[10] Darwin Ch., *The Descent of Man*, (The Modern Library, published by Random House, Inc., New York).
[11] Shipman J. T., Wilson J. D., *Fundamentals of Physical Science*, (D.C. Heath and Company, Lexington, Massachusetts, Toronto, 1992).
[12] Phillips E. A., *Basic Ideas in Biology*, (The Macmillan Company, New York, 1971).
[13] Giese A. C., *Cell Physiology* 3rd Ed., (W.B. Saunders Company, Philadelphia, London, Toronto, 1969).
[14] Howland J. L., *Cell physiology*, (The Macmillan Company, New York, 1973).
[15] Herrmann H., *Cell Biology*, (Harper & Row Publishers, New York, 1989).
[16] Kaufman D.G., *Biosphere 2000*, (HarperCollins College Publishers, 1993).
[17] Arms K., *Environmental Science*, (Saunders College Publishing, a division of Holt, Rinehart and Winston Inc, 1990).
[18] Miller G.T., *Environmental Science*, 4th Ed., (Wadsworth Publishing Company, Belmont, California, a Division of Wadsworth, Inc., 1993).
[19] Nebel B.J., Wright R.T., *Environmental Science*, 4th Ed., (Prentice Hall, Englewood Cliffs, New Jersey, 1993).
[20] Shannon C.E., Weaver W., *The Mathematical Theory of Communication*, University of Illinois Press, Urbana and Chicago 1949, Illini Books edition 1963, ISBN 0-252-72548-4.

Natural Selection helps to select species which are most effective in survival and can efficiently utilize energy and negative entropy. The Sun provides the energy and entropy to produce basic organic compounds.

A change in the environment, man-made or natural, can change the "Pyramid of Life". This could result in the elimination of the species at the apex of the food chain because they are dependent on the lower levels of the pyramid (Fig.4). After any interference the equilibrium of the "Pyramid of Life" could change and lead to the extinction of some species. This could be the fate of mankind, due to man-made pollution and changes in the ecosystem. Management of entropy resources must be taken under serious consideration.

Sexual recombination of genetic material is an effective way to protect genetic information stored in DNA and RNA. This is one way to protect the genetic information from an increase of entropy according to the II Law of Thermodynamics.

The rate of aging and length of life span of a particular species could be programmed into the genetic code to optimize survival of a species [3]. This would explain why there are vast differences in the life spans of different species. Their life span was optimized during evolution to insure survival of a species in a particular niche of the ecosystem.

Conclusions

This paper explains the missing component which is responsible for the creation of life on Earth. The concept of negative entropy (first introduced by E. Schrodinger -ref [2]) or information (Shannon -ref [20]) and the ability of the Biosphere to effectively extract it from the Sun's radiation is very important for life on Earth. This concept was not included in the original work of Darwin [9,10], which explained the natural selection of species, but did not explain the origin and maintenance of Life on Earth.

Presented theory is based on known laws of Physics and shows that life does not violate these laws as has been suggested [4,5,6,7]. This paper provides the ground for further explaration of the phenomenon of life on Earth or other planets and provides a new outlook on the evolution of complex negative-entropy-driven systems.

In author's opinion there are profound implications of this work for the maintenance of natural resources (one of which is entropy). Also author belives that the human interactions with the Environment and Biosphere have to be carefully evaluated and considered in order to maintain the delicate balance needed for life to exist on Earth [16,17,18,19].

References

[1] Kittel Ch., Kroemer H., *Thermal Physics* 2nd Ed., (W.H. Freeman and Company, San Francisco, 1980).
[2] Schrodinger, *What is Life ?*, (Cambridge University Press, 1967, first published in 1944).
[3] Oliwenstein L., *By a Thousand Cuts*, "Discover" Magazine, 24-25 (February 1993).
[4] Wright R., *Science, God And Man*, "Time" Magazine, 34-41, (December 1992).
[5] Margenau H., Varghese R. A., *Cosmos, Bios, Theos - Scientists Reflect on Science, God, and the Origins of the Universe, Life, and Homo sapiens*, (Open Court, La Salle, Illinois, 1993).
[6] Levy S., *Artificial Life - The Quest for a New Creation*, (Pantheon Books, New York, 1992).
[7] Kauffman S. A., *The Origins of Order - Self-Organization and Selection in Evolution*, (New York, Oxford, Oxford University Press, 1993).
[8] Ebeling W., Feistel R., *Theory of Self-Organization and Evolution - The Role of Entropy, Value and Information*, J. of Non-Equilibrium Thermodynamics, Vol 17, Iss 4, 303-332 (1992).
[9] Darwin Ch., *The Origin of Species* , (The Modern Library, published by Random House, Inc., New York. First Edition was published on November 24, 1859).

