RESISTANCE OF LIVING ORGANISMS TO THE SECOND LAW OF THERMODYNAMICS: IRREVERSIBLE PROCESSES, OPEN SYSTEMS, CREATION, AND EVOLUTION

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Resistance of living organisms to the degenerating effects called for by the second law of thermodynamics is considered. Discussion is approached from the avenues of classical and irreversible thermodynamics. Whether a living system is considered as open or as a steady state, eventually the effects of the second law will destroy it. The methodology of thermodynamics is not advanced enough as yet to be applied quantitatively to life. However, it is felt that the complexity of living systems is a result initially of creative acts by God and not a result of evolutionary processes.

I. Introduction

Inorganic systems are known to obey the second law of thermodynamics and hence tend to reach a state of maximum entropy. Living organisms also tend to reach a state of maximum entropy, but at a relatively slower rate.

The "life principle," whatever it may be, appears to sustain great order (low entropy) in the organism so much longer than one would expect in an inanimate system that it has led some scientists to claim that the second law of thermodynamics does not apply to living organisms.[1] This is a serious charge. If this basic law of science is violated in the living realm of nature, why can it not be violated under proper conditions in the inanimate realm of nature?

There is no valid experimental evidence of a violation of the second law of thermodynamics in either animate or inanimate material. This places the evolutionist in the position of passively or actively denying the observable (second law) to believe the unobservable (macroevolution).

The purpose of this paper is to examine the methodology of the thermodynamics of irreversible processes and its relation to living organisms, to see if creation or evolution, offers the best interpretative framework for what is known. From this paper it is hoped that the reader will see that living systems do not appear to violate the second law. Not enough is known to relate thermodynamic methods rigorously to living systems.

II. Classical Thermodynamics and Time

Living systems appear to be more successful in resisting degeneration than non-living systems. The obvious variable involved is time. The living system will eventually degenerate, but not as rapidly as non-living material.

In classical thermodynamics time is *not* a variable, and is never considered. Normally a system is investigated in one state, allowed to change to another state and investigated again. Typical independent variables are temperature, pressure, volume, concentration, and entropy. They are specified at the state of interest.

After a change has occurred the total entropy change (dS) can be determined. Never is the rate of entropy change $\left(\frac{dS}{dt}\right)$ considered. Systems are never investigated conceptually in a state of change, but between one definite state and another.

The concept of entropy has taken on many interpretations from the necessary wastage of heat[2] in heat engines to a measure of disorder from statistical considerations[3]. Entropy can be considered as a thermodynamic potential, the sign of which indicates the direction taken by a spontaneous process.

If $dS > 0$ the process occurs spontaneously, and if $dS < 0$ the process is not spontaneous, but is forced by some external source. For irreversible processes in isolated systems the sign of dS will always be positive (i.e $dS > 0$)[4]. Isolated systems are considered conceptually simply because *only spontaneous* changes can occur in them[5]. The conclusion from this is that the entropy of any thermodynamic system will always increase during a spontaneous change.

Once the process is completed the entropy difference ($dS = S_2 - S_1$) between the initial state (1) and final state (2) is calculated. The rate of entropy change $\frac{dS}{dt}$ is never known.

If one wishes to calculate $\frac{dS}{dt}$ there must be a "wedding" between thermodynamics and kinetics (study of rate processes) so the rate of change can be introduced. The science of thermodynamics of irreversible processes has developed from these considerations. Although this relatively new science offers promise, the best efforts of researchers have simply verified the results obtainable from classical thermodynamic techniques[6].

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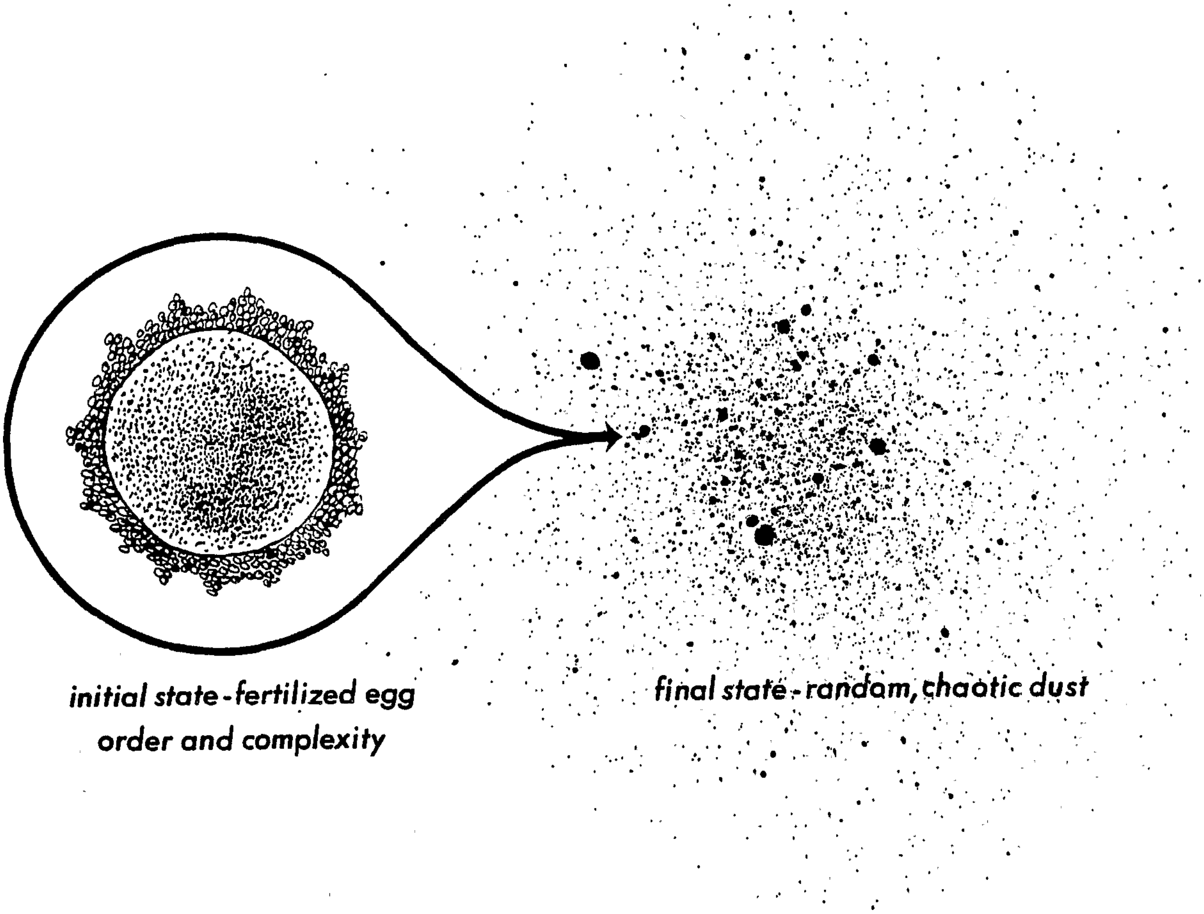

