Pak. J. Sci. Ind. Res. 2006 **49**(6) 373-378

Critical Study on Conventional Concept of Entropy

M. K. Afridi[a] and M. Sharif Nizami[b]*

[a]44-Harrison Ave, Edison, N.J. 08837, USA

[b]PCSIR Laboratories Complex, Lahore-54600, Pakistan

(received April 19, 2005; revised December 7, 2005; accepted December 30, 2005)

Abstract. The concept of increase in entropy or disorder as a result of all natural processes has been critically reviewed on the basis of experimental facts and ongoing phenomena on our Globe. Similarly, order-disorder statements have also been judged under new and fresh look. In fact, these are not absolute but depend upon defining specific purpose and considering that whether that purpose is being served or not? The new concept has been elaborated by considering natural biological processes, spontaneous mixing of four different gases, distribution of four points in space and assembling of a packaged electronic gadget. Actually, this order-disorder dilemma is the result of not defining the specific purpose of a process which leads to so-called concept that 'disorder' is increasing day by day in our universe. The traditional concept of entropy has been finally tested under heat exchange and probability considerations, which also yield no information to discern it as a measure of disorder. Consequently, increase of entropy translating into increase of disorder could not be applied to all natural processes especially the natural biological systems.

Keywords: critical, entropy, facts

Introduction

According to the Second Law of Thermodynamics, entropy is thought as a measure of disorder of a system and it increases as a result of all natural (spontaneous) processes in universe. Thus, when a system achieves a configuration of maximum entropy, it reaches equilibrium which is disorder or chaos (Moore, 1990). But practically we see life flourishing on our Globe spontaneously in multiple forms. Obviously, the purpose of nature seems to protect, organize and promote life activity in general. However, whole of the material world under the present scientific thought is being governed by the so-called Law of Entropy. It is a serious question that how this contradiction can be resolved. In fact, the concept of entropy is based on the principles of Physics but when we consider Biology, the situation becomes quite different.

A good number of researchers have given due attention to the above referred aspect and offered the views based on their observations. According to Smolin (2003), Physics must explain natural biological processes because living creatures are made of atoms which obey its laws and if it does not make the existence of life comprehensible, must eventually give way to one that does. Kirby (2003) formulated Adaptability Theory by introducing the quantum entropy relationship after reviewing the entropy adaptability concept put forward by Michael Conard who focused the quantum process in life. Similarly, Schwarz and Inesi (1997) determined the close relationship of entropy with biology and demonstrated the important role of entropic mechanism in some specific enzymes. John (2002) put forward the idea of negative entropy during his study in neurology based on significant variations. Loewenstern and Yianilos (1999) reported entropy estimates for DNA, a highly ordered and purposeful molecule. While mechanism of photosynthesis and respiration under revolutionary Chemiosmotic Hypothesis, giving due consideration to the relationship between accumulated order of bio-organism and entropy was explained later on (Harold, 2001).

Actually, the dilemma under consideration is the result of our lack of understanding that what we really mean by "order" or "disorder", while referring to various arrangements and forms of matter and having blind faith in the principle of ever increasing entropy. The first thing to do in this regard is to look around afresh and examine down trodden statements deeply, as sometimes a crucial evidence lies right in front of us that has till now lacked any significance when looked at in a new way, it can all of a sudden reveal new meanings (Smolin, 2003). This becomes more important when we consider the interesting historical fact that the laws of thermodynamics were put in their present form during middle of the nineteenth century (Smolin, 2003). It is also well known that science is based on the belief that definite order is prevailing in this world. The researchers of different disciplines are required to develop co-operation for searching ultimate truths regarding this aspect, as there are still many gaps in science to be filled. The

* Author for correspondence: E. mail, pcsir@brain.net.pk

ideas of Holy Books are intended to fill in such gaps, therefore these should also be consulted keenly for this purpose (Lipson, 1983).

The present paper in above perspective deals critically with the traditional concept of entropy under a new and fresh look on it, in view of the experimental facts, phenomena going on around us on our Globe, and guidance from the Holy Quran.