On Fig.3 b) maintenance of the particular system of atoms is illustrated. In order to maintain a particular Final System, certain minimum N-Entropy (Information - ref [20]) and Energy flow will be required. Depending on the efficiency of the process (which depends on many parameters) N-Entropy and Energy flow in a particular process will be larger than the theoretical minimum. Establishing these requirements is not an easy task and for complex systems could be determined via experimental rather than theoretical estimations.

Global estimation of the required N-Entropy and Energy flow could be estimated for a particular subsystem on Earth or for whole Earth and compared with available N-Entropy and Energy flow for a particular region. This could be of help in better agriculture, aquaculture, urban, etc. planning. There are rigid physical constraints imposed by the N-Entropy and Energy flow to Earth which cannot be violated.

"Pyramid of Life"

Biological systems have evolved in such a way that they efficiently extract negative entropy from the black body, photon radiation of the Sun.

Life on Earth is organized in the form of a pyramid of interdependence (Fig.4). At the base of this pyramid are species which use photosynthetic processes [11,12,13,14,15] to synthesize basic organic compounds. Negative entropy and energy flows from the Sun and is converted into highly-structured organic compounds such as carbohydrates [11,12,13,14,15]. The entropy of the material used in the process of photosynthesis is decreased due to negative-entropy-driven structuring of this matter. Without photosynthesizing organisms the Biosphere could not exist.

Animals use the Sun's energy and negative entropy indirectly and are therefore dependant on photo-synthesizing species. During digesting and utilization of organic food, energy and negative entropy is extracted in order to build and maintain higher - level organism. Digested food has a much lower energy content and much higher entropy as is returned to the environment. Therefore all species use energy and negative entropy flowing from the Sun to Earth.

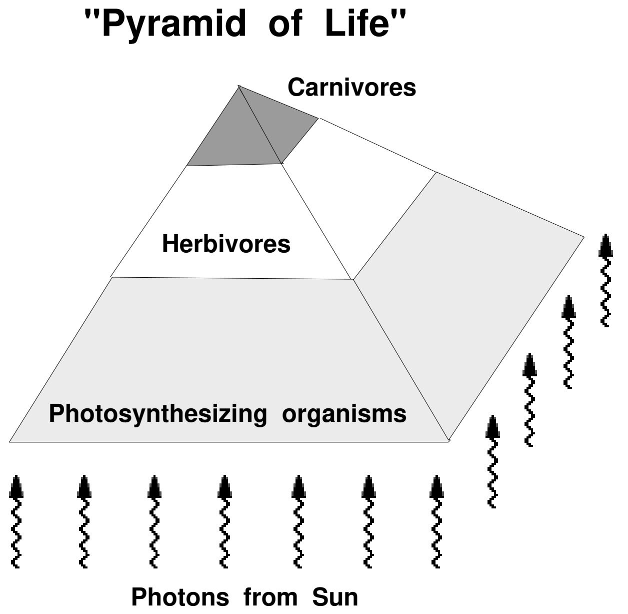

Fig.4. Interdependence of the organisms in the Biosphere can be illustrated by "Pyramid of Life". Base of this pyramid is occupied by organisms which are utilizing photosynthesis for extraction of energy and negative entropy from the Sun's radiation. Other organisms are utilizing energy and negative entropy stored in food, during the process of digestion.

