logic functionality like more complex machines, albeit simpler in form.

Initial Conditions: The constructed design of the mousetrap is the starting point as with all machines. In addition, to be functional, the trap must be baited, then set (rotate the hammer to the “set” position, rotate the trigger rod over it, latch under the trigger clasp).

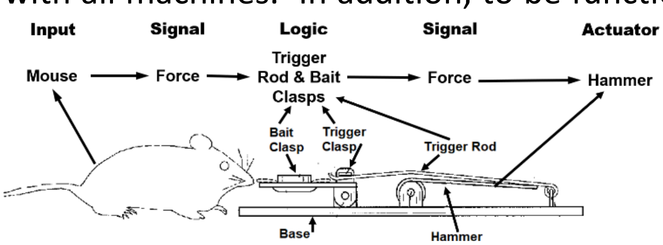


Figure 1. Mousetrap Process Actions Diagram

Process Initiation: The actual iProcess does not start until a mouse applies a force (intelligent action) to the bait clasp and releases the trigger clasp.

Sensing/Input Means: The sensing mechanism is the bait clasp. The energy to activate the sensor comes from the mouse. The form of the signal is the force of the mouse pushing on the bait clasp when trying to eat the bait.

Logic Processor Means: The logic processing means is the design of the mechanism that converts the input (mouse force) into the logical output of "kill the mouse" by the signal of un-restraining the trigger rod made possible by the design of the bait clasp, trigger clasp, and trigger rod mechanism. The off-equilibrium matter that implements the logic is the spring induced strain in the trigger bar, trigger clasp and bait clasp while the trap is set.

Actuator: The actuator is a simple spring mechanism extended to be a hammer that strikes the mouse when released. The spring is in a non-equilibrium state even when it is not set to provide a substantial force to hold the mouse in place after being struck. The power source for the kill is provided by the human that further winds the spring during the bait/set process. If the mousetrap was left to decay by natural causes, eventually the wood base would disintegrate and release the remaining "non-set" spring potential energy.

The mousetrap is an excellent example because it shows how logical functionality is contained in even the simplest of machines and the of use off-equilibrium conditions that normally exist in working machines. It illustrates the embedded intelligence in a machine that extends the possibilities of natural causes.

Engine

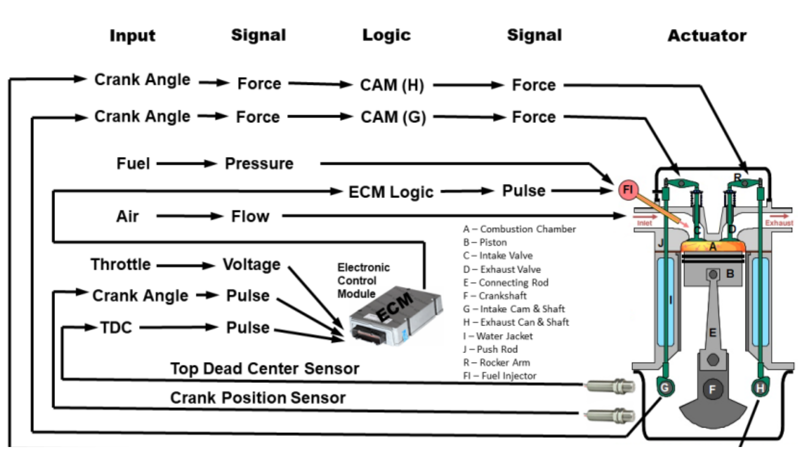


FIGURE 2. DIESEL ENGINE PROCESS ACTIONS DIAGRAM

An engine is a more complex machine that has many coherent elements that must work in a precise manner for the engine to work. Figure 2 shows a simple cross-section drawing of a one-cylinder diesel engine with detail to show the actions needed to identify the input, signaling, processing, and actuator for each process action. Missing in the figure are cooling system, starter motor, and the battery to power the ECM (Engine Control Module). This could be a gas engine if a spark plug was included. More cylinders could be shown to illustrate the coherence to create a smooth performance by staggering the connecting rods on the crankshaft and of the cams on the camshaft.

Initial conditions: The mechanical design is the first initial condition. In addition, the cooling system fluid, crankcase oil, and fuel must be added. The fuel lines and the coolant circuit must have trapped air removed. And the battery must be charged.

Intelligent Process Initiation: The engine must be started by rotating the engine, details omitted.

Intelligent Process Actions: There are three actions.