Materials and Methods

Electronic gadget. A package of electronic gadget was received in perfectly ordered form of its components from the packaging point of view to reach the destination safely. However, its components were in total disorder for the purpose of receiving by the end user. The package was torn up, the said order disturbed completely and all the components were assembled according to the circuit diagram in order to serve the ultimate purpose.

Arrangement of point-objects in space. Four different points were arranged in space under five distinctly different arrangements: a, b, c, d and e as depicted in Fig. 1.

Natural biological process. Natural biological process was observed which reached an end of life cycle into two distinct stages, first half cycle and second half of it. The complete life cycle has been diagrammatically elaborated in Fig. 2.

Dropping of sugar cube in coffee. A sugar cube was dropped in the coffee and observed keenly what happens to it within the volume of this fluid.

Growth of teenager. The passing life of a healthy young boy was kept under constant and close observation and the changes occurring i.e. growing from teenage to adult stage etc, with the passage of time were noted.

Four gases system. Four different gases A, B, C and D were separated by adiabatic constraints, as shown in Fig. 3, and then their constraints were removed. At this, the final volume and temperature adjusted itself spontaneously.

The broken egg. An egg placed on a shelf was given external stroke to fall down. This got spattered on the floor and all of its constituents spread as a consequence.

Rain and evaporation. It rained during dry hot weather. The thirsty soil absorbed incessant raindrops and the remaining water filled up the ponds and other low lying areas. The evaporation of such collected water started just on next sunshine, ultimately giving rise to the phenomena of precipitation of produced water vapours under suitable weather conditions.

Results and Discussion

Electronic gadget. Proper assembling of gadget components resulted in a useful robot. Let's investigate the order/disorder problem in this respect. The product arrives in a package of unassembled components consisting of various parts. This, apparently, looks like an orderly state for the parts of the gadget. But this, indeed, is a disorderly state compared to the whole packaged product. However, what happens when the parts of the gadget and operation of the robot is tested? The order of the components in the assembled robot is entirely different from their order in the package. The question is, which state of the gadget's parts is to be considered more or less orderly? And what happened to the entropy of the components in this case? Although this is not an example of a natural (spontaneous) process, it clearly identifies the problem which is, how does one define order and disorder?

Arrangement of point-objects in space. What changes occur to entropy or disorder when the arrangement (Fig. 1) transforms from (a) to (b) and from (b) to (c), etc. The last formation (e), geometrically speaking is found completely random. Obviously, no single distribution is more or less orderly than the other one, unless some reference terms or purposes are established a priori. For example, the point objects may be the "charges" to be distributed in space in order to create a desired electric field in the region. Once we have stated the purpose for distributing or redistributing material objects, then follows the assessment of order or lack of it. Without fixing our purpose of distribution, the question of increase or decrease of order is totally meaningless.

Natural biological process. Creation of organization on our Globe (Fig. 2), where none existed before life, seems to run contrary to the laws of Physics. According to Smolin (2003), it was thought initially by many during last century that the law of increasing entropy (second law of thermodynamics) contradicted the observed biological evolution. Scaruffi (2001) has stated in this regard that life happens at the edge of chaos, which thermodynamically is extreme disorder of a system. Furthermore, the force of gravity remains constantly active and the earth stores all forms of life in its bosom in proper order (Auolak, 2000). The fossil record also tells us that the biosphere (all of the matter which is used to build living organisms) has become more organized, while the laws of thermodynamics say that there is a tendency for systems to become less organized with the passage of time (Smolin, 2003).

In general, natural biological processes reach end of the life-cycle in two distinct stages. First half-cycle consists of the birth, growth and maturity of a member of a species out of

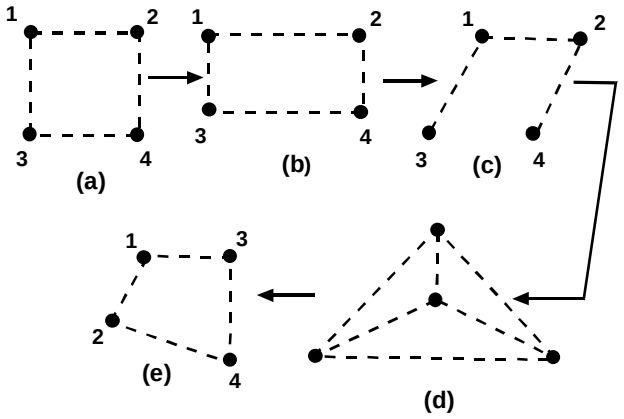

Fig. 1. Possible arrangements of four points in space.