Figure 1. Qualitative representation of the initial and final state of a living organism.

III. Living Systems and Classical Thermodynamic Methodology

Living systems can be investigated qualitatively using classical thermodynamic methods. The necessary procedure is to choose an initial and final state and to determine *qualitatively* an order vs. disorder relationship between the two. If we use biological systems that require a male-female reproduction, immediately after conception we have a cell or cells with all of the genetic information available to grow into a mature adult if the proper energy is provided. Energy includes mass as well as it other forms. This initial state is highly ordered.

Consider the organism sometime after physical death (Ecc. 3:20). The organism has decayed into dust. This final state is an example of gross disorder. From the initial order to the final state of disorder the entropy of the organism has increased. (See Figure 1) Thus it can be seen that living systems are subject to the second law. In any living system, this analysis will be true.

Any living organism survives because it takes energy in from its surroundings. These energy transfer operations are inefficient. This inefficiency could contribute to the organism "wearing out" and finally dying. If these processes were 100% efficient, the organism could maintain itself much more easily.

It is impossible to perform many realistic quantitative calculations on the thermodynamics of living systems because of the state of the art of biology and the present methodology of classical thermodynamics. One of the problems is that conceptually all systems in classical thermodynamics must be able to be completely reversible, i.e. be able to return to an initial state at the finish of a cyclic process.

Very little thought is necessary to realize that living systems are in no way reversible, but they may be *carefully* examined as systems in which irreversible processes occur. But one must be extremely cautious in doing this. Note this comment by Kestin[7]:

> The need for the stipulation that the initial state 1 can *always* be restored from state 2 which had previously been reached by an irreversible process is fundamental to the

> development of thermodynamics because only then is it possible to determine the properties of systems by measurements conducted prior to the performance of a process. Without the knowledge of properties, no process could be analyzed in quantitative terms. Not all systems encountered in nature possess this attribute. A notable exception is afforded by all living organisms. Superficially, living organisms perform an irreversible process during their life cycle, but in stating this we yield to the impulse of using the term "irreversible process" semantically, and not in its technical meaning appropriate in thermodynamics. For this reason, systems like biological ones cannot be analyzed in terms of the equations of thermodynamics because no earlier state of such a system can ever be restored from a later state. Loosely speaking, one can say that a thermodynamic system possesses no "memory" or "history." A given state of the system is always described by its properties as they are measured at that state, and not by the details of the process, which enabled the system to assume the state under consideration.

Bridgman[8] makes this interesting remark:

> One may anticipate that the extension of the entropy concept to more complicated phenomena, perhaps including ultimately the biological phenomena of life, is coextensive with the discovery of macroscopic parameters adequate for the exhaustive description of these phenomena.

Are these parameters available in the methodology of non-equilibrium thermodynamics?

IV. Methodology of Thermodynamics of Irreversible Processes

Irreversible thermodynamic methods are used to deal with the behavior of a system during the course of an irreversible process[9]. As mentioned earlier this is a combination of the sciences of thermodynamics and kinetics. However some new postulates must be introduced, and if the calculations made using these new postulates check with those made assuming reversible transformations and classical laws, the postulates are assumed to be correct[10-12].

In many cases the validity of the postulates are not known[13]. This requirement poses the restriction that any process investigated cannot at anytime be too far from an equilibrium state since this is where classical laws apply. Much should be known about the irreversible process so that no mistakes are made in formulating the proper equations of state.

The central concept in both irreversible and classical thermodynamics is entropy[14,15]. The science has been developed on the premise that entropy increases in any irreversible adiabatic process[16]. In other words

$$dS \geqq \frac{dQ_{rev}}{T} = dS_{rev} \tag{1}$$

where dS is the entropy change because of an irreversible change, dS_{rev} is the entropy change because of a reversible change, dQ_{rev} is the heat gained or lost in a reversible process, and T is the absolute temperature.