Air/Fuel Mixture

The first action of the engine's intelligent process is to provide the right air to fuel mixture inside the piston during what is called the intake cycle. During this time, the exhaust valve is closed, the intake valve is open, and the piston is moving downward, drawing in air/fuel mixture from the intake manifold. The air coming into the combustion chamber passes by the injector, shown under the logic column in Figure 2. The injector[15] in combination with the ECM[16] are the components that provide the coordinated, logical functionality of converting the inputs of fuel pressure, air flow, throttle position voltage, crank position pulse train, and top-dead-center pulse marker into an air/fuel mixture as a function of time to deliver a properly timed and specified air/fuel mixture to the combustion chamber.

Valve Action

The other two actions are the operation of the intake valve and the exhaust valve. This is accomplished with a cam that rotates at ½ the rate of the crankshaft

[15] The injector and ECM are both machines and could have their own process action diagrams. Instead, for simplicity, the injector in combination with the ECM are shown in Figure 2 as the components that provide the coordinated, logical functionality. Physically, however, the injector is located next to the intake valve in the engine.

[16] Wikipedia has a good description of the Engine Control Unit with explanation of mechanisms using various sensors and algorithms that adjust for various operating conditions.

accomplished by gearing that is not shown in Figure 2, and which is part of the logical function that is not identified in the figure. The camshaft has one cam that operates the intake valve to be open during the intake cycle (process step) and closed during the compression, power and exhaust cycles (process steps) and a second cam that operates the exhaust valve to be open during the exhaust cycle and closed for the other three cycles. The cam operation of the valves, with the help of the valve springs, rocker arm, tappets and pushrods provide the mechanical logical functionality.

The power to operate the logical processing comes from the power generated from the engine, in two forms. The first is the torque generated by the engine which drives the gearing that rotates the cams and it keeps the battery charged. The second is the battery which powers the ECM and the injectors.

Actuator Actions: The actuator of the engine consists of the pistons, connecting rods, crankshaft, bearing and the mechanical structure surrounding and supporting these moving parts that create the combustion chamber and the oil pan areas. The combustion that repeatedly occurs in the combustion chamber resulting from the coherence created by the design and actions of the sensing and logical pieces described earlier, creates the up and down motion of the pistons which is turned into rotational torque by the crankshaft. This assembly converts the thermal, expanding gas energy into torque in a repeating cycle that occurs every two rotations of the crankshaft.

An engine is an example of a complex mechanical machine[17] whose sensor/input, signaling, processing and actuator functionalities are all merged together in the mechanical design of the system. Mechanical engineers normally do not identify or think in terms of signal and processor means in machines they design as these functionalities are typically merged together in the design. However, electronic engineers design processing equipment where these functionalities are clearly separated and identified. However, all machines, of all types, necessarily have these functionalities even if they are merged or hidden.

[17] Wikipedia has a nice animation of a four-cycle gasoline engine. A diesel engine is the same except there is no spark plug. Here is a video that has great animation of the various engine functions by Toyoda.

Feedback Systems and ECM

An engine is, in engineering terms, an example of a feedback control loop since output in the form of rotation and torque is used as inputs to the logical processing components (see Figure 2), as compared to an open loop system like the mousetrap. This adds another complexity: stability. Closed loop systems are often inherently unstable, meaning that they will revert to some form of oscillation, and with many systems, cause self-destruction. Means to stabilize the feedback control systems must be engineered and included as part of such a system.

Feedback control technology is a complex area of engineering and its impact with respect to the engine example was not discussed as this is an area of design that is not obvious to non-engineers.

Diesel engines in earlier days used mechanical fuel injection systems operated by cams. One benefit of the use of the ECM coupled with electrically actuated injectors is the ability to add algorithms to stabilize and enhance the performance of the engine compared to the inflexible mechanical means. The ECM is a machine, but it is treated as a component for the purposes of this discussion.

Tools – All Static Things Embedded With Information

The discussion to this point has been about engineered machines. But there is a whole different category of intelligent work creations which are not machines. For the purposes of this paper, all such entities are called tools. Therefore, the definition of the term tool will be an object created by intelligent work that does not perform intelligent work. This is a very broad definition because it includes everything created by life except for machines. This includes things we think of as tools (hammer, saw, wrench) but also art (paintings, literature, music, sculpture), medicines, buildings and other structures, telescopes, batteries, makeup, birds nest, beehive, etc.

Tools are made by intelligent machines, that is, living things plus machines designed and built by engineers. Tools are static entities that have embedded information, but not embedded dynamic intelligence like machines. A logical distinction is that there is a statistical probability that natural causes could create some tools. In this sense, the ID argument "where does the information come from" is treating life as a tool instead of a machine; both massive understatement because life is so much more than either!

Natural Causes can create objects that can be used as tools. An example is a rock that has a shape that makes it convenient to use as a hammer. Or a human can shape a rock to do the same thing. Other tools, such as an adjustable (Crescent) wrench, must be engineered, i.e., designed and fabricated using intelligent work.