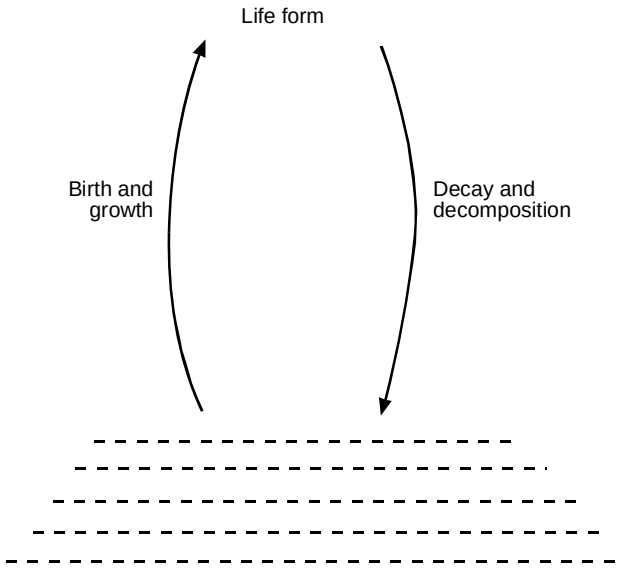

Fig. 2. Natural life cycle manifesting bioactivity.

raw material and seed. During the second half of the life cycle, a given life-form starts aging, degenerating and culminating into total annihilation (Fig. 2). The purpose of downhill journey of all the life forms is to return matter from which they are made back to their ground-level of bioactivity (Auolakh, 2000). Through an unknown initiation, matter again organizes itself into a tiny life-form, the property of an ecological system (population of organism) and grows stronger and stronger by each passing moment till it is full blown, after which the journey towards death sets in (Scaruffi, 2001; Auolakh, 2000). Similarly, Calloway and Kujak (1966), as a result of their study regarding biological growth and decay, found that there is a continuance of processes which occur at a constant rate throughout the life. They also showed this rate is more rapid in very early period of life and the changes are so related to each other these can be described even by certain mathematical equations. The wheel of life-cycle in this way keeps on spinning, resulting in multitude of life forms appearing and disappearing at the same time in its wake. Bio-organisms 'live' because they absorb energy from the external world and process it to generate an appropriate internal state of entropy. This process goes on as long as it can avoid falling in the equilibrium state which is its death (Scaruffi, 2001). The age or length of this life-cycle for each species is different. The smaller cycles nest into the bigger cycle (Fig. 3) which represents the age of the longest living creature, be it an animal or plant.

No doubt, thermodynamics does involve irreversibility but only as an empirical observation and not as a fundamental law of nature while the arrow of time i.e. directionality is of tremendous importance in biology. This is because it directly relates to the phenomena of generation and growth of biological order and maintenance of organisms in their healthy adult age (Lestienner, 1988). Entropy, as already stated is a measure of disorder and it can only increase while spontaneous emergence of order in living organism seems to violate this law. This leads to the "two arrows of time", the behavior of physical systems pointing towards entropy increase (disorder increase) and the behavior of biological systems pointing the other way, by building increasingly complex structures of order (Scaruffi, 2001).