In the "steady-state period" when evolution of life on Earth reaches it's limit the change of energy and entropy of the Biosphere should be :

$dE_B / dt \;_t \approx 0$ (the energy stored in the Biosphere is almost constant) (9 a)
$d\sigma_B / dt \;_t \approx 0$ (the entropy of the Biosphere is almost constant) (9 b)

The Biosphere's entropy ($d\sigma_B/dt$) without external flux of negative entropy ($d\sigma_{INPUT}/dt$ - eq.(7)) will increase spontaneously ($d\sigma_{SPONTANEOUS}/dt$). This will depend on the complexity and structure of the system (Biosphere). External "destructive forces" such as cosmic and other types of radiation, pollution, deforestation, extinction of species, etc. are responsible for the induced increase of the Biosphere's entropy ($d\sigma_{INDUCED}/dt$). The rate of change of the Biosphere's entropy is therefore :

$$d\sigma_B/dt = d\sigma_{SPONTANEOUS}/dt + d\sigma_{INDUCED}/dt + d\sigma_{INPUT}/dt \qquad (10)$$

The negative entropy input ($d\sigma_{INPUT}/dt$) has to offset the increase of entropy ($d\sigma_{SPONTANEOUS}/dt + d\sigma_{INDUCED}/dt$) for life to evolve or to be maintained on Earth (eq. (8 b) and (9 b)).

Creation and maintenance of the organized system of atoms

On Fig.3 a) creation of the particular system of atoms is illustrated. In order to form a particular Final System from the Initial System, certain minimum N-Entropy (Information- ref [20]) and Energy input will be required. Depending on the efficiency of the process (which depends on many parameters) expenditure of N-Entropy and Energy in a particular process will be larger than the theoretical minimum. Establishing these requirements is not an easy task and for complex systems could be determined via experimental rather than theoretical estimations. The final System could be anything - living organism, building, farm, city, car, TV set, etc.

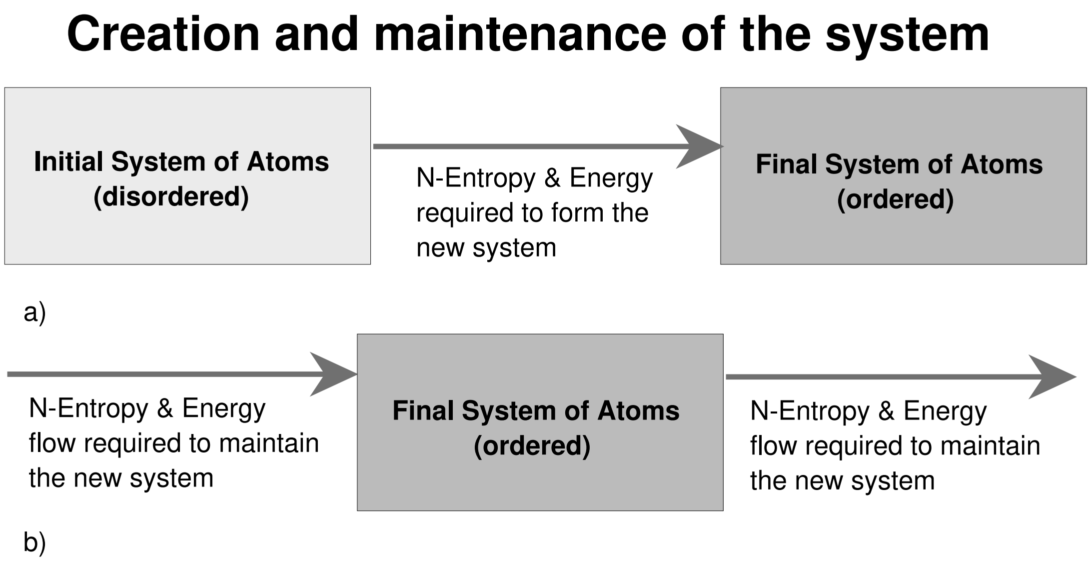

Fig. 3 **a)** In order to form Final System certain minimum N-Entropy (Information) and Energy is required. The particular N-Entropy and Energy used will depend on the efficiency of the process.
b) In order to maintain Final System certain minimum flow of N-Entropy (Information) and Energy is required. The particular N-Entropy and Energy flux will depend on the efficiency of the process.