Processes: Natural Processes (nProcesses) and Intelligent Processes (iProcesses)

Merriam-Webster Definition: Process

1. a series of actions or steps taken in order to achieve a particular end.

Author's Definition, nProcess:

1. a series of actions or steps resulting from nCauses.

Author's Definition, iProcess:

1. a series of actions or steps taken designed to achieve a desired end.

Definitions are included for both nProcesses and iProcesses because they are the result of two different paradigms and have different capabilities. The outcomes resulting from nProcesses are determined by initial conditions, free energy availability and the laws of physics. iProcesses can extend outcomes because they use machines which can direct the use of matter and energy to accomplish logical goals based on sensed conditions.

Distinctions between nProcesses and iProcesses

All processes involve state changes of matter and energy over time. But there is profound difference between nProcesses and iProcesses.

nProcesses have no intelligence conducting or guiding the process. The process steps are determined by the initial conditions created by previous nProcess steps coupled with the available free energy and the laws of physics. There is no energy consumed performing logical functions. The outcome of nProcesses is caused by nCauses.

iProcesses, on the other hand, must make logical decisions based on sensed conditions. Logical functionality requires the intelligent use of energy. Macro machines require energy to perform the logical functionality that is in addition to the work required to achieve the specified end. Some micro machines, like some enzymes, do not require additional energy for the logical functionality. The reason is that the logical functionality is achieved by atomic bonding forces, and the specified work is energy in the same form. Since energy is conserved at this level, and the logical functionality is achieved by specified weak bonds that position the reactants, the logical energy is conserved.[18] iProcesses can include nProcess steps, but at least some of the process steps must use machines doing iWork. The outcome of iProcesses is caused by iCauses.

A machine, when not running is still a machine. When it is running, it is running a process to accomplish whatever task it was designed to do. This may seem like a trivial distinction, but it is not when discussing life.

A distinction between iProcesses and nProcesses is that designed processes use a local, specified power source compared to a nProcess that uses free energy – energy available to do work from previous nProcess steps – no machines involved.

Characteristics of an iProcess

An iProcess is Action; It Requires Machinery and Energy to Function

An iProcess is not a static thing, it involves iWork, which requires functioning machinery, designed to accomplish a specific goal. When an intelligent process is running, it is continually consuming energy[19] due to the on-going actions required to implement the embedded intelligence. This contrasts with a natural process which is consuming energy only during the time the natural state change is taking place.

[18] The aconitase enzyme is an example, Ibid 2, p.304

[19] There are many intelligent processes that go into a pause or stop mode whereby the stop conditions are the initial conditions needed for restarting. An example is a reservoir that is filled with water by a pump raising the water from a river. When the water level drops to a preset level it resets the timer that runs the pump motor which later turns the motor off, resetting the water level to an initial condition for the pause/stop mode.

An iProcess Must be Designed

An iProcess is intelligent action and therefore must be designed by an abstract intelligent entity.

The iProcess Machinery Must be Built

The machinery required to do the iWork for each process step, plus the signaling and material transport means connecting process steps must be assembled. Since some of the components of the system are held away from equilibrium, this can be a serious challenge requiring specialized assembly tools and machinery.

iProcess is a Hierarchy of sub-Processes

An iProcess was defined to be is a series of actions designed to achieve a desired result. All iWork is part of an iProcess. The "actions" are performed by machines. Machines use intelligent processes because they must provide a specified end based on logical decisions. Intelligent processes can be thought of as a hierarchy of actions, layered, both vertically and horizontally such that when executed, the actions achieve the desired goal.

An iProcess Requires Specified Initial Conditions

Each step of an iProcess requires specified initial conditions. The first condition is the specified arrangement of the matter/energy involved (design) in the iProcess coupled with setting all state variables, e.g., load software, charge batteries, set switches to specified positions, fill fluids, etc. The action of an iProcess step will normally change this arrangement and will be the initial conditions of the next step. Stated differently, iProcesses are creating a specified result, requiring specified initial conditions being acted upon by intelligently guided energy. nProcesses will lead to an unspecified result that is determined by previous natural actions reacting to the available free energy. Both, intelligent and natural processes follow the laws of physics.

iProcesses Must Be Started by Intelligent Action

Think of any iProcess – it always starts with some event or intelligent decision to take the "first step". All processes require the use of controlled energy, so the start is often the action of activating the power source.

iProcess Steps Require Inputs

Each step of an iProcess is intelligent action. To be intelligent, the action must be contingent. The contingencies are provided as "inputs" to the logical processing means. The contingency might be time, a switch position, a fluid level or a logic input. The parameter involved must be converted to a signal or mechanism that can be "understood" by the machinery. The conversion device might be a sensor, or a mechanical device or an electrical signal. Simple examples are the trigger catch mechanism on a mousetrap and a float valve in a toilet. A gasoline engine has a camshaft to provide a force to open and close the cylinder intake and exhaust valves as needed for the engine to operate. A home computer has a keyboard and mouse that provides standardized signaling.

iProcesses Require the Use of Machines

iProcess steps require the conversion of logical decisions based on information provided by the initial conditions to command and execute specified work, i.e., a machine.

