

**THE VIROID-THERMODYNAMIC THEORY ON THE ORIGIN OF LIFE
(V.T.T.)**

E. A. Greenhalgh *

Abstract

V.T.T. is a theoretical discussion suggesting that viroids were at the beginning of an Energy/Information flow that continues today (through many forms and ages) to be called Life. As an Energy Flow, Life/Evolution must obey the Laws of Thermodynamics and turbulence; life assumes energetic conservative forms to resist entropy. V.T.T. may be viewed as a Unified Cell Theory: evolution from ions and carbon atoms, the most basic precursors to unify cellular origin. This basic origin theory argues that CHAOS and GAIA theory interact, and so continues to affect cells and populations. V.T.T. argues that radiation, metal ions, entropy, energy conservation, and viroids/protenoids form the basis for evolutionary development. The Laws of Thermodynamics, Chaos, Darwin's Rules of Competition, combined with Hypercycle/Quasispecies theory form both a CONTINUUM of physical chemicals, and an INFORMATION and ENERGY FLOW from simple molecules to complex life forms. Life is an Endothermic reaction, and only the most Energetic Conservative survive. Information is the ultimate form of energy conservation. If one accepts the origin of life starting with short nucleotide sequences, and viroids are short nucleotide sequences, then a viroid was the originating point of life.

*original roster presentation at the University of Guelph, 10 May 1996 in a Reproductive Biology Forum.

BASICS: WHAT IS LIFE?

0. Necas (6) defined life as having two basic properties:
 1. An unusually high degree of organization, or Negative Entropy to a level unknown in inanimate objects, and,

2. the ability to grow, i.e., a tendency towards exponential* reproduction.

I would like to add a third point:

3. Without energy, life can not exist. Evolution is controlled by energy input. Only those organisms that can continue to grow by storing information and energy (Entropic Resistant Forms) evolve. As long as energy is continuously added to the environment, living organisms will evolve to use (and store) it. As such, Life is a Thermodynamic Flow.

Life is composed of chemicals, but chemicals are not considered to be living. Neither are viroids considered alive, nor not alive. WHAT MAKES A LIFEFORM "ALIVE" AND A CHEMICAL NOT? WHAT IS THE LINK

BETWEEN NONLIVING CHEMICAL AND LIVING MAT~TER? V.T.T.

proposes that life forms are Entropy fighters: specialized energy traps (with electrons and chemical bonds the stores) in a DYNAMIC FLOW/CONTINUUM, with the link being:

Entropy (S) is the tendency to randomize or, put in other terms, the quality of systems that increases under the Second Law: MIXING, DISORDER, RANDOMNESS.

Thermodynamics includes the principles found in mathematics and physics: so concepts of turbulence and harmonics will be noted. And musical composition.

The LAWS OF THERMODYNAMICS

First Law: Energy can neither be created nor destroyed, and the energy of the Universe *is* constant.

Second Law: The Entropy of the Universe is always increasing.

*see May and his work related to the parameters of an equation on population growth, and the development of bifurcations. The "boom or bustiness" of Life.

COOKED SOUP OR PLASTIC? The Medium is the Message (Marshal McLuhan)

Oparin, creator of molecular biological origins, considered prehistory as a 'PRIMORDIAL SOUP', a much richer environment to develop life than presently exists. Eigan et al., in the Origin of Genetic Information (Sci. Am. 244, 1981) said, "the total amount of potential organic material was immense. If the carbon now found in coal, carbonate rocks, and living matter were uniformly distributed in all of the present ocean water, it would make a CARBON SOLUTION AS CONCENTRATED AS A STRONG BOUILLON." See Figure 1 for a conceptualization. But, a "soup" isn't a DYNAMIC

state, rather an end product (STATIC - COOKED). A better reconsideration may be of an Energetic chemical PLASMA (matrix or mould) in FLUX (a Thermodynamic Flow), and the Earth is the reactor vessel. Please compare the “Primordial Plasma” to the Blood Plasma (whose salt concentration and pH are similar to the oceans) which is a fluid matrix supporting many components: ions (and electrons), chemical molecules, proteins, colloids and cells. Then there should be no problem in accepting the planet as a reactor vessel (GAIA and Daisy World models exemplify a homeostasis) originally formed with

A MASSIVE AMOUNT OF ENERGY (CONSTANT RATE),
PARTICULARLY IN THE FORMS OF HEAT AND ELECTRON
FLOW IS GENERATED BY THE EARTH'S CORE.

an initial energy state, E_1 .