Entropy balance for Earth

The entropy of photon gas in a black body cavity of Kelvin temperature T and volume V can be calculated from the formula [1] :

$$\sigma = (4 \bullet \pi^2 \bullet V / 45) \bullet (k_B \bullet T / \hbar \bullet c)^3 \qquad (4)$$

where : $k_B = 1.38066 \bullet 10^{-23}$ J K^{-1} - Boltzmann constant, $\hbar = 1.05459 \bullet 10^{-34}$ J s - Planck constant,
$c = 2.997925 \bullet 10^8$ m/s - velocity of light

Rate of entropy flow $d\sigma_L/dt$ (entropy/sec) from "Circle of Life" can be calculated on the basis of eq.(4) :

$$d\sigma_L / dt = 0.5 \bullet (4 \bullet \pi^2 \bullet \pi \bullet R_L^2 \bullet c / 45) \bullet (k_B \bullet T_S / \hbar \bullet c)^3 \approx 5.6 \bullet 10^{36}\ s^{-1} \qquad (5)$$

If one assumes that the Earth's surface radiates energy as a black body at temperature T_E then the rate of entropy flow $d\sigma_E/dt$ (entropy/sec) from Earth can be similarly calculated on the basis of eq. (4) :

$$d\sigma_E / dt = 0.5 \bullet (4 \bullet \pi^2 \bullet 4 \bullet \pi \bullet R_E^2 \bullet c / 45) \bullet (k_B \bullet T_E / \hbar \bullet c)^3 \approx 122 \bullet 10^{36}\ s^{-1} \qquad (6)$$

Approximated flow of the entropy (maximum possible value), which is responsible for the formation and sustenance of Life on Earth is equal to (from eq. (5) and eq. (6)) :

$$d\sigma_{INPUT}/dt = d\sigma_L/dt - d\sigma_E/dt = [1 - 4 \bullet (R_E/R_L)^2 \bullet (T_E/T_S)^3] \bullet d\sigma_L/dt \approx -20.7 \bullet d\sigma_L/dt \approx -1.16 \bullet 10^{38} \text{ bits/s} \qquad (7)$$

This influx of the negative entropy (information - ref [20]) estimated in equation (7) is the magic "Life Force" responsible for the organization of organic and non-organic matter into more complex, living things (Fig.2). There is no magic self-organizing force as implied by some researchers working in the area of the Theory of Complexity [4,5,6,7].

The organizing flow of negative entropy develops more complex structures from organic and non-organic matter and these structures in turn compete with each other, due to limited resources in terms of space, matter, energy and entropy. Natural selection as described by Darwin's theory is one part of this equation [9,10]. Another is the negative entropy-based structuring of matter.

For example : A child builds structures from LEGO blocks (Theory of negative entropy-based structuring of matter), a second child chooses the best designs and throws away other structures (Environment and Natural Selection -Darwin), a third child destroys all structures (II Law of Thermodynamics). Depending on the rate at which each child works different configurations (Biosphere) will be seen in the box with LEGO toys (Earth).

" Equations of Life "

In the "growing period" of evolution of life on Earth the time-averaged change of energy (E_B) and entropy (σ_B) of the Biosphere was :

$$dE_B / dt \;_t \geq 0 \quad \text{(energy was stored in the Biosphere)} \qquad (8\text{ a})$$

$$d\sigma_B / dt \;_t \leq 0 \quad \text{(entropy was decreasing in the Biosphere)} \qquad (8\text{ b})$$

During this initial stage of Evolution, only part of the Sun's radiation was interacting with the Biosphere, since only part of the Earth's surface was covered by terrestrial and aquatic plants. Over time the living part of the Biosphere became larger, more complex and more efficient in the extraction of energy and negative entropy from photon gas flowing from the Sun.