Reverse Engineering a Process

Reverse engineering of any iProcess could be systematically organized by first identifying the actions that are used to achieve the specified result; then for each action:

1. identify the initial conditions required for the action,
2. identify the event or intelligent action that starts the new action step,
3. identify the machine that does the iWork to complete the action, and,
4. determine how each of the machine functionalities is implemented.

Science

Collins American Dictionary Definition

1. the state of fact of knowledge; knowledge;
2. a. the systematized knowledge of nature and physical world

Author's Definition

1. the systematic knowledge of the natural world gained through observation and experiment.

Note: This definition of physics and chemistry excludes matter/energy with embedded intelligence.

Merriam-Webster's first definition is "the state of knowing." This definition applies to any field, e.g., art and philosophy. It implies that something that is not understood is not science, e.g., entanglement, dark matter and energy. I am sure that scientists would disagree. And the phrase "the science of (fill in the blank)" is commonly used even as titles of classes and curriculum in universities. This definition is too broad for purposes of this paper.

I learned that science is about the physical sciences (physics and chemistry) and philosophy was about the mind (logic, math) by the department they were taught. However, engineering was in the school of science. But this was over 50 years ago. I see that today, the sciences are typically divided into two divisions, natural sciences and formal or applied sciences[20]. Natural sciences are what I thought of as "science" and engineering as applied science. Applied science implies adding intelligence to science and fits with the idea that engineering merges the realms of science and philosophy.

However, mathematics, now called a formal or applied science, should remain in the realm of philosophy as it is a mental abstraction, in my opinion.

[20] Princeton University calls their engineering department "School of Engineering and Applied Science", see: https://engineering.princeton.edu/

For the purposes of this site, the term science, without an adjective, means physics and chemistry, geology, weather, etc.

Part of the purpose of this site is to make a clear distinction between outcomes that result from nCauses (laws of physics sans intelligence) and matter/energy with embedded intelligence resulting from engineered manipulation, and that science and intelligence are two separate things. This is impossible with the many meanings that terms related to the realms of science, philosophy and theology in use today.

Engineer

Oxford Dictionaries Definition

Noun 1. a person who designs and builds machines and objects for a specified purpose.

Verb 1. Design and build a machine or structure.

Author's Definition

Noun 1. a person who designs and builds machines and objects for a specified purpose.

Verb 1. Design and build a machine or object for a specified purpose.

Noun 2. a person who performs iWork to create entities that nCauses either cannot create, or cannot create in the quantity, time or speed desired.

Note: This definition is included to distinguish design vs. actualization as it seems they are often conflated, and to exclude maintenance with is typically the role of a technician.

An Engineering Perspective

Engineers think of themselves as "applied scientists,"[21] as opposed to those who embed intelligence into matter/energy. But we do embed information and intelligence into matter/energy, and, as a result, are a link between the realms of science and philosophy. Therefore, this theorem is logically true:

Theorem: Engineering merges the realms of science and philosophy.

The experience of doing this work leaves an engineer with some valuable lessons.

All designs must have a mechanism, defined broadly to mean the methodology that determines the outcome of any action. Engineers design mechanisms as they are the means of creating functionalities. To work, mechanisms must follow the laws of physics and at the same time, overcome the limitations of materials, sources of usable energy, and other logical limitations.

An engineer quickly realizes all outcomes that do not violate the laws of physics are not possible, for many reasons. In addition to design, an engineer builds prototypes and tests them. Each is an unpublished experiment and an education regarding the difficulty of making complex systems work. There are thousands of mistakes that can be made, and any one of them can result in failure making engineers keenly aware of limitations that restrict outcomes.

Complex systems have many components and subsystems that share information and cooperate with each other. This produces the need for standards, specifications, protocols, and languages to achieve the coherence necessary for all the pieces to work together. One impact is that the information and structure needed for any given functionality will be intertwined with others and therefore is dispersed. This fact also means that the idea of evolution by singular changes in a system is, in most cases, impossible due to coherent information being required in multiple locations.