Dropping of sugar cube in coffee: When a sugar cube is dropped in coffee, it dissolves immediately; though no physical law forbids its recomposition but in practice it never occurs, and we intuitively know it cannot occur. Hence, the "order" is destroyed and cannot be recreated, which is a

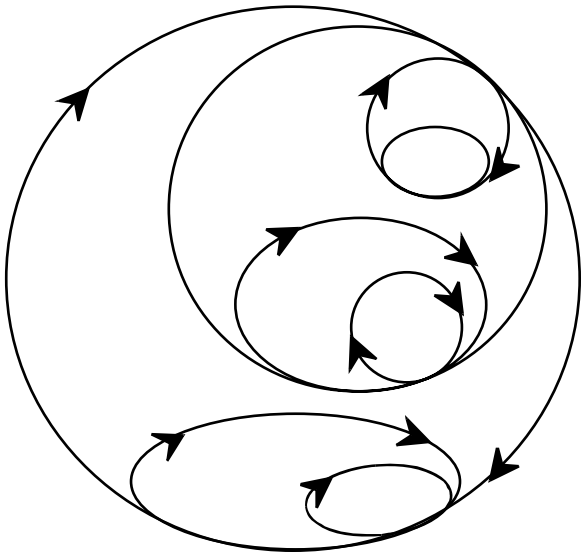

Fig. 3. Life cycle of different species.

manifestation of the second law of thermodynamics.

Growth of teenager: A teenager grows into an adult and while no biological law forbids it, the adult never regresses to youth. This is a manifestation of the opposite arrow of time; order is created and cannot be undone. A law was formulated on the basis of this fact that reproduction is biological organization whose behavior is irreversible and can never results in disorder (Scaruffi, 2001). It has practically been observed that the behavior of living things implies a sense of time or chrognosis, which seems to be built in all living organisms through biochemical timers playing their role throughout the life-span, which are duly encoded by the genotype. It is because these respond to stimuli from the environment which is dynamic and therefore anticipate the future in relation to the present (Harold, 2001). It is important to note here that "time" is a byproduct of the above discussed bioactivity, simply serving as a measure of aging of the species. But, in addition to bioactivity, some other natural processes, stipulating some kind of measurable change in the state of matter may also serve as the yardstick of time. Cycle processes serve only to measure relative lapses of time but not the absolute time. Time in this sense is a record of changes that matter has undergone in an active state, life or otherwise (Murad, 2003).

Four gases system. In this particular case (Fig. 4), if entropy or disorder is recognized as mixing or homogenization of these four different gases, then indeed the Equilibrium State may be one of the maximum mixing. "Relative Disorder" from the previous constrained state does occur, if the separation of gases were an imminent "purpose". But, if the purpose is to mix all these gases for obtaining their mixture for certain requirement, then the same phenomena would be referred to as order and not so called disorder.

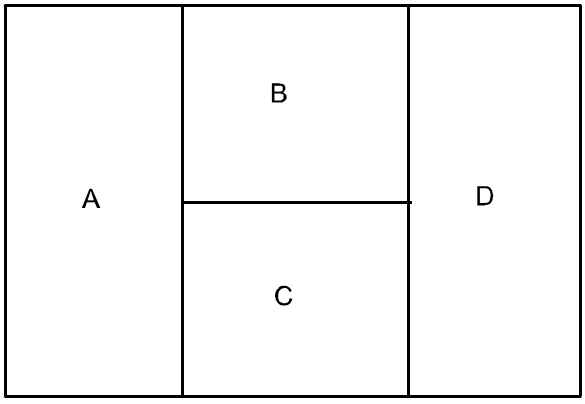

Fig. 4. Four gases separated by adiabatic constraints.

The broken egg. Spattering of an egg results in a state where its components can not reconstitute a whole unbroken egg. It is also a helpful situation to discuss co-relationship of entropy and disorder in nature. In order to justify the hypothesis of increase of disorder, the argument purported is to ask why the elements of a shattered egg do not reconstitute into a whole, unbroken egg? The answer is very simple. If it does happen we would never be able to make an omelet. Similarly, we also would never be able to fry a chicken as soon as a chick cracks its shell struggling to step out of it, the shell would close itself into an egg again. This pure absurdity is prevented from happening in nature. Hence, disorder in the present case adds to sustain the order of our life and not leading it to chaos.