What is the source of negative entropy ? The Sun's energy is highly organized and carried by photons. Our Biosphere absorbs this energy and then releases it back to the Universe -the global balance of energy is zero (Fig.2). However energy released to the environment is in the form of electromagnetic radiation, which is on average at longer wavelengths than the absorbed photons (Fig.1 and 2). The black body radiation of the Sun (5800 K), which is absorbed by the Biosphere has a much higher temperature than the black body radiation from the Biosphere and Earth (280 K) flowing to the Universe (3 K) (Fig.2).

The explanation is that the Biosphere does not accumulate energy when it is in steady-state condition, but it accumulates negative entropy and increases in organization. This is the difference between the entropy of absorbed radiation and the emitted radiation at longer wavelengths of photons (Fig.1 and 2). On the basis of this theory quantitative calculations of the total "negative entropy" balance on Earth, can be made.

The Energy balance for Earth

The solar constant for Earth is $sc = 1360\ W/m^2 = 1.36\ GW/km^2$ [1]. Assuming that the radius of the Earth is $R_E = 6{,}366$ km then the total rate of energy flow (power) on Earth is equal to :

$$P_E = sc \bullet \pi \bullet R_E^2 \approx 1.7 \bullet 10^8\ GW \qquad (1)$$

Some of this energy accumulates in the Biosphere, but most of it is radiated back to space in the form of electromagnetic radiation.

The temperature of the Sun's surface is $T_S \approx 5800$ K. Assuming that the Sun is a black body at temperature $T_S = 5800$ K and that all of the energy impinging on Earth from Sun is radiated back into space in the form of black body radiation it can be shown that the Earth black body temperature T_E is [1] :

$$T_E = (0.25)^{1/4} \bullet (R_S / R_{SE})^{1/2} \bullet T_S \approx 280\ K \quad (\text{or} \approx 7\ ^{\circ}C) \qquad (2)$$

where: $R_S \approx 7 \bullet 10^8$ m - radius of the Sun, $R_{SE} \approx 1.5 \bullet 10^{11}$ m - average Sun-Earth distance

The Sun is the major energy source for Earth. Geothermal energy is comparatively minor, since ice caps formed on the Earth's Poles where the average intensity of the Sun's radiation is low.

"Circle of Life"

The visible surface of the Sun contributes energy and entropy which reaches the Earth. If one assumes that photons are propagating radially from the Sun, then only a small circle on the Sun's surface will contribute to energy and entropy flow from the Sun. The radius of this circle R_L can be calculated from the geometrical considerations (Fig.1) :

$$R_L = R_E \bullet R_S / R_{SE} \approx 29\ km \qquad (3)$$

Result (3) shows that energy and entropy flow which sustains Life on Earth is due to black body radiation from the equivalent 'Circle of Life' of radius $R_L \approx 29$ km and temperature $T_S \approx 5800$ K. This is our 'Furnace of Life' - a limited resource indeed ! The human population on the Earth is about 5.5 billion. Therefore, only about 0.5 m^2 of the Sun's surface is available to supply the needed energy and negative entropy for each person on Earth. This limited supply is needed for the production of oxygen, food, heat, clothing, living space, vehicles, etc. What about other species ? It is estimated, that currently only about 1% of Sun's radiation is absorbed by the photosynthesizing organisms [19]. The influx of the Sun's energy and negative entropy will not be able to sustain our growing population and growing individual consumer demand. A closer look at the above numbers raises the question : do we want to survive ? Do we want a decent life ?. Limiting the Earth's population and lowering individual consumption of energy and negative entropy is essential for the survival of the Biosphere.

The above statement is true for a closed system which is not interacting with the environment. However, the Biosphere is an open thermodynamic subsystem, which can exchange matter, energy and entropy with the environment (defined here as the rest of the Universe). One can by 'manipulation' from outside the system decrease the entropy in the subsystem. This is not a violation of the II Law of Thermodynamics since the entropy of the total system (subsystem and outside environment) will increase as stated by the II Law of Thermodynamics. During the production of clothing , cars, chemical compounds etc., the entropy of the system is decreased because the components are organized. However this is done at the expense of the manufacturing system (including people) whose entropy will increase during this process. In a refrigerator entropy of the air is decreased by lowering the temperature. This occurs at the expense of increased entropy of the environment and the refrigerator. Therefore, one subsystem is able to decrease the entropy of an other subsystem. However the entropy of the total system will increase with time and the total system will follow the II Law of Thermodynamics. In other words the entropy of one system can be manipulated via another system.