The Driving Force

If earth is a reactor vessel, what is driving the reaction? V.T.T. proposes that Life can not exist (be created) on planets without a thermonuclear core and a protective mantle. There are contained nuclear reactions resulting in a heated core (CONSTANT HEAT/ENERGY SOURCE) and radioactivity. Radioactivity is the result of SPONTANEOUS (re. CHAOS and consider Shaw's dripping faucet/information flow experiment) changes occurring in the nucleus of the atom with radiation release: alpha particles (the nuclei), beta particles (electrons and positrons) and gamma particles.

Nuclear Fusion: The Proton Cycle
(as found in cooler stars such as the Sun, or the Earth's core)

The net reaction is the conversion of 4 protons into an alpha particle, with the release of 26.6 MeV of energy. This quantity of energy includes that derived from the “annihilation” reaction of the positron with an electron:

The simplest point from the Proton Cycle is this:

(4)

More simply (relate to GAIA), the Earth is a reactor vessel, and since fusion is spontaneous, chaos concepts apply so turbulence may be cited and a STATIC balance does not exist; nor should it be expected to.

The First Law of Thermodynamics may be restated as: Any system in a given state has a given quantity of energy (its internal Energy, E). By the release or absorption of energy, a system changes from an Initial State (Internal Energy, E_1) to a different final state (Internal Energy, E_2). The change in internal energy is:

$$\Delta E = E_2 - E_1$$

The earth in prehistory had a more reduced atmosphere (E_1) while the present one is more oxidized (E_2). That is a large bulk comparison. Later discussions will center more on each age (and mini age) having their own E_{11} state where $\Delta E = \sum E_n E_i$ and the “Enthalpies” of each age compared.

Two important concepts were introduced:

Reduced vs. Oxidized

The First Law may also be written as: $\Delta E = q - w$; q = heat absorbed (from core, and later the sun); w = work performed, usually on a closed vessel, but the earth may be described as such. Work is mechanical (volcanic explosions, ocean currents, winds, etc.) and chemical (the conversions of carbon in the Primordial Plasma into different molecular species and bonds = a great amount of stored energy). In effect, work was done TRAPPING and storing energy. The prebiotic world was a reduced one, and the Daisy World/GAIA (of Lovelock and Margulis) concept may have commenced immediately on earth: if we accept life commenced in the reduced world.

Here is a paradox: if the huge molten core is giving off energy at a constant rate, can the loss be negated, or is it real? The answer that I wish to concentrate on is that the energy being given off represents a Thermodynamic flow, and all the rules, and those related to CHAOS theory, can be applied to biological life right from the very beginning. And like “Mandebrot sets” continue to apply and be connected (see Figure 2).

What is Redox? Why is it Important?

Earth in prehistory had a Reduced environment while the present atmosphere is

Oxidized: all investigators of evolution agree on this point. Briefly note Figures 3 and 4: arrangements of the periodic table. The transition metals have differing redox states and important catalytic roles in many biological reactions. Specifically, iron would reduce any oxygen produced by hydrolysis, and not until photosynthesis did the atmosphere change.

Please note further regarding Figures 3 and 4 concerning the many elements listed that only a very few are highlighted. Biology (and genetics) are very concerned with probability, randomness and astronomical possibilities. CHAOS also deals with probability and randomness, but time and time again this phrase will come up, “sensitivity to initial conditions”. Figures 3 and 4 suggest limitations because the initial conditions are already limited to a set of elements and the reactions that they can conceivably undergo in inter-relationship to each other, especially the workhorse of the group: Carbon. And the reduced atmosphere allowed the existence of chemicals (and ions) not to be found in the presence of oxygen.