Natural causes and time are enemies of engineers and nCauses. Metals corrode. Plastics age and change properties. Sealed areas are breached. Fluids become

[21] Princeton University calls their engineering department "School of Engineering and Applied Science", see: https://engineering.princeton.edu/

contaminated. And the list goes on. The second law of thermodynamics tends to degrade engineered entities by reducing the specificity of the embedded information.

There is no such thing as perfection. Everything is a trade-off. Virtually all designs must balance performance, cost, reliability, appearance, longevity, size and weight, capabilities not possible by natural causes.

Perhaps the most valuable lesson is the realization of the difficulty of finding and inventing designs that work and finding the fine balance that is usually needed to achieve the desired result. Many physicists marvel at the "fine tuning" required to create a universe that could support our life. Engineers routinely deal with this problem. We are surrounded by marvels of complex design and mistakenly take them for granted.

Mechanism

Cambridge Dictionary Definition

1. a part of a machine, or a set of parts that work together.
2. a. a way of doing something, esp. one that is planned or part of a system.

Brick's Law Definition

1. Components, elements, or parts, and the associated energy and information flows enabling a machine, process, or system to achieve its intended result within this type of logical assembly.

Author's Definition

1. a methodology including components, elements, parts and the associated energy and information flows enabling a machine, process or system that has demonstrated the ability to achieve its intended result.

Note: This definition is tweaked to include only proven methodologies.

The concept of mechanism is included since the materialist view of how beginning life could be created by nCauses lacks the mechanism for the design, build and starting of life. Building life requires finding and assembling all the components of life, at one place and time. This is a formidable task, especially considering the fragile nature and limited life of many of the components. Perhaps it takes a design engineer who created processes and machines to appreciate the constraints involved even when intelligence with exquisite machine capability (ability to put things together, setup initial conditions, start, test, etc.) is involved, let alone without these capabilities.[22]

The Limitations of Natural Causes

It is generally acknowledged by materialists that life seems to be a violation of the second law of thermodynamics. However, the argument goes, if there is an outside energy source that can be used to lower entropy (like the sun), there is a finite, albeit insanely small, theoretical probability that beginning life could start by natural causes. This is also false. The probability is zero because natural causes are incapable of performing the intelligent work required to live. This is a logical constraint, not a scientific one.

This is an example where engineering experience is useful. It is obvious to an experienced engineer that most entities (arrangements of matter/energy) cannot be created by design, let alone by nCauses. Here is a thought experiment that provides illustrates the difference between nCauses and iCauses.

Image a house with a hallway. On the floor in the hallway is a picture, and a nail in the wall above the picture. The doors and windows and all other openings to the house are closed. The man of the house is sitting at the kitchen bar sipping on a cup of coffee. His wife asks him to hang the picture she left on the hallway floor. He says, “no, I’m enjoying my coffee, let nature do it.” She responds, “I don’t have time for that”, so he obediently goes to the hallway, picks up the picture and hangs it. He gets rewarded with a kiss.

The man is a theoretical physicist. He believed that any configuration of matter/energy that does not violate the laws of physics can occur naturally – it would just be a matter of statistical probability coupled with time.

[22] James Tour, a synthetic organic chemist at Rice University agrees! See this article and this video.

The thought experiment is to answer this question: what possible series of natural events could accomplish this task? Here is a straw-man scenario, that will work only if the picture is not directly below the nail in the wall. A giant asteroid with the right momentum hits the earth at the right place in the right direction that causes the earth to accelerate the house with respect to the picture such that the house (nail) moves toward the picture.[23] If the picture is directly below the nail, the asteroid would have to hit the house to move the earth in the right direction. Assuming this is not the case, just as the nail passes the picture, another, asteroid hits the other side of the earth in the exact right direction to cause the house to move back in just the right direction such that the picture frame catches the nail in the wall. Done. The picture is hung by natural causes.

Of course, all this happens in a few milliseconds or seconds. Before equilibrium is reached, the house is destroyed, the earth's orbit is changed and eventually, all life on earth is destroyed. But the picture was hung if only but a few milliseconds.

This is a trivial but instructive example. It is common sense that the picture cannot hang itself, because no available naturally caused forces could hang the picture without damaging the house. Thermal energy cannot do the job. Neither could electromagnetic or electrostatic forces as the picture is not made of magnetic material nor is the picture electrically charged. However, the physicist was able to hang the picture without violating any law of physics.

Theorems

The logical conclusion is that with all the openings to the outside shut, there is no internal free energy source capable of hanging the picture. Free energy results from natural events. If the inside of the house is in a state of equilibrium, no natural event could create the necessary free energy. Even if there was free energy

> **Theorem:** Natural Causes cannot achieve all outcomes allowed by the laws of physics.