The Sun as a Source of Negative Entropy

The Biosphere is defined here as all of the matter which is used to 'build' living organisms. Part of this matter is in the living organisms and part in the 'recycling' stage. The environment is defined here as all the other matter on Earth and in the Universe, including radiation.

In order to get more organized, the Biosphere requires an influx of 'negative entropy' (first mentioned by E. Schrodinger -ref [2]) from external sources (entropy is extracted from the Biosphere) in order to conform to the II Law of Thermodynamics. What are the sources of this 'negative entropy' ? The Sun is the major source of the energy on Earth. Another source of 'natural energy' is geothermal energy. However, the total balance of energy for the Biosphere is on average zero for energy from the Sun, the same amount of energy is absorbed as is released, and is also on average zero for the Geothermal energy from Earth, when the Biosphere is in a steady-state condition.

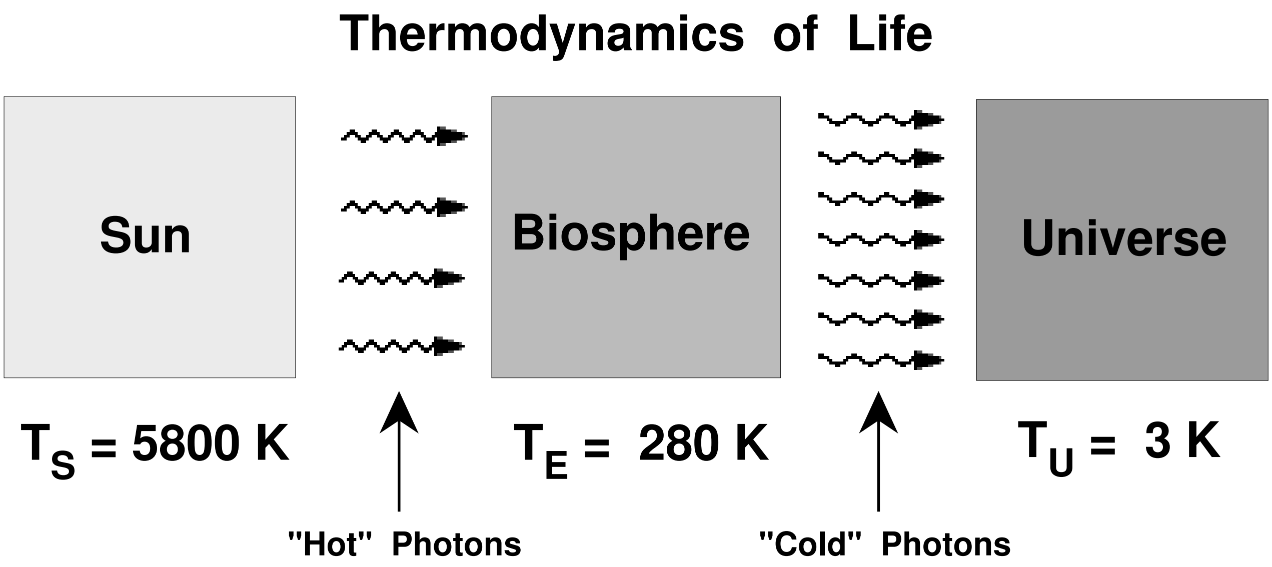

Fig.2. Three Thermodynamic Subsystems - Sun, Biosphere and Universe. The Biosphere extracts negative entropy in the process of exchanging"Hot" Photons (Black Body radiation at T= 5800 K) to "Cold" Photons (Black Body radiation at T=280 K). This process is responsible for the mysterious "Life Force" which seems to defy II Law of Thermodynamics.