MAIN POINT: LIFE IS AN ENDOTHERMIC PROCESS

For life to begin in a Reduced atmosphere again limits the number of potential reactions. For free oxygen to exist required energy to be put into the system. Therefore, from prehistory to present, the environment has continuously received energy. Therefore, a THERMODYNAMIC FLOW EXISTS TRAVELLING IN A CARBON-BASED MEDIUM-PLASMA. Hans G. Schiegel (Gen. Micro., 1986) wrote that all living organisms absolved a COMMON EVOLUTIONARY PATHWAY, having arisen from simple forms, and the CHEMICAL evolution could have only proceeded in an oxygen-free atmosphere. Oxygen is important to later, more complex forms. Again, life started out in “sensitive initial conditions” where randomness was somewhat limited: only specific chemical reactions would

be favoured (“Borders to randomness”). Early life had to be protected from oxygen to proceed. We should note that modern cells have protective mechanisms against oxidative damage. These had to evolve.

V.T.T. will attempt only to follow the Thermodynamic Flow

Energy Input: Common to all origin studies is the consensus that almost ANY SOURCE OF ENERGY: lightning (electrons), radiation, shock waves, hot volcanic ash, or UV would have converted surface material to a great variety of organic molecules: amino acids, and protenoids and lipids. And these chemicals represent stored energy derived from the environment. We must state Le Chatelier’s Principle:

If a stress is applied to a system at equilibrium,

the equilibrium will shift to reduce the stress.

The stress being (continuously) applied was constant energy input (first from the molten core, later when the cloud cover dissipated, sunlight). And this is an endothermic reaction so entropy must increase. How was this done?

1. Energy was converted to chemical bonds and new molecules.
2. Entropy increased. Lauffer (1,2) developed arguments concerning water molecules. Essentially, his arguments came down to this: as molecules became more complex, H₂O molecules were released to the environment, not ordered and random. Therefore, as the carbon molecules were removed from the “strong bouillon” (see Figure 1), more H₂O molecules were released into an ever increasing dilute solution (oceans). Entropy balanced the stored energy of the new molecular species.
3. Similarly, as earth evolved and more energy was input to reverse the $\frac{1}{2}$ Cell reaction associated with oxygen, the increased amount of oxygen may also be viewed as increased entropy: random disorderly and mixing oxygen molecules to compensate for increased nitrogen and carbon based organic molecules. A further curiosity associated with the above would be the reduction of RNA to DNA, i.e.



Multiply that oxygen molecule by the billions of DNA molecules found in cells and it is a big number.

And lipids are known to form micelles that exclude water from surfaces, so fulfilling Lauffer’s criteria for increased entropy by making H₂O molecules more disordered.

MAIN POINT. The energy produced by the earth’s thermonuclear core gave rise to the building blocks of life, the amino acids (see Figures 5 and 6). And all the necessary structures for the formation of a nucleic acid chain, phosphate, sugar (ribose) and base existed. Autocatalysis and reflexive catalysis are accepted arguments. Eigan et al. (3) demonstrated the formation of sequences in the 200-250 nucleotide sequence range. These were RNA molecules. If the equivalents were formed in prehistory, then these represent VIROIDS.

Accepting this as correct (see Figure 7 the hypercycles), the Thermodynamic Part to the origin of Viroids is that energy was stored in these molecules both as chemical (1) energy and (2) information. I accept Eigan et al’s theory as

essentially correct and wish to extend it. Every time the hypercycle loops, there is effectively an increase in the viroid-“genome” or “chromosome”. Again, two things have happened:

1. energy stores as chemical bonds
2. increased information.

But you must note: the hypercycle can not operate outside of the environment. The environment affects the amount of raw material suspended to be used. The raw material is only available as energy is made available to the environment. Therefore, the hypercycle, and “genome or chromosome growth” is a direct reflection of increasing energy (see Figure hA). And further, if we consider the changing of the hypercycle species to reflect an evolution, the direct consequence in simple terms: evolution is a product of energy input from the environment.