[23] The dynamics of this event are complicated, and the actual outcome might differ from the description. The difference between the picture and the acceleration of the earth – asteroid collision assemblage is a chaotic, non-linear event that defies analysis. However, I think that, in principle, such an event is possible, but for logical reasons may not be.

available, how could it occur at the right time, in the right form and amount to do the job? Since natural causes cannot do the job, yet a man can, this theorem must be true:

Materialist ideology denies the truth of this theorem, and, in effect, claim intelligence is created by science and therefore is in the same realm. This theorem is true not because the picture on the wall violates any law of physics; it is true because there are logical constraints on the ability of natural causes to deliver energy at the right place, in the right form at the right time to accomplish many tasks.

A man can perform iWork, i.e., can control matter/energy to achieve desired ends not possible by n/Causes making this theorem true:

Theorem: Machines can expand upon the outcomes allowed by the laws of physics.

Life

There is no universally accepted or official definition of life, but it has been thought, and written[24] about since the beginnings of civilization. From the outside, the reason seems to be that there is no universal agreement what life is, how it started or how it works. As stated in *BioChemistry*,[25] "Despite the work of life scientist over several centuries, a definitive answer to the deceptively simple question has been elusive."

Life is an iProcess

Author's Definition, Life:

> a: a state of matter/energy continuously running a vital process in a cell or organism that sustains and perpetuates itself as distinguished from dead matter/energy.

[24] Rizzotti, M. Defining Life: The Central Problem in Theoretical Biology; University of Padova Press: Padova, Italy, 1996.

[25] Ibid 2, p2.

From an engineering perspective, this simple definition of life is obvious. At all levels, life is an iProcess, a series of actions designed to maintain, perpetuate and grow itself. Biologists often refer to life as a process, not realizing they are dealing with an iProcess, not a natural one. All life, taken together is an iProcess because life depends upon other life by means of environmental transformation, a "food-chain" and systematic recycling of raw materials. At the cell level, the life processes find and gather raw materials, extract energy to run and maintain the cell's life processes including cell division. The same is true at the organism level except maintaining and growing the population is accomplished by reproduction and functionality is obtained by specialized cells. Each organism has hundreds of intelligent processes that control the temperature, digestion, respiration, etc.

Understanding what iProcesses are and what is required to make them work encompasses all the functionalities that are in textbook definitions of life.

Comparison of Life and Manmade Machines

All life forms are machines because they do intelligent work. However, even the simplest life is much more; it is an intelligent process that is self-sufficient and adaptable to the point of reproducing so that it can continue to exist even after the demise of the original life form. This is an indication of the high level of embedded intelligence, especially when compared to man-made machines.

The other major difference is scale. Life's machines are highly complex, specified molecules whereas man's machines are macrostructures. Life's smallest living unit, the cell, is so small that we cannot see it without a microscope. Life also has macro level forms, organisms, that are composed of trillions of specialized cells. Groups of specialized cells are used to build macro machines, organs, and other macro structures such as fingernails, hair and teeth enamel using specialized molecules.

Transcription

1. A molecular machine unwinds a strand of DNA
2. An enzyme called RNA polymerase initiates mRNA synthesis and copies the DNA
3. mRNA is formed and leaves the nucleus through a nuclear pore into the cytoplasm

Translation

4. The mRNA connects to a ribosome in the cytoplasm
5. The tRNA interprets the code and brings a specific amino acid to the ribosome
6. The ribosome uses a mRNA codon to bind with the complementary shape of the tRNA anticodon
7. Amino acids link to each other to form a polypeptide chain

FIGURE 3. PROTEIN SYNTHESIS PROCESS STEPS SANS FOLDING

Compared to lifeless machines, living machines are orders of magnitude more complex and sophisticated. However, both obey the laws of physics and therefore both must have the logical functionality required of machines. This concurs with observation despite our limited ability to see and instrument at the microscopic size and speed levels. This lends credence to the belief that we are not missing some yet-to-be-discovered property that makes life different regarding the ability to perform logical actions due to our incomplete knowledge of physics.

I would like to be able to put together a process action diagram like Figure 1 and Figure 2 for some action that takes place in life, such as the building of a protein shown in the video. There are seven high-level steps to this intelligent process as shown in Figure 3 and there are several machines involved, but there are far, far more details involved that are not shown. A molecular cell biology textbook explains[26]: "A ribosome is composed of several different ribosomal RNA (rRNA) molecules and more than 50 proteins, organized into a large subunit and a small subunit."