The expression is normally integrated between an initial and final state (the start and finish of the process). This definition of entropy[17] is valid for closed systems (exchange of energy with surroundings), but biological systems are considered open systems (exchange of energy and mass with surroundings)[18].

Since it is necessary to visualize the flow of mass into and out of an open system* the change in entropy (dS) is split into two parts,[19] dS_e and dS_i where dS_e is the change in entropy because of interactions between system and surroundings (externally induced) and dS_i is the change in entropy occurring because of changes within the system (internally induced). Then,

$$dS = dS_e + dS_i \tag{2}$$

and $dS_i > 0$ for irreversible processes. (3)

Since it is desired to find the entropy change during a process, how can $\left(\frac{dS}{dt}\right)$, the entropy change with time, be visualized conceptually? Entropy is treated as a nonconserved fluid and the equation of continuity from fluid mechanics is used[20,21].

> The key to a successful manipulation of the entropy property is the artifice of visualizing entropy as a substance capable of flowing like water from one part of space to another[22].

Since entropy is an artificial construct, entropy flow cannot be measured directly (if such flow exists), whereas liquid flow (water, etc.) can be measured by a flowmeter. However there is no such device as an entropy flowmeter. This happens to be one of the weaknesses of the model. Using such a model a scientist can never be sure his calculations are correct unless he checks them against known results.

Normally the only way to check the calculated results is to compare them with known classical thermodynamic and kinetic evidences. If the calculations cannot be verified by direct observation, experimentation, or firmly established classical laws, then they are merely hypotheses.

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*Obviously mass is a form of energy. Possibly in the future scientists will develop parameters so that energy in any form can be represented quite generally in thermodynamic equations of state.

There is certainly nothing wrong with this procedure. However no great weight should be placed on unverifiable equations.

Pushing this objection aside, the model will be further developed. The entropy flux density (J_s) is defined as the direction and magnitude of the entropy crossing a unit area perpendicular to the flow per unit time. (See Figure 2). Thus.

$$J_s = \frac{dS}{dt}\frac{\mathbf{n}}{dA} \qquad (4)$$

where **n** is unit vector perpendicular to dA the unit area and dA = dzdy. Equation 4 can be better represented as a scalar quantity.

$$\frac{dS}{dt} = \int \mathbf{n} \cdot J_s dA \qquad (5)$$

$\frac{dS}{dt}$ is sometimes called the rate of entropy production, or the amount of entropy created per unit time in an irreversible process. The amount of entropy leaving a unit volume per unit time is the excess of entropy that leaves the unit volume minus the entropy that enters the volume and can be represented using the divergence of a vector field[23].

$$\text{div } J_s = \nabla \cdot J_s = \frac{\partial J_{sx}}{\partial x} + \frac{\partial J_{sy}}{\partial y} + \frac{\partial J_{sz}}{\partial z} \qquad (6)$$

Using the divergence theorem[24] the rate of entropy production for a volume (V) becomes

$$\int_A \mathbf{n} \cdot J_s dA \doteq \int_V \text{div } J_s dV \qquad (7)$$

Then for any volume (dV) the rate of increase of entropy inside dV plus the outward flux of entropy from dV equals the entropy production inside dV (See Figure 3). Mathematically this is represented as

$$\frac{\partial(\rho s)}{\partial t} dV + (\text{div } J_s)\, dV = \sigma dV \qquad (8)$$

where ρ is the density of the matter in dV and s is the entropy per unit mass such that $S = \int_V \rho s dV$.

s is used to denote the rate of entropy production per unit volume $\left(\frac{dS}{dtdV}\right)$ Cancelling out dV,

$$\frac{\partial(\rho s)}{\partial t} + \text{div } J_s = \sigma. \qquad (9)$$

This can be called the equation of continuity for entropy flow. For reversible processes[25]

$$\sigma = 0 \qquad (10)$$

For irreversible processes

$$\sigma > 0 \qquad (11)$$

Actually the quantities J_s and *s* in equation (9) are undefined[26]. Other postulates must be introduced so that a *choice* can be made for J_s and *s*. Remember that a scientist's presuppositions will primarily determine what choice will be made. As yet there is no clear-cut way to find out J_s or *s*, so that there is no direct verification for any chosen quantity unless it can be shown to agree with experimental results.

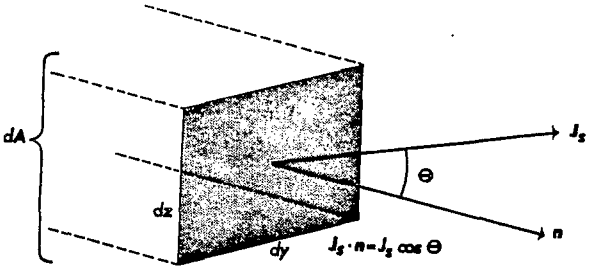

Figure 2. Representation of entropy flux (J_s) through a unit area (dA = dydz).

The mathematical sign (+ or -) of certain quantities is known from classical thermodynamics. Equations (3) and (11) are positive because entropy increases with irreversible changes that occur inside the system. Using these as guidelines some calculations yield verifiable results[26]. This is done by introducing empirical flow equations that depend upon gradients, such as heat flow which develops because of a change in temperature with distance. Examples of some gradient equations are given below:[27]

Heat Flow:

J_H = —K_T grad T (Fourier's law) (12)

Electric Current:

J_E = —K grad V (Ohm's law) (13)

Fluid Flow:

J_F = —C_F grad P (Poiseuille's law) (14)

Diffusion:

J_D = —D grad C (Fick's law) (15)

K_T is the thermal conductivity, K is the electrical conductivity, C_F is a frictional coefficient related to the viscosity, and D is the diffusion coefficient. T is temperature, V is electrical potential, P is pressure, and C is concentration. Yourgrau et al[28] state what has been accomplished utilizing this methodology:

> We should emphasize that this step represents a marriage between a purely thermodynamic result and a set of equations not derivable from thermodynamic principles. Admittedly the adoption of the recommended procedure has so far led only to relatively trivial results. This is attributable to the fact that we have ignored the possibility of one process affecting or interfering with another when they happen simultaneously.