Summary:

1. Evolution represents an increase in gene sequence which represents increased stored energy, and stored information.
2. Increased environmental energy drives evolution to utilize and store this energy in increased “genome” size and information content.
3. Evolution is a hypercycle.
4. Life and the hypercycle are dependent on the environment for material.

Another basic point: all the mechanisms associated with viral control evolved from this early relationship, and therefore modern cell function can trace vestigial relationships and functions back to this origin. Important ramifications are implied and will be illustrated.

Hypercycle Summary (Eigan et al.)

1. Single stranded RNA template developed. Eigan et al. used a tRNA model.
2. RNA molecule was capable of self replication: both (i) source of instruction (due base pairing) and (ii) the target molecule to be synthesized according to instruction.
3. S.S. RNA can fold to form a great variety of 3-D structures, whereas DNA has the uniform double helix. S.S. RNA are more resistant to hydrolysis: cleavage by H₂O molecules, the ultimate fate of polymers in water.
4. In “modern” cellular machinery, when ever both functional and instructional properties are required, RNA is found.

5. QB replicating enzyme (protein) was able to reproduce virus in cell-free system. A magnesium ion requirement was noted. Other experiments noted Zinc ions which are required in modern RNA polymerases.
6. Found template-(RNA)-free did occur.
7. Two models (i) Template-induced, (ii) Template-free. The two mechanisms are quite different.
8. Template-induced model more deterministic, and information flow was more faithful to sequential instruction.
9. Template-free required the coordination of several substrate monomers in the rate limiting step. One enzyme molecule apparently substitutes for the missing template by exposing bound substrate monomers to the polymerizing enzyme. A variety of template products would be formed. Therefore, a less faithful form of instruction transmission.
10. Does the discovery of the de novo synthesis of RNA violate the Central Dogma of molecular biology, according to which information can flow only from nucleic acids to proteins, and not the other way? Eigan et al. expressed the opinion that the uniformity of the de novo products was a consequence of Natural Selection and not of faithful sequential instruction by the enzyme. They concluded the Central Dogma was safe in essence.
11. Hypercyclic coupling operates today when an RNA virus attacks a cell. If viral RNA were just another template in host environment, it would not be able to outgrow host templates. NOTE: what it does is SPECIFY information for a REPLICATION MACHINE that is HIGHLY SELECFWE for the viral RNA itself. The cell provides the machinery, the viral RNA completes the specific hypercyclic linkage.

Although I obviously believe Eigan et al. to be correct, small hypotheses will be extended on top of their work (see Figures 7 & 8). I would like to add:

- A. A role for enzymes and metal ions. As previously stated, enzymes may have developed to take the role of the metal ion. Ions are often associated with many enzymes as cofactors. A consequence of an oxidizing environment was the loss of various metals. Proteins may have developed to fill a need.
- B. The Prion: scrapies and Creutzfeldt-Jakob diseases exist. The prion may be a primitive hold over of the hypercycle.
- C. The environment, through diseases and infections, may influence the local protein environment intracellularly and so the hypercycle operates inside the

cell. This may explain Adaptive Radiation and other (quick) evolutionary adaptations (see Figure 8).

Before going on, the environment and the finite carbon source/plasma must be mentioned. For every new species formed, building material must come from somewhere. Methods to salvage obsolete models to reuse the materials for new growth had to be developed. Such techniques will not be explained, but noted. Therefore, with each New age of new life forms, energy was transferred (flowed) from older models which were becoming fewer to new (more energetically conservative), more numerous species. This concept applies equally to chemical species, viroids, cells and multicellular organisms. Hence, thermodynamics are the basis for evolutionary change.

Thermodynamic Flow, Turbulence Chaos and Evolution

Charles Darwin's Rules of Natural Selection are valid. The Central Dogma of Genetics is valid and the best method to ensure the integrity of information transfer. However, hypercycles, and prions and intracellular proteins and viral particles are felt to exist and play important roles. And what follows is a discussion how macrobiology evolves based on the principles of thermodynamics. A broad overview is offered. Life is a continuum.