The complexity is obvious. A process action diagram like Figure 2 for building a protein molecule would likely take several hundred pages. Such a diagram would have to explain how the functionality of every functional protein is accomplished. It is obvious that much has been learned at a high level despite the difficulties of understanding what is going on in real time at the molecular level. However, this understanding is minuscule compared to the understanding engineers have of the very much simpler machines we design and build. It is obvious there is much yet to be learned about life.

[26] Lodish et al, *Molecular Cell Biology,* Fourth Edition, 125

Limits of nCauses at the Micro Level

A thought experiment was used to illustrate why nCauses cannot do the work of a machine, that is, iWork in the macro world. But does this analogy work at the micro level?

The answer is yes because providing the right form and amount of energy, at the right time and profile and direction is not possible at the micro level as well. The difference is that at the micro level, it is necessary to perform work on specific atoms in a molecule as opposed to a macro object.

The sources of energy available are atomic-level forces including bonding forces (covalent bonds, hydrogen bonds, ionic interactions, Van der Waals interactions and hydrophobic bonds), concentration gradients and momentum (temperature). The most common source of free energy in fluids is the kinetic energy due to Brownian movement (temperature/pressure) acting as the activation energy that causes chemical reactions which cause new equilibrium states based on different bonds.

We know that a cell environment is a controlled, non-chaotic environment; therefore, nCauses will always lead to a more stable or probable state. The state of the matter/energy in a cell-like enclosure filled with the type of molecules that exist in living cells, without iWork, would be one of chemical equilibrium, therefore incapable of logical functionality. Temperature and pressure will impact all the atoms of a microsystem at the same time, reducing the specificity of the matter/energy in the object. Indeed, one of the main struggles for the survival of life is repairing the damage caused by nCauses. nCauses cannot do iWork either at micro or macro sizes, even though nCauses can create some molecules needed for life.

Outlooks; Chemist vs. Engineer

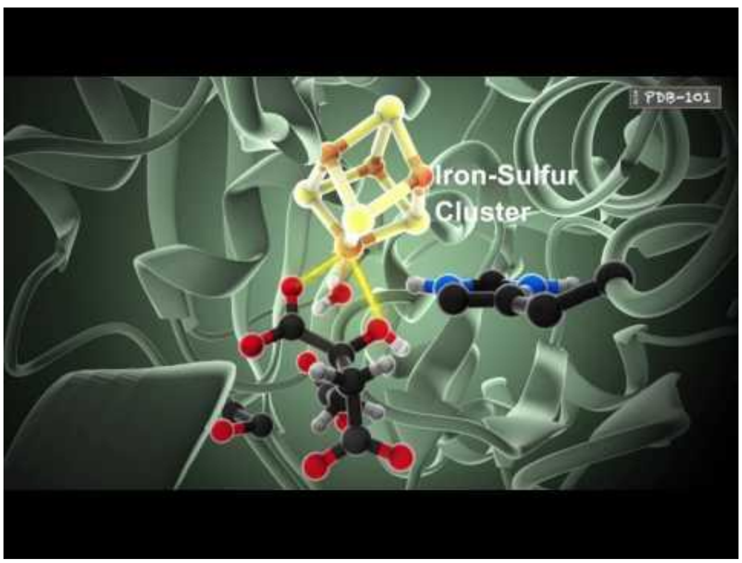
A chemist looking at Video 1 or Video 2 sees chemical reactions taking place while an engineer sees molecular machines at work. The differences are profound. A chemical reaction is the result of natural causes while a machine creates state changes by performing intelligent work which is beyond the reach of natural causes. Chemistry is 100 percent science while machines are part science and part logic from the realm of philosophy.

To an engineer, calling the actions taking place in the video chemical reactions is analogous to calling road construction workers cutting a ledge in a hillside erosion. If an enzyme catalyst speeds up a chemical reaction, then road builders speed up erosion!

Life Needs to be Reverse Engineered

We will not fully understand or appreciate life until it has been reversed engineered to the level of understanding we have of human engineered entities. Engineers, in a broad sense, understand functionalities that are needed for life. But without knowing the mechanisms of the design, how the molecular machines achieve their functionalities, the algorithms, protocols, languages, the degree of natural vs. directed activity employed, etc., we will not be able to reach such knowledge.

A systematic approach to reverse engineer processes posited in the iProcess definition section. I do not know how close we are, technology-wise, to gain this information for cell intelligent process actions today, however Video 2 comes close for the example it depicts. The animation, which converts a citrate molecule to an isocitrate molecule using the enzyme aconitase, shows how the enzyme captures and holds the citrate molecule in place, the mechanism for converting to the intermediate reactants cis-aconitate and a water molecule, then completing the bonding to make the isocitrate molecule and releasing it from the interior of the enzyme.