Rain and evaporation. Raining is also a natural process, which may aptly be considered from 'order- disorder' point of view. Does it contribute to the traditional increasing pool of disorder in the universe? One may simultaneously question the existence of the reverse of this process namely evaporation as it is possible everywhere on our planet. We have to see now whether this adds to the increase of proclaimed disorder or not? It will be of interest to note in this context that both of these inverse processes constitute a single cyclical event constantly repeating itself without any perceivable change in the order of our world (Bucaille, 1998). Rather it is inevitable from the point of view of life activity of all kinds. This is due to the fact that new life is given to the dead land by the blessed water i.e. rain (Bucaille, 1998). Without it, most of the life-forms would vanish from the scene, at least from the land portion of our planet earth. Actually, the life is revived, organized, multiplied and supported by this natural process.

Entropy in heat exchange process. This is exactly where the concept of entropy was born and later incorporated into further developments of laws of thermodynamics. The change in entropy by definition, is related to heat-exchange through the following equation (Moore, 1990):

$$ds = dq/T$$

Where ds is the change in entropy accompanying a heat exchange dq at absolute temperature T. Suppose m_1 g of a substance at absolute temperature T_1 with specific heat C_1 is brought in thermal contact with m_2 g of another substance with specific heat C_2 and which is at an absolute temperature T_2. Assuming no heat is lost in the process and final equilibrium temperature of the composite system is T_f, a simple straightforward calculation shows that ΔS, the net change in the entropy of the system as a result of this process is given by:

$$\Delta S = m_1 \times C_1 \text{ In } (T_1/T_f) + m_2 \times C_2 \times \text{In } (T_f/T_2)$$

Initial and equilibrium conditions ensure that:

$T_1 > T_f > T_2$

Thus, both terms in the expression for ΔS are definitely positive i.e., entropy of the universe increases as a result of this natural heat exchange process.

In fact, the entropy function S is inherently defined in such magic terms that the change in entropy ΔS must be positive in heat exchange process to make it happen. We examine the expression ds=dq/T, where dq is the exchange of heat energy at temperature T. This heat exchange takes place between two objects, one at temperature T_1 (higher) and the other T_2 (lower). Let the exchange takes place in steps of infinitesimally small heat quantities ∂q's. Then,

$$\partial q_1/T_1 + \partial q_2/(T_1 - \partial T_1) + \partial q_3/(T_1 - 2\partial T_1) + ... + \partial q_n/\{T_1 - (n-1)\partial T_1\}$$

represents the total incremental decrease of entropy of the hotter body and,

$$\partial q_1/T_2 + \partial q_2/(T_2 + \partial T_2) - \partial q_3/(T_2 - 2\partial T_2) + ... + \partial q_n/\{T_2 + (n-1)\partial T_2\}$$

measures the total incremental increase of entropy of the colder body.

It is notable that each term in the second expression is greater than the corresponding term in the first expression. This is necessary for the flow of heat from the body at temperature T_1 to a body at (lower) temperature T_2. Thus, at each step of the exchange of heat, we must have:

$\partial q_1/T_2 > \partial q_1/T_1$

since $T_1 > T_2$

and $\partial q_2/(T_2 - \partial T_2) > \partial q_2/(T_1 - \partial T_1)$ $(T_1 - \partial T_1) > (T_2 - \partial T_2)$

Similarly, $\partial q_n/\{T_2 - (n-1)\partial T_2\} > \partial q_n/\{T_1 - (n-1)T_1\}$

Since $\{T_1 - (n-1)\partial T_1\} > \{T_2 + (n-1)\partial T_2\}$, otherwise heat flow would stop.

And finally:

$T_1 - (n \times \partial T_1) = T_2 + (n \times \partial T_2)$

This is the final equilibrium condition where heat exchange stops. Thus, we see there is no mystery shrouding the mathematical function traditionally called entropy. Its mathematical definition (ds=dq/T) ensures its monotonous increase in the heat exchange processes to make these exchanges happen. In fact, we have already correctly defined temperature as a variable of the system to conform to our common experience of heat flow from hot to a cold body.

Entropy and probability/statistical mechanics. Present discussion would remain incomplete without mention of the probability or maximum probability of finding an ensemble of systems in an equilibrium state. By maximizing the probability of finding a system in a given state with given energy, one gets the defining equation:

$$S = k \ln W(E) \quad \text{(i)}$$

Where S is entropy of the system, k is the Boltzmann constant and W is the number of microstates available with a given energy E. Here, the entropy again by definition is a monotonously increasing function of energy. To make it behave and tame for being an extensive parameter, the logarithmic form is adopted here.