The hypercycle and quasi species offered explanations for the emergence of RNA genes: which I termed a viroid based on description solely. The hypercycle also explained how a new RNA segment could grow. V.T.T. accepted this growth as the incorporation of energy. Therefore, two species developed (old and new) from a minor change. Now we must discuss Edward Lorenz and the weather (see Figure 9). Lorenz, in 1962, had a computer weather model that required information input with six decimals, i.e. 506127. To save space he printed **.506** assuming the difference \cdot one part in a thousand \cdot was inconsequential. He expected to see the same pattern. At first he did, but later the two lines separated and went their own ways. The observation becomes that the minor change in something like one basepair may have major consequences. Lorenz's work would be followed up and others would describe the effect under strange attractors and bifurcators. See Figure 9. May and the population Equation.

What I wish to explore with May and his fish population graph is that the Viroids/tRNA in the hypercycles were populations. I wish to suggest that genes and other life forms follow the same patterns. But before examining May further, a slight side note must be made.

Historic Note (from A. New Guide to Modern Valence Theory, by G.I. Brown):

The Periodic Table

Even before many relative atomic masses were known, Dobereiner (1829) noticed that certain groups of three chemically similar elements had values that were approximately in arithmetic progression (Dobereiner's triads). Other similar but mysterious numerical relationships using both relative atomic and equivalent masses were noted, leading to Newlands's Law of Octaves (1864). He arranged the elements in ascending order of relative atomic mass and assigned to the elements a series of ordinal numbers (he called atomic numbers). He then noticed elements with similar chemical properties had atomic numbers that differed by SEVEN or a multiple of seven. Newlands discovered that the chemical properties of elements were similar for every EIGHTH or SIXTEENTH element, like the notes in octaves of music.

Newlands received some ridicule, but his ideas were essentially restated by Mendeleef and Meyer (1869) in the Periodic Table, and the elements were arranged in ascending order of relative mass: the essential point of the Law of Periodicity.

Dr. S. Ohno has noted in a series of papers, perhaps exemplified by "Repetition as the Essence of Life on this Earth: Music and Genes" (Haematology and Blood Transfusion, v.31, 1987). Dr. Ohno applied musical notes to bps. and drew some interesting similarities. Whatever the final outcome, he is forcing us to reflect on information transmission. Arid to draw attention to his theme of Repetition as essential and music composition to Newlands. A basis did exist! Ohno discusses "Inherent periodicities of v-helix encoding base sequences can best be revealed by musical transformation." The analysis of the coding sequence for muscurinic acetylcholine receptor revealed the entire sequence started as repeats of three closely related PRIMORDIAL base heptamers: CCTGCTG; CCTGGCC and GCTGGCC. What I wish to draw attention to is PRIMORDIAL heptamers V.T.T. has been developing an argument of increasing base pairs to increased genomes as a measure of energy conservation. Such may serve as an example.

Further, in an earlier paper Ohno found other interesting number sequences. "As these basic repeating units ELONGATE themselves by the golden mean either 4, 7, 11, 18 series, or 5, 8, 13, 21 series, all coding sequences embody inherently melodious quality" (The Universal TAICG-deficiency-TG/CT excess rule renders the melodious quality to all coding sequences. S. Ohno's paper supplied without publishing info.) Please note number sequences and relate to May and Fiegenbaum's bifurcations. And because Ohno's number sequences suggest an underlying mechanism to gene growth, perhaps genome sequences, as suggested by Ohno, should be examined. Perhaps the paper, "Coexistence of Cycles of a Continuous Map of a Line into Itself" (A.N. Sarkovski, Ukrainian Mathematics Journal 16, 1964) would be a good comparison since a genome may also be considered to be a line.