Life on Earth
- flow of Energy and Entropy

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Abstract

Darwin's Theory of Evolution [4,5,7] explains how and why life evolved [9,10]. However, some aspects of this theory are still not clear [4,5,7,8,12,14,15]. According to Darwin ,natural selection allows the strongest and most fit species to survive in a particular environment [9,10]. What remains to be answered is how these complex systems (organisms) were first formed and how they maintain their presence on Earth. It is obvious that the entropy of the Biosphere is decreasing continuously (at least it was before the industrial revolution and deforestation).This means that the matter involved in the formation of the Biosphere is getting more and more organized (less random). It was pointed out by many that life seems to defy the II Law of Thermodynamics, which states, that entropy of any system should be increasing [4,5,6,7]. Several attempts were made to explain this striking phenomenon on the basis of the "Theory of Complexity", which suggest, that there are undiscovered laws of nature which are responsible for "Self-Organization" of organisms and the Biosphere [4,5,6,7]. This paper explains the principles responsible for the formation and maintenance of life on Earth and shows that there is no violation of the II Law of Thermodynamics in the case of organisms and the Biosphere.

II Law of Thermodynamics and the Biosphere

It is generally accepted that the Biosphere is getting more complex and organized or less random and that global entropy of the Biosphere is decreasing, due to increased organization. This seems like a paradox which contradicts the II Law of Thermodynamics, which states, that the entropy of a system tends to get higher as time progresses because disorganization increases.

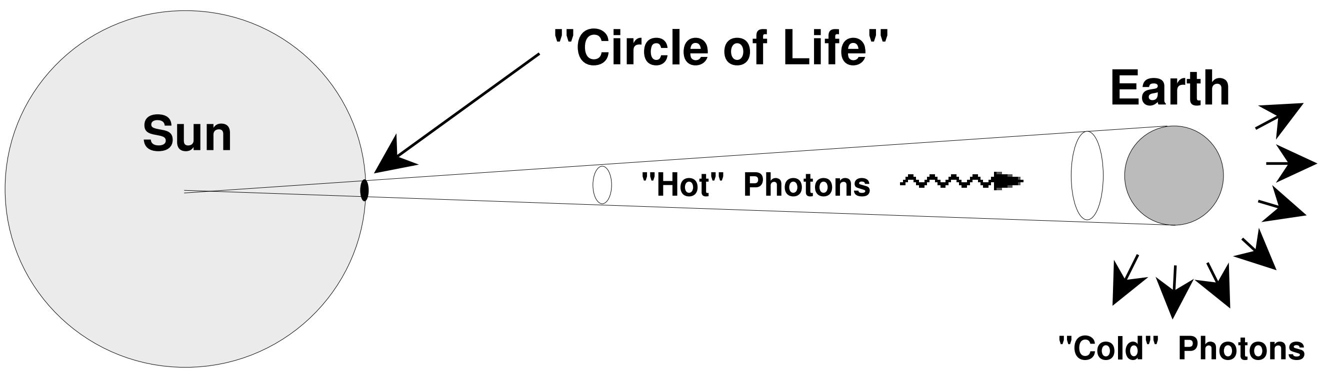

Fig.1. The Biosphere absorbs "Hot" Photons from the Sun and emits "Cold" Photons at longer wavelengths. Energy and entropy flow from the Sun is equivalent to the total energy and entropy flow from "Circle of Life".

Note from the author to the NeXTSTEP users :

Is there a link between Information,Life,NeXT and DFG?

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Since the NeXTSTEP users are among the brightest and the most open-minded people on Earth I decided to share with you this theory and knowledge, which in my opinion is of paramount importance.

It appears that computers are not the only place where information is created, shaped and used. All of the information which is "created" by us (including NeXTSTEP folks) is a small fraction of the information flow (negative entropy) from the Sun, which is captured in the process of photosynthesis. Without this information flow ($1.16 \cdot 10^{38}$ bits/s) there will be no Biosphere, no us or in that matter no NeXTSTEP and DFG.... : -)

This paper does not pertain to have anything related to religion. In author's opinion these mystic matters may be outside of our comprehension and investigation. This should not, however, prevent us from investigating the God's clockwork. We are allowed to do that.

If you have any questions or comments please feel free to contact the author.

This paper was generated entirely on the NeXT computer using WordPerfect and Draw software.

Next 8 pages are for the curious minds ....