Generalized flow equations are introduced for each process occurring in the system to overcome the difficulty with competing processes. The form of these equations is

$$J = LX \qquad (16)$$

where X is the gradient or affinity causing the flux (J) and L is a constant. X is sometimes referred to as the thermodynamic force or potential. This would make equation (16) a thermo-

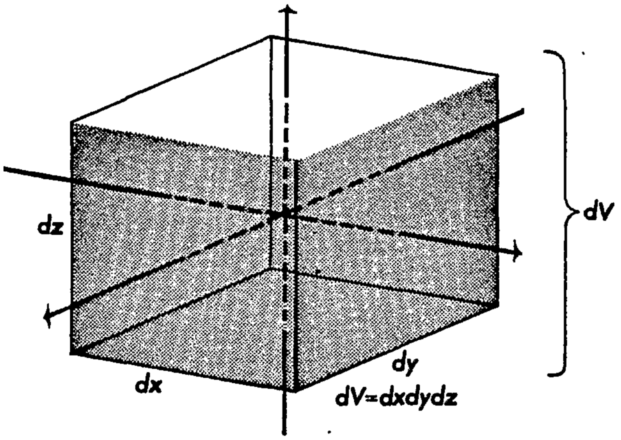

Figure 3. Unit volume (dV) from which entropy can flow.

dynamic equation of motion. For n competing processes the total flux J_i is

$$J_i = \sum_{j=1}^{n} L_{ij} X_j \quad (i = 1, 2, \ldots, n) \tag{17}$$

$$L_{ij} = \left(\frac{\partial J_i}{\partial X_j}\right)_{X_k} \quad k \neq j \tag{18}$$

Higher order terms are ignored. From this the entropy production *(s)* is given as

$$\sigma = \sum_i J_i X_i \tag{19}$$

or for several competing processes at once,

$$\sigma = \sum_i \sum_j L_{ij} X_i X_j \tag{20}$$

The postulates for irreversible thermodynamics are as follows: I. The Gibbs equation for the first law is assumed to be true (even though the system is not at equilibrium).

$$dU = TdS - PdV + \sum_i \mu_i dw_i \tag{21}$$

where dU is the change in internal energy of a system, TdS = dQ, the heat gained or lost by system, PdV is mechanical work done on or by steam (P is pressure and dV is volume change), m_i is the partial specific Gibbs function of substance (i) (chemical or thermodynamic potential), and dw_i is the mass fraction of substance (i).

II. The rate of entropy production *(s)* is the sum of the products of the forces and fluxes and is always greater than or equal to zero.

III. Each flux, to account for entropy production, is a linear combination of the forces (equations 16 and 17). These postulates cannot be considered to be as rigorous as the first and second laws of thermodynamics and are not new principles equal to these two[29].

Obtaining answers using the above equations is an arduous task (due to various system interactions). The Onsager reciprocity relations[30] are used to overcome many of the difficulties. The general form of the relations is shown below. They deal with the relationship between the gradients.

$$L_{ij} = L_{ji} \tag{22}$$

The relations are developed from atomic models and statistical assumptions on the behavior of these models.

The procedure used in determining the forces and fluxes, if not done properly, will completely invalidate the results[31]. As the theory becomes more advanced and more experimental work is accomplished, possible selection of forces and fluxes may become more scientific, but the reciprocity relations can never be considered universally valid, as are the first and second laws[31].

Caution should be observed when working with the phenomenological equations so that a result contrary to the first and second laws is not obtained. The "tail should not wag the dog." The first and second laws must be given pre-eminence over kinetic considerations. Many evolutionists in their zeal to do away with the second law may choose to ignore this warning and allow kinetic considerations to override the second law regardless of the unscientific results of such a procedure. Tykodi[32] notes that

> An obsessive concern with the explicit dependence of currents on affinities and other parameters of the system is rather uncharacteristic of thermodynamics: in the case of chemical equilibrium, for example, we do not need to know the exact kinetic mechanism (the precise forward and backward rate expressions) in order to find the thermodynamic conditions of equilibrium and the expression for the equilibrium constant. I feel that just as ordinary thermodynamics places its main emphasis on the conditions of equilibrium so the thermodynamics of steady states should place its main emphasis on the conditions of migrational equilibrium in given spatial fields rather than on problems of "matter and motion" (items that are more a part of general physics than of anything else). Furthermore, the fundamental experimental system is the container plus the contents plus the interaction of container and contents with the surroundings. The experimenter would prefer a global language that reflects the laboratory realities. Now the experimenter never *measures* directly what happens at a single point in space, and a language couched in terms of local properties and gradients makes his life that much more difficult and gives him little or no guidance in dealing with the effect on the container or the process being studied and in deciding on ways to minimize that effect.