May (see Figure 10) explored the “boom-and-bustiness” of a population using the equation:

$$X_{next} = rx[1-x]$$

He asked how a single population behaves over time when lambda gets bigger than the point of accumulation. What happens to a population's growth rate (tendency to boom or bust) when a critical point is passed? When the parameter was low, extinction followed. A rising parameter raised the population equilibrium to a steady state. When the parameter became higher, the steady state broke apart, oscillating between two alternating values. Too' high, and the system behaved unpredictably. The two alternating parts plotted as a bifurcation: the population going from a 1 year cycle to a 2 year cycle. As the parameter rose, the bifurcations had bifurcations (the periods doubled: 4, 8, 16, 32 and then would break off). Beyond a certain point of accumulation, periodicity gave way to chaos. Then stable cycles return (like the Mandelbrot set - Figure 2). Though the parameter rises, non-

linearity driving the system, a window opens with a regular period: odd like 3 or 7 year cycles. And the period doubling bifurcations begin all over again at a faster rate, passing through cycles of 3, 6, 12 or 7, 14, 28 and then breaking off again to renewed CHAOS.

Hypothesis/Question: If the viroid population of “genes” begin as short repeats, what would happen if they were treated to the aforementioned parameters? How did growth progress from “viroid” to circle bacterial chromosome to eukaryote chromosome? The suggestion is that sequences and parameters should be looked for. Ohno has suggested he has found some primordial heptamers. If the hypothesis has a basis, then genomes could be constructed on the basis of mathematical equations. The implications are significant.

Implications of Life as a Thermodynamic Flow

That higher genomes developed from the most simple RNA molecule (VIROID) is the most potent observation. That Life obeys the Laws of Thermodynamics is also an observation. Figure 1 1A is a simple concept graph illustrating a direct relationship of stored energy to increased genome size. V.T.T. then has serious implications concerning evolution.

DID THE DINOSAURS DIE OF AIDS?

Extinctions are a normal functioning part of life. All ages experienced crashes. There were crashes in ages. V.T.T. suggests that genomes develop as Constructs or platforms. There is a basic model. There was an Amphibian Genome Construct.

A Reptilian Construct. A DINOSAUR-BIRD CONSTRUCT. A MAMMAL CONSTRUCT. A Genome construct is very basic. It has all the information for a particular group. To fill niches, Adaptive Radiation occurs: specific sections are amplified and characteristics are exaggerated or held back. For example, the cetaceans started out as a land bear-dog like animal. As a whale it is still a cetacean, however differing parts of its genomes were selectively amplified or squelched to adapt to its environment. Environmental pressure pushed the cetacean. V.T.T. will argue a number of forces, including the hypercycle, caused the modifications. Whether it was on land with legs or in the sea with flippers, its genome was still a cetacean genome. The forces driving the changes include viral infections and other disease agents allowing hypercycle modification and RNA/protein expression to influence the genome. Certain genes would be amplified while others reduced. The full explanation is beyond this presentation. The above merely asks you to consider the possibility.

Amphibians represented one level of energy storage. The food they ate also represented a level of storage. ENERGY continued to be added to the reactor vessel (EARTH) from both the thermonuclear core and Sunlight. V.T.T. dictates that energy had to be stored. STORAGE occurs in the form of information: in the genome. Eventually so much storage occurs (and the complicated arguments of point mutations, plus amplification, plus retro viruses will not be touched) that the genome is different. There is a new population, albeit small, but more energetically conservative, and able to use the new energy produced around it. Animals and plants (whole planet: GAIA theory) are interlinked. Most probably, a new food source (more energetic) developed. Then the animal.

What occurs next is the building blocks of life must be made available to the new animal/plant forms. But, that material is tied up in the older animal/plant genomes. Then they must be eliminated. Competition: head to head is too slow; the incoming energy, like an overrunning faucet, demands a bigger bucket now! Then how? Disease.

V.T.T. suggests that retro-viruses play a role in modifying life. Viruses, like in lower bacteria, are able to incorporate into higher genomes. When they do so at the proper site location, an improvement has occurred; perhaps immunity has been inferred to the new genome not found in the older genome construct. The older animals and plants die off, though not completely (recall adaptive radiation-reduced genome may have a different recognition site) while the new animals (Reptiles) dominate.

This scenario is suggested for the dinosaur. And an immunodeficiency disease would fit the requirement exactly and specifically.