VIDEO 2. HOW ENZYMES WORK ANIMATION

This is obviously an intelligent process with several steps. If the video accurately represents the action within the enzyme, then the logical functionality for this enzyme is explained,[27] but the energy sources and exchanges are not. What are they, and what triggered this action?

There are many questions that come from this outsider trying to determine how much is understood about the life process. It is understood by all that the information for making proteins is contained in the DNA molecule, and the proteins are the "workhorses" and "building blocks" of the cell. But workhorses must be guided to be of any use. How is this accomplished? Only about 2-5% of the DNA is devoted to specifying the protein polymers. The intelligent process control functionality needed to make life viable is mindboggling and there must be a mechanism in the cell to do this work. It would seem obvious that much or most of the 95-98% remaining DNA not devoted to proteins must be involved with intelligent process control. But how?

Until the recent ENCODE project, much of the DNA was thought to be "junk." Those of this opinion had to be totally oblivious to the need for, and the complexity of the intelligent process control element of life. Gaining an understanding of the life process to the degree we understand machines we create will most certainly find the "junk" DNA to be gold.

It is the opinion of this engineer that reverse engineering life is perhaps the most significant advancement that mankind should now be pursuing. The benefits of having a detailed understanding of life are obvious, especially in the field of medicine. It would enable us to be better stewards of the world.[28] Very likely we will discover design concepts that would never occur to mankind, such as neural networks. To reach such a goal, the field of biology must embrace the idea that life is dependent upon machinery and intelligent process control, including closed-loop control theory.

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[27] This video does not explain the energy exchanges taking place during the process. Research indicates that there is no intelligently added energy (ATP) involved, and that the enzyme works in both directions. This poses several questions which will hopefully be resolved. Is this enzyme a machine or tool? I've modified the characteristics of a machine in the paper to indicate that the energy for logic functionality is intelligently controlled, but not necessarily intelligently supplied. I believe that understanding how this enzyme works will require understanding the dynamics involved. My guess that this will take computer modeling that is more advanced than currently available.

[28] This is also the conclusion of Ken Dill in this informative TED talk about protein folding.

Tests to Falsify Claims of This Paper

Falsifiable, First Life Required Specified Initial Conditions to Start

This paper presents the argument that life is an intelligent process and all successful intelligent processes must start with specified initial conditions coupled with an intelligent action. These arguments, taken together, can be disproven about beginning life. Here is the logic.

All cells propagate by cellular division. That means that the first cell must have been built by a super intelligent engineer that could not only design life but make all the specified molecules with the embedded intelligence, including instructions for cellular division, then construct the cell and start the life process.

Materialists contend that understanding how life started can be solved by finding natural mechanisms with the ability to create the molecules needed for life. My contention is that even if all the molecules, including the DNA that contains the information needed for life, were put together in a life-friendly environment, life would not start because the process instructions for building the cell walls and internal structures from scratch will be missing. Sustaining life is different from starting it.

Verifying this claim is testable. The test would amount to putting the components of a cell, that is the DNA, proteins, properly folded, plus all the other molecules in sufficient quantities needed for life in a life-friendly setting and observe if life starts. Certainly, some activity would occur, because the cell machinery, including the logical hardware and software, will be in place, but the cell construction will be unsuccessful because the process control instructions are not compatible with the initial conditions.[29]

It seems that the field of biology can test this hypothesis. Compared to other achievements in the field of biology, this should be easy. Why spend millions of dollars searching for chemical pathways to create life if it can be demonstrated that there is no possible chemistry alone pathway? Science alone cannot come to this

[29] It is possible this is a wrong assumption. It could be that the entity that engineered life included “from scratch” assembly instructions that still exists in the cell.

conclusion because scientific reasons do not preclude life starting by natural causes, logical reasons do.

Conclusion

The physics textbook referenced earlier, bemoaning the fact that the second law of thermodynamics is not a scientific law of physics says this: "The second law is a broad generalization inferred from experience."[30] At the end of the discussion regarding the statistical definition of entropy, the book says: " Hence, the second law of thermodynamics shows us the most probable course of events, not the only possible ones."[31] The implicit assumption is all that is theoretically possible from a scientific point of view, is also possible in nature. We know why the lake can never freeze over on a hot summer day[32] – its molecules are exchanging momentum, so they cannot all move in the same direction at the same time due to the first law. We know that matter and energy diffuses, spreads out, and is lost to a system, and is the reason that the second law is valid in most thermodynamic systems. These are logical reasons why the 2nd law is true. Logical reasons, as well as scientific reasons, constrain outcomes.

Likewise, natural causes cannot perform the logical functions required for life for similar logical reasons.

[30] Ibid 13, p. 540
[31] Ibid 13, p. 551
[32] Ibid 13, a claim made on page 552