V. Entropy Sinks Impossible

Many evolutionists try to justify their processes of development by making a claim that entropy could increase in one part of the universe while it is decreasing in this part of the universe as long as the total entropy content of the universe increases. This allows "evolution" to occur in a small part of the universe while the entropy of the total universe increases. Such a statement cannot be supported, and is an appeal to blind faith.

What the evolutionist is demanding is to have an entropy sink in a system. No part of any thermodynamic system, living or inanimate has ever been shown to act as an entropy sink. Essentially the claim is this:

$$dS_I \geqq 0 \qquad (23)$$

I—An entropy increase in most of the universe. However,

$$dS_{II} \leqq 0 \qquad (24)$$

II—An entropy decrease in the part of the universe where evolution has occurred. This would be justified as long as

$$dS_T = dS_I + dS_{II} \geqq 0 \qquad (25)$$

where dS_T is the total entropy change in the system and $dS_I > dS_{II}$. However since evolution is an irreversible process[33], and $dS > 0$ for irreversible process, then $dS_T = dS_I + dS_{II} \geqq 0$, but

$$dS_I \geqq 0 \text{ and } dS_{II} \geqq 0 \qquad (26)$$

since irreversible processes are occurring in both I and II and the first situation (equation 24) cannot be true[34].

Thus in one part of a system there can be no absorption of entropy (entropy sink) compensated by a sufficient production of entropy in another part of the system. Any irreversible process that occurs must cause an increase in entropy. In any living system there can be no entropy sink where entropy can be removed so that the organism can evolve. Eventually death will claim any living material and no rise in complexity and order can be expected from such a mechanism as this.

VI. Living Systems as Steady States

In recent years a great deal of emphasis has been placed on mature or adult systems as being steady states[35-39]. It is imagined that as the living system grows to maturity or adulthood it changes from a non-steady to a steady state. The steady state is defined as a state that is time independent. Once a steady state is achieved it does not tend to change with time.

Obviously, no living system can exist forever as a time independent system. The model *completely* fails. Living systems are not steady states, since they die. Any attempt to avoid this by restricting the investigation to growth processes completely distorts the true picture of living organism.

> Living organisms, in particular the human body, can be looked upon as constituting fuel cells. In a living organism the food intake serves as the fuel and the blood stream plays the part of the electrolyte. The chemical reaction is enhanced by the catalytic action of enzymes, and as a result energy is produced by direct conversion from the chemical energy of the fuel-oxygen intake. A portion of this energy is electrical in nature. However, in contrast with man-made fuel cells, living organisms cannot operate in steady state over their life span, and cannot be regenerated; the irreversible changes which occur in them inevitably drive them to death[40].

Many times the wording of the thermodynamicist has been misunderstood by evolutionists. Consider this comment by Prigogine[41].

> Further, the fact that during growth living organisms actually show a decrease of entropy production during evolution up to the stationary state.

Prigogine claims that $\frac{dS}{dt}$(rate of entropy production) decreases as an organism grows to maturity. It is not claimed that entropy decreases, only that the rate at which entropy increases is slower at maturity than during growth. The stationary or steady state is considered to be the state of minimum entropy production. This is very similar to equilibrium states in classical thermodynamics. The equilibrium state is the state of maximum entropy, and as the system approaches the equilibrium state its rate of increase of entropy becomes less and less until at equilibrium it reaches maximum disorder, and the entropy production rate is zero (no further increase in entropy possible), or the system approaches equilibrium asymptotically so that the rate of entropy increase is very slow as it nears equilibrium, as illustrated in Figure 4.

Evolution in this sense is simply limited change and not macroevolution from molecules to man. In other words as the living system grows (changes) to maturity (wrongly identified as the steady state) the rate of entropy production decreases. This is not a violation of the second law, and is similar to systems approaching the equilibrium state in classical thermodynamics.

Evolutionists err when they claim that the second law does not apply to living systems. In their zeal to claim an entropy decrease they fail to realize that it is the rate of entropy production that decreases, and not the entropy itself!

Many evolutionists erroneously conclude that during growth the organism is increasing in complexity and order. But growth should not be looked upon as a time of increase in order and complexity. Growth is definitely an increase in

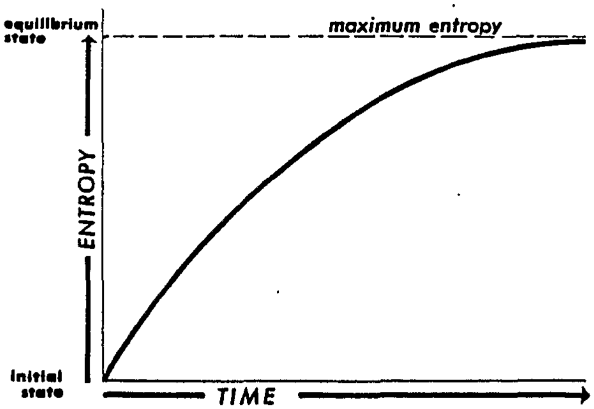

Figure 4. Asymptotic increase of entropy as system approaches equilibrium state.

size, but the complexity and the genetic information necessary for growth was initially in the starting cell of the organism. The cell in no way "evolves" or acquires this order from any outside source. The capacity to attain maturity is in this starting state. The starting cell must be more complex than any cell in the mature organism or at least equal in complexity.

Consider growth from a creationist standpoint. God created a fully-functioning universe and living organisms on earth. As far as can be determined from scripture the organisms were created fully grown. Using a classical thermodynamic qualitative approach the organisms simply fill the earth after its kind and replicate the original created order when adult produces adult, etc. (See Figure 5)

Adam had children which grew to maturity, they had children which grew to maturity, etc. From the initial to the final state there is no increase in order. Original order is at best being duplicated. When sin entered the world the disordering effects of the second law would have reduced the order in successive generations by mutations.