Meteor vs. AIDS

James Lovelock in Healing GAIA wrote: “CASE HISTORY The Planetary Gunshot Wound and Dinosaurs” regarding the iridium layer found at Cretaceous/Tertiary boundary and a huge meteor strike.

“The vast energy of the impact would have vaporized.” Dr. Lovelock in GAIA theory believes the planet would compensate for such a sudden energy increase. V.T.T. accepts such homeostatic mechanisms would play a role, but an additional heat sink would be the forced development of the mammals (as to thermodynamic principles already discussed).

“What caused the excitement was that the boundary occurs more or less at the time when the dinosaurs became, if not extinct, at least much less conspicuous than they were before.

So it seemed natural to associate this great injury 65 million years ago with the demise of the dinosaurs, ... paleontologists resented the suggestion that their pets were suddenly destroyed as the result of a planetary gunshot wound. They were sure that the extinction occurred gradually ... by natural selection.

Scientists are beginning to realize that both explanations could be right” (James Lovelock in Healing GAIA). V.T.T. concurs.

V.T.T. would also like to make one final suggestion: cancer is not a classical disease but a fail safe mechanism to protect the integrity of the genome. All I will say is **.think** about it.

SUMMARY

1. Life requires energy.
2. Life arose out of lifeless chemicals driven by thermonuclear energy.
3. Life strategy is to develop more and more energy conservative forms.
4. Genes and Genomes represent a thermodynamic flow that obey laws associated with turbulence and chaos.
5. Hypercycle Theory is important to understanding life and life functioning.
5. All the aforementioned represented a theoretical discussion based upon the concepts of many ingenious people.

DEFINITIONS: What is?

GAIA HYPOTHESIS: original hypothesis that supposed the Earth to be kept at a state favourable for life by the living organisms. A theory proposed by Lynn Margulis and James Lovelock.

GAIA THEORY: present theory that sees the Earth as a system where the evolution of the organisms is tightly coupled to the evolution of their environment. Self-regulation of climate and chemical composition are emergent properties of the system. The theory has a mathematical basis in the model “Daisy World”.

CHAOS: “simplisticly” chaos may be described as the underlying (non-linear) mathematical-physics principles used to describe order in disorder. Disorder may be seen to occur at the borders/boundaries of two (or more) separate, and (apparently) orderly states. The disorder is what links the two. Inherent to chaos are the following terms: thermodynamics; non-linear; turbulence; phase space and transitions; bifurcations; strange attractors; cycles and limits; oscillations; sensitive dependence on initial conditions; stability; fractals; scaling; fluid; intermittency, randomness; and ENTROPY.

Enthaiphy (H): may be considered to be heat (“energy”) flow of any system and is related to the heat absorbed (q) and work (w) done on the system dependent upon the condition related to that system.

VIROID: low molecular weight (75,000 to 120,000 Daltons) RNA molecule, so viroids are about 1/10th the size of the smallest known plant virus. Viroids exist both intra- and extra-cellularly as circular, single-stranded RNA molecules of an average length 50mm (300-400 bp.s). Viroids are smaller than any known viral chromosome.

N.B. with only 359 nucleotides, PSTV is the smallest self-replicating pathogen: no viroid proteins are evidenced by the absence of any initiation AUGcodon or protein synthesis in vitro translation system. VirOids exist and are transmitted as coat-free nucleic acid, and appear to be replicated by a cellular enzyme which normally recognizes a DNA template (DNA-dependent RNA polymerase II). They are thought to produce disease by interfering with the process which controls the expression of the host genome. Viroids are clearly independent genetic systems, with properties determined by the nucleotide sequence of their respective RNAs.

VIRUSOIDS: are encapsidated, circular, linear-like RNA closely associated with much larger viral RNA molecules in certain virus particles. Apparently these viroid-like RNAs or virusoids need the viral RNA to aid in their replication. While they also differ from viroids in other ways, their relationship to viroids, if any, needs to be determined.