Equation (i) on differentiating gives:

$$ds/dE = k \, d\ln W/dE \quad \text{(ii)}$$

$$\text{or } 1/k.\, ds/dE = d\ln W/dE \quad \text{(iii)}$$

It is already known that:

ds = dE/T (by definition)

$$\text{or } ds/dE = 1/T \quad \text{(iv)}$$

Multiplying equation (iv) by 1/k on both sides we get:

$$1/k.ds/dE = 1/k.1/T \quad \text{(v)}$$

Equating (iii) and (v):

$1/k.\, ds/dE = d\ln W/dE = 1/k.1/T$

$$\text{or } 1/k.\, ds/dE = 1/k.\, 1/T \quad \text{(vi)}$$

Deleting 1/k from both sides of equation (vi) as common factor:

ds/dE = 1/T

or T.ds = dE

It is notable here the last expression deduced above is the defining equation for entropy in thermodynamics which does not concern any order-disorder concept or claim. Thus, no new information to discern entropy S as a measure of disorder is developed in statistical mechanics also.

Conclusion

We may talk of disorder or entropy only after the specific purpose of a process has clearly been described and certainly not in absolute terms without it. Hence, the idea of increase of disorder in the universe has no meaning at all unless the purpose of a certain process or ultimately this universe is stated in unambiguous terms. But, it is well known that our present understanding of the dynamics of this universe is insufficient and inadequate. Therefore, we

can not make a boastful claim of increase of its disorder by observing merely the transfer of heat from hot to cold body, in a closed system, spontaneously; being just a microscopically tiny part of this immense universe that we call earth and atmosphere around it. Secondly, the concept of continuous increase in entropy leading to chaos or disorder could not be applied at least to the natural biological processes i.e living organisms, these being open systems. Consequently, these are to be excluded from its general statement on the basis of solid evidence that the internal order of natural biological processes increases with the passage of time.

Acknowledgement

The assistance of S.M. Kinaan regarding the literature survey for revision of this paper is highly appreciated.

References

Auolakh, A.M.A. 2000. *Translation of Holy Quran,* pp. 857, 588, 594, Awais Company, Lahore, Pakistan.

Bucaille, M. 1998. *The Bible, The Quran and Science,* pp. 173-175, 177, Islamic Book Service, Lahore, Pakistan.

Calloway, N.O., Kujak, K. 1966. Patterns of water, ash and organic matter changes in senescence, *J. Am. Geriater. Soc.* **14:** 505-514.

Harold, F.M. 2001. Clearing of Chemiosmotic age, *Bioessays* **23:** 848-855.

John, E.R. 2002. The neurophysics of consciousness. *Brain Res. Reviews* **39:** 1-28.

Kirby, K.G. 2002. Biological adaptabilities and quantum entropies, *Biosystems* **64:** 33-41.

Lestienner. 1988. From physical to biological time, *Mech. Ageing Dev.* **43:** 189-228.

Lipson, H. 1983. The implications of the theory of evolution on the relationship between science and religion, In: *Proc. of Conference on Science in Islamic Polity,* pp. 222-223, Manchester, UK.

Loewenstern, D., Yianilos, P.N. 1999. Significantly lower entropy estimates for natural DNA sequences. *J. Comput. Biol.* **6:** 125-42.

Moore, W.J. 1990. *Physical Chemistry*, pp. 80-81, 83, 5th edition, Longman Science and Technical Publishers, London, UK.

Murad, H.S. 2003. The Islamic concept of time. *Tarjuman-ul- Quran,* **53:** 130.

Scaruffi, P. 2001. *Thinking About Thought,* pp. 1-4, I Universe Inc. Lincolin, USA.

Schwarz, F.P., Inesi, G. 1997. Entropic drive in the sarcoplasmic reticulum ATPase interaction with Mg^{+2} and Pi. *Biophysics J.* **73:** 2179-82.

Smolin, L. 2003. *The Life of Cosmos,* pp. 3, 5-10, Oxford University Press, Oxford, UK.