Thus growth cannot be considered as a violation of the second law or an increase in complexity of the organism. The original order (full grown adult) had to be created by God. It did not evolve to the ordered state. Once the order is present it can reproduce itself (reproduction and growth).

Another qualitative argument that can be brought to bear against evolution is from a statistical viewpoint. The statistical, mechanical approach to entropy[42] is given by

$$S = k \ln w \qquad (27)$$

where S is the entropy, w is the possible number of microstates of a system and k is Boltzmann's constant.

For the disordered state, w is very large and for the ordered state it is quite small[42]. It would appear that w would be very small for a living system since no more than a few microstates would be possible. Never at any time could these number of microstates decrease measurably since they would be low already. So there is no realistic way of discussing growth as a means of decreasing w which would then cause a decrease in the entropy content of the organism.

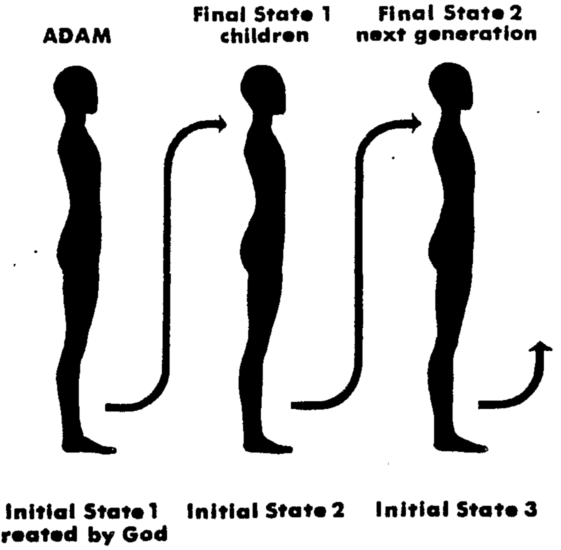

Figure 5. Schematic diagram of reproduction and growth of succeeding generations from initial created state.

This difference is overlooked by many evolutionists when comparing living and non-living systems. For living systems the number of microstates available should be very small (if the system remains alive). Whereas non-living systems should have many available microstates. Thus the entropy of a living system will always be lower than that of a non-living system, but this order had to be created originally not evolved.

Again, with regard to growth, consider the starting cell, cells, or fertilized egg. It would appear that $w \approx 1$, or any gross rearrangement after fertilization would cause death or degeneration in the growing organism.

However when the organism is full-grown, more possible microstates would be possible such that $w \geq 1$. More microstates could be visualized from the sheer bulk of the system. Also more system contamination could be tolerated in a mature organism and the possible microstates could be increased as a result of this.

This increase in w (number of possible microstates) could be visualized as the different ways of arranging cells with various degrees of difference and various levels of contamination and still have the adult organism remain alive. Thus there will be a decrease in system order with growth, or *no more* than a maintenance of the same order. Certainly no increase in order or complexity should be expected. No rigor is attached to the above argument, but is used simply to illustrate how growth cannot be considered as an ordering procedure.

Often evolutionists claim that decreases in entropy are easily attained[41] and thus evolution from disorder to order is easily possible. The "proof" given for such assertions are examples of reversible processes. For instance the thermal transpiration of gases to develop a pressure gradient under a maintained temperature gradient is sometimes used[42]. The gas in this state has a lower entropy than the initial disordered state with no gradient present. However this steady state has to be maintained by a temperature gradient.

Once the gradient is removed, or given enough time the system would fail, and the gas would return to the original state. If the temperature gradient was reapplied, the pressure gradient would develop. The process is reversible and cannot be compared with a system that has only irreversible processes taking place. It does not approximate a living system. For instance life cannot be reversibly removed and reinstated in a living system. It is impossible to return the living system to some prior state in past time. Again the evolutionary analogy fails.

The temperature gradient mentioned above or any other restraint maintained on the gas system or any other system is not a natural process depending upon random changes only. Such a situation is a controlled process and would not apply to basic evolutionary postulates (random variations). Intelligent beings can set up a system to effect many "ordering" operations, but such ordering cannot be accomplished by natural, "unintelligent" processes.

Sometimes the freezing of water, thawing, refreezing, etc. is used to illustrate how order can be easily obtained. Again this is a reversible process, ice $\rightleftharpoons$ liquid. The solid is assumed to have more atomic order than the liquid, and everytime the water solidifies the system order increases. Of course defects in the solid state[43] are ignored in such an argument. However this reversible change can occur over and over again, and no evolution can be observed in the system other than ice $\rightleftharpoons$ liquid. How can this be applied to living systems where irreversible changes occur? It is impossible.*

In approaching the problem of evolution using open systems and stationary states, life is already assumed to be present. This is an improper place to start any discussion about the possibility of evolution for it has already been assumed that life spontaneously generated. This faith-postulate has been very neatly avoided. The arguments against evolution become more weighty when inanimate systems are considered, and there is no hope for chemical evolution[44] in face of the second law of thermodynamics.

The problem must always be faced, not avoided, of how did life get here. One cannot talk about evolution in living systems without assuming spontaneous generation and completely ignoring creation. No evolutionist should be allowed to start his argument at such a point and should continually be pushed back to beginnings rather than left alone to assume any starting conditions he wishes.