Satellite RNAs: Specific virus-dependent replicating RNA molecules are present in varying numbers in the protein coats of certain helper, or satellite viruses. They are similar in size to viroids, replicate only in the presence of specific viruses, and may or may not produce devastating effects in infected plants. Their mechanism of action is poorly understood.

PRIONS: PRoteinaceous infectious particle. Prions attack the CNS and are slow infections (viruses are fast) re., scrapies in sheep (mad cow disease), Kuru and Creutzfeldt-Jakob disease in humans. Electrophoresis has revealed a single protein termed p~ion protein (PrP) of molecular mass of about 30,000D. They have filamentous form smaller than any known viroid. As a protein material they are resistant to radiation and enzymes that attack nucleic acids.

Since prions appear to be proteins instructing DNA, some have suggested that this constitutes proof against the Central Dogma of Genetics: information moves only one way, from the nucleic acids to the proteins, and not the reverse.

Redox: The name given to the joined reaction where one agent is reduced (gain of electrons or hydrogen molecule) at the expense of the other agent being oxidized (loss of electrons or gain of an oxygen atom).

References

1. Lauffer, Max A. (1975). Entropy-Driven Processes in Biology. Polymerization of tobacco mosaic virus protein and similar reactions. Springer Verlag, N.Y.
2. Lauffer, Max A. (1989). Motion in Biological Systems. Alan R. Liss, Inc., N.Y.

3. Eigan, M., Gardiner, W., Schuster, P., and Winkler-Oswatitsch (1981). The origin of genetic information. *Sci. Am.* 244(4), 88.
4. Fraenkel-Conrat, H., P.C. Kimball and J.A. Levy (1988). *Virology*, 2nd ed. Prentice Hall, N.J.
5. Lovelock, James (1991). *Healing GAIA*. Harmony Books, N.Y.
6. Necas, O. (1984). The cell as a reproductive automaton, p. 1-6, chpt. 1 in *The Microbial Cell Cycle*. CRC Press Inc., Boca Raton, FL, USA.
7. Gleick, James (1988). *CHAOS. Making a new science*. Penguin Books, N.Y.
8. Marchalonis, J.J., and Schluter, S.F. (1994). Development of an Immune System in Primordial Immunity, p. 1-12. *Annals of the New York Academy of Sciences*, v.712.
9. Brown, **G.I.** (1980). *A New Guide to Modern Valence Theory*. Longman Group Ltd., London.
10. Woese, C.R. (1981). Archaeobacteria. *Sci. Am.* 244(6), p. 98.
11. Schlegel, H.G. (1986). *General Microbiology*, 6th ed. Cambridge Press.
12. Adams, Roger L.P., J.T. Knowler, and D.P. Leader (1992). *The Biochemistry of the Nucleic Acids*, 11th ed. Chapman and Hall, 673 p.
13. Wistreich, G.A. and M.D. Lechtman (1988). *Microbiology*, 5th ed. MacMillan Pubi. Co., N.Y.
14. Ohno, S. (1991). 2.4. The Grammatical Rule of DNA Language, p. 97-108 in *Evolution of Life*. Springer-Verlag, Tokyo.
15. Ohno, S. The universal TA/CG-deficiency-TG/CT-excess rule renders the melodious quality to all coding sequences. Publishing data missing from paper.
16. Ohno, S. (1988). Of Words, Genes and Music, p. 131-147. *The Semiotics of Cellular Communication in the Immune System*. Springer-Verlag, Berlin.
17. Dimmock, N.J. and S.B. Primrose (1988). *Introduction to Modern Virology*, 3rd ed. Blackwell Scientific Pubi., Oxford.
18. Olmo, S. (1987). Repetition as the essence of Life on this Earth: Music and Genes, p. 511-518 in *Haematology and Blood Transfusions*, v.31. Springer-Verlag, Berlin.
19. Ohno, S. (1988). On periodicities governing the construction of genes and proteins. *Animal Genetics*, v.19.

20. Olmo, S. (1986). The all pervasive principle of repetitious recurrence governs not only coding sequence but also human endeavor in musical composition. *Immunogenetics* 24: 71-78.

See attachment – University of Guelph Program