VII. Negentropy and Living Systems

A great deal of work and study has been done on the idea that the second law does not apply to living systems[45-47], since they exist and feed on a substance called negentropy which allows them to resist the effects of the second law and maintain their high degree of complexity[48]. The system takes in food which is a high-grade energy (low entropy content); it degrades this high energy form to refuse (high entropy) and supposedly lives off of this degradation of the food. This allows the feeder to stabilize and increase its own order. The refuse becomes an entropy sink where the living system can reject excess entropy.

The refuse cannot be an entropy sink and if it is, why can't the "feeder" organism maintain its state of low entropy indefinitely? Why does the organism eventually die? Again the time factor is overlooked in this approach. To consistently use this argument the organism should be able to maintain itself indefinitely. It is questioned that negentropy applies here. It has a definite place in information theory, but when considering this aspect of living systems there will be nothing that the system takes in that will have negentropy.

A simple example will illustrate this. Food coming into any organism has a definite positive entropy content since it is taken from a cursed creation. The digestive processes are irreversible processes and cause an entropy increase within the organism. While food is being degraded the system must work to digest the food. This work generates entropy. Thus there has been an irreversible increase in entropy. If the food was providing a quantity called negentropy, it would be possible for the organism to decrease its entropy content.

Let us follow this process of supposed entropy decrease. As the organism grows and takes in negentropy to grow, it decreases in entropy con-

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*In the above "reversible" change the entropy change of the system plus the entropy change in the surroundings always is positive. The so-called entropy decrease is really artificial when the total analysis is made.

tent. Supposedly, the organism is becoming more and more ordered, attaining more complexity. It is getting better and better.

Yet all through the stages of conception, birth, and growth to a "stationary" state death is possible. Growing systems die. Indeed, if they are decreasing in entropy, why do they die? The entropy decrease should indicate the organism is being rendered more resistant to changes such as death.

Why, at adulthood, does the organism suddenly stop decreasing in entropy? Why can't this entropy rejection continue until there is a uniform low entropy in all living organisms? Such a process would enable them to maintain this low entropy instead of aging and eventually dying. As can be seen, the analysis may fit a small time in the cycle of a living system, but it is far from complete.

Food intake may allow a system to maintain its present entropy content, or the entropy increase may be very slow for awhile, but never can there be any justification for an entropy decrease. Continual ordering or betterment would render death less likely, whereas the probability of death increases with the passage of time for any organism.

Suggesting the introduction of system poisons to cause death does not solve the problem either. This is like "having your cake and eating it too." You want an entropy decrease and you conceptually provide for it. You then want an entropy increase and you provide conceptually for it. The reasoning is not consistent.

It appears that the most consistent approach to the problem is to allow at all stages of life for an increase in entropy. It certainly would not be as rapid as a closed or isolated system but nevertheless it would increase. Once death occurred, the entropy increase would become more rapid. It is felt that this approach would be more consistent with the second law of thermodynamics.

VIII. Conclusion

The life principle and order of a living system, etc. was placed in the original kinds at creation. God gave these systems the ability to reproduce this order (fill the earth, after its kind). When sin entered the world, this created order began to decrease; each successive generation containing slightly less order than the previous one. However one must be careful with this analysis for the possibility to replicate this order cannot be completely overcome by the effects of the second law of thermodynamics. This biological conservation is a strong principle, and the increasing disorder from generation to generation in our time appears to be slight.

A great deal has been done by biologists and thermodynamicists to apply thermodynamics to living systems, but an immense amount of additional work needs to be accomplished. Also if evolutionary overtones are maintained as presuppositions, a great deal of the study will be invalidated from the start. Creationists must approach the problem from their standpoint. Always a creationist study must be guided and undergirded by Biblical considerations. Never can Biblical truth be rejected, disregarded or explained away.

So far irreversible thermodynamics has been applied mainly to growth of a living organism to adulthood. Weaknesses of this approach have been explored. This is a far cry from any evolutionary development of molecules to man. Creationist alternatives have been suggested. No one can show scientifically that living systems violate the second law of thermodynamics. Only evolutionary interpretation or wishful thinking can suggest this. There is simply not enough scientific information available to substantiate the claim that living systems violate the second law of thermodynamics. Creationist alternatives should be more appealing to Christians. Open systems offer no escape hatch for evolutionists to avoid the second law.

Actually it is not possible to speak of living organisms from a quantitative thermodynamic standpoint. Landsberg[49] states that

> There is also no clear understanding yet of the best way of using thermodynamics to elucidate the key properties of living matter. It seems that thermodynamics should have a greater contribution to make than has so far been possible, but there are clearly several major conceptual difficulties to be overcome first.

The complexity of living organisms makes any analysis intractable. This may lead one to the conclusion that life is more than "a sack full of chemicals." The author believes that the complexity of living organisms is a result of creation by God. God's power is shown in His creation. To Him be the Honor and Glory!

References

[1] von Bertalanffy, L. 1950. The theory of open systems in physics and biology, *Science,* 111:25.

[2] Crawford, F. H. 1963. Heat, thermodynamics, and statistical physics. Harcourt, Brace, and World, New York, p. 228.

[3] Williams, E. L. 1966. Entropy and the solid state, *Creation Research Society Quarterly,* 3(3):18.

[4] Prigogine. I. 1967. Introduction to thermodynamics of irreversible processes. Third Edition. Interscience, New York, p. 16.

[5] Crawford, *Op. cit.,* p. 236:

[6] Bridgman, P. W. 1950. The thermodynamics of plastic deformation and generalized entropy, *Review of Modern Physics,* 22:56.

[7] Kestin, J. 1966. A course of thermodynamics. Blaisdell. Waltham, Mass., pp. 132-33.

[8] Bridgman, *Op. cit.*

[9] Yourgrau, W., A. van der Merwe, and G. Raw. 1966. Treatise on irreversible and statistical thermophysics. Macmillan, New York, p. 2.

[10] *Ibid.*, p. 3.

[11] Fitts, D. D. 1962. Nonequilibrium thermodynamics. McGraw-Hill, New York, pp. 22-24.

[12] Prigogine, I. 1985. Evolution criteria, variational properties, and fluctuations in non-equilibrium thermodynamics, variational techniques and stability. Edited by Donnelly, R. J., Herman, R. and Prigogine, I. Univ. of Chicago Press, pp. 3-4.

[13] Fitts, *Op. cit.*

[14] Yourgrau, *et. al.*, *Op. cit.*, p. 7.

[15] Williams, *Op. cit.*

[16] Yourgrau, *et. al.*, *Op. cit.*, p. 8.

[17] Williams, *Op. cit.*

[18] Williams, E. L. 1970. Is the universe a thermodynamic system?, *Creation Research Society Quarterly*, 7:46.

[19] Prigogine, 1967. *Op. cit.*, p. 18.

[20] Yourgrau, *et. al.*, *Op. cit.*, pp. 10-11.

[21] Prigogine, *Op. cit.*, pp. 33-34.

[22] Yourgrau, *et. al.*, *Op. cit.*

[23] Hague, B. 1965. Fifth Edition. Introduction to vector analysis. Methuen, London, p. 39.

[24] Ibid., p. 59.

[25] Prigogine, *Op. cit.*

[26] Yourgrau, *et. al.*, *Op. cit.*, p. 13.

[27] Castellan G. W. 1964. Physical chemistry. Addison-Wesley, Reading, Mass p. 560.

[28] Yourgrau, *et. al.*, *Op. cit.*, p. 18.

[29] *Ibid.*, p. 23.

[30] Onsager, L. 1931. Reciprocal relations in irreversible processes, *Physical Review*, 37:405, 38:2265.

[31] Yourgrau, *et. al.*, *Op. cit.*, p. 43.

[32] Tykodi, R. J. 1967. Thermodynamics of steady states. Macmillan, New York, p. 79.

[33] Huxley, J. 1955. Evolution and genetics (in) what is science? Edited by J. R. Newman. Simon & Schuster, New York, p. 278.

[34] Prigogine, *Op. cit.*, p. 17.

[35] *Ibid.*, pp. 75-92.

[36] Yourgrau, et. al., pp. 48-53.

[37] von Bertalanffy, *Op. cit.*

[38] von Bertalanffy, L. 1949. Open systems in physics and biology, *Nature*, 163:384.

[39] Prigogine, I. and J. M. Waime. 1946. Biology and thermodynamics of irreversible phenomena, *Experienta;* 2:451.

[40] Kestin, *Op. cit.*, p. 353.

[41] Prigogine, *Op. cit.*, p. 92.

[42] Prigogine, *Op. cit.*, p. 87.

[43] Williams, 1966. *Op. cit.*

[44] Williams, E. L. 1967. The evolution of complex organic compounds from simple chemical compounds: is it thermodynamically and kinetically possible?, *Creation Research Society Quarterly*. 4:30.

[45] Brillouin, L. 1949. Life, thermodynamics and cybernetics. *American Scientist*. 37:554.

[46] Schrödinger, E. 1945. What is life? Macmillan, New York.

[47] Raymond, R. C. 1950. Communication, entropy and life, *American Scientist*, 38:273.

[48] King. A. L. 1962. Thermophysics. W. H. Freeman, San Francisco, p. 253.

[49] Landsberg, P. T. 1970. Thermodynamics makes progress, *Nature*, 225:1206.

ON THE FITNESS OF THE LAWS OF NATURE

HAROLD ARMSTRONG*

In this paper there is an attempt to examine the origin of "natural laws." The special creationist and general evolutionist are both asked to explain the obvious "fitness" observed in these natural laws. It is concluded that the laws are difficult if not totally impossible to comprehend in terms of evolutionary origin because the laws point unerringly to a lawgiver.

Introduction

When I was a boy, at school, we used to have a subject which we called Nature Study. Nowadays it would be included under Science. One thing mentioned in Nature Study was "how animals are adapted to their environment."

It is undoubtedly true that animals are adapted to their environment: birds—light and with great strength in their wings; aquatic animals—well able to swim and dive; and animals of the plains, the jungle, the Arctic, etc.—each adapted to its respective home. That there is such adaptation nobody disputes.

Where people part company is on the question of priority. Is the adaption prior to the animals, or posterior? Was the animal designed to fit into a certain environment; or was it thrown first into the environment, and left to become adapted, if it lasted long enough? The first answer, of course, is that of Creation; the second, that of evolution.

Much of whatever apparent success evolutionists may have had in explaining adaptation comes from concentrating on rather superficial adaptions, and not considering the more profound ones. For instance, at first thought Darwin's theory of how the giraffe got his long neck might carry a bit of apparent plausibility. (However let it be remarked that Darwin's stories of this kind are not nearly so interesting as Kipling's "Just So" stories. Nor, upon a little consideration, are they any more believable!)

Yet there are difficulties about the giraffe, for the alleged natural selection, according to en-

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