Possible Entropy Decrease in Biology and Some Research of Biothermodynamics

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ABSTRACT
First, biothermodynamics and bio-entropy are introduced briefly. Next, we propose possible entropy decrease due to internal interactions in some isolated systems in biology, in which the neuroscience, the permeable membrane, the molecular motor, etc., are all some internal interactions. Further, a sufficient and necessary condition of entropy decrease is expressed quantitatively. Third, the moderate input negative entropy flow is discussed quantitatively. Fourth, the thermodynamics of physiology and psychology are introduced, and Qigong and various practices are often related to these order states with entropy decrease. Finally, some new research in biothermodynamics are discussed, for example, we propose entropy decrease as an index of therapeutics in biophysics, and life lies in a combination between motion and rest, etc.

Key Words: entropy, biology, thermodynamics, internal interaction, negative entropy flow, isolated system, physiology, practice.

1. Introduction
It is well-known that biophysics includes thermodynamics, which corresponds to the metabolism of living matter (Kane et al., 1978), and the second law of thermodynamics usually is:

\[(\Delta S_{\text{system}} + \Delta S_{\text{surrounding}}) > 0,\]  


Jean (1978) introduced a concept of entropy in the domain of growth as an application of the Principle of Optimal Design, and presented this development using the four kinds of axioms found in axiomatic mathematical physics. But, it is different from 'entropy' in the physico-chemical sense. Matthews, et al. (1987) proposed that the stability of a protein can be increased by selected amino acid substitutions that decrease the configurational entropy of unfolding. Mekjian (1991) presented a similarity in the
mathematical structure for cluster distributions in physics and genetic diversity, and discussed maximum entropy methods.

The Gibbs conference on biothermodynamics arose in the late 1980's as a ‘self-organized’ endeavor, and has fostered the development of new thermodynamic approaches and their applications in biochemistry (Ackers et al., 1997). Page and Williams (1997) discussed entropy of activation, in which smaller entropy changes from the restriction of internal degrees of freedom occur in cyclization reactions. The electrostriction effect is well exemplified by the dissociation of neutral species such as carboxylic acids where the ionization constant is associated with some 84J/(Kmol) decrease in entropy. Hydroxide ion attack on esters is associated with a large decrease in entropy. Scully (2001) discussed extracting work from a single thermal bath via quantum negentropy. Scully proposed that this process is attended by constantly increasing entropy and does not violate the second law of thermodynamics. The application of concepts, principles and methods of thermodynamics of equilibria and processes to bioengineering systems has led to a new and growing field: engineering biothermodynamics. Keller (2008) gives an outline of basic aspects, changes and actual examples in this field, the basic concepts and laws of thermodynamics extended to systems with internal variables, which serve as models for biofluids and other biosystems. Stockar (2010) reviewed biothermodynamics of live cells as a tool for biotechnology and biochemical engineering.

The basis of thermodynamics is statistics; from this we research some basic problems on entropy in biology.

2. Possible entropy decrease in biology
In the statistics a basic principle is statistical independence: The state of one subsystem does not affect the probabilities of various states of the other subsystems, because different subsystems may be regarded as weakly interacting (Landau et al., 1986). It shows that various interactions among these subsystems should not be considered. But, if various internal complex mechanism and interactions cannot be neglected, a state with smaller entropy (for example, self-organized structure) will be able to appear under some conditions. In this case, the statistics and the second law of thermodynamics should be different (Chang, 1994; 1997; 2005; 2012c; 2013b). Because internal interactions bring about inapplicability of the statistical independence, entropy decrease in an isolated system is possible. In particular, it has a possibility for attractive process, internal energy, system entropy and so on. Therefore, we proposed that a necessary condition of entropy decrease in isolated system is existence of internal interactions (Chang, 2009b). The internal interactions often are related with nonlinearity (Chang, 1997). Because any biological system has the complexity, based on their inseparability and correlativity, we proposed the nonlinear whole biology and four basic hypotheses (Chang, 2012b). Further, we combined the loop quantum theory, and proposed a new method of quantum gravity for protein folding, and obtained four new approximate solutions and researched three possible origins for protein folding (Chang, 2012b).

We proposed a universal formula for any isolated system (Chang, 2005):

\[ dS = dS^a + dS^i \]  

where \( dS^a \) is an additive part of entropy and is always positive, and \( dS^i \) is an interacting part of entropy and can be positive or negative. Eq.(2) is similar to a well-known formula:

\[ dS = d_s S + d_e S \]  

in the theory of dissipative structure proposed by Prigogine. Two formulae are applicable for internal or external interactions, respectively.

Further, based on the Eq.(2), a sufficient and necessary condition of entropy decrease in isolated system may be expressed quantitatively (Chang, 2012c):

\[ 0 > dS^i > -dS^a, \quad \text{i.e.,} \quad |dS^i| > dS^a \]  

(for negative \( dS^i \)).  

In usual cases, the condition corresponds to that in isolated systems there are some stronger internal attractive interactions. Negative temperature is based on the Kelvin scale, we find that it will derive necessarily entropy decrease. The known negative temperature is a fallacy in thermodynamics, and is contradiction with usual meaning of temperature and with some basic concepts of physics and mathematics (Chang, 2012c).
We proposed entropy decrease due to fluctuation magnified and internal interactions in some isolated systems, and calculated quantitatively the possibility of entropy decrease (Chang, 2005; 2009a). Some possible tests for entropy decrease in isolated systems in physics, chemistry (Chang, 2013b), etc., are researched. Generally, it should be confirmed by many stable states in Nature.

The complex biological systems provide some modes on entropy decrease in an isolated system. This is known that any organism all is a typical self-organized system, and must be an order process of entropy decrease. As long as this process is isolated at least in a certain time, it all is a violation for the second law of the classical thermodynamics. Simultaneity, the cell membrane and ferment show a control for direction, which is a similar with the Maxwell demon.

Brain, consciousness and neuroscience are namely some internal interactions, which even possible take a key role for decrease entropy in isolated system. Dormancy of living body is an order state, whose entropy pass through adjustment and decrease to smaller. For the typical instance, the hibernation of animal, and the dormancy of Madagascar’s lemur and of various hexapods all show obviously the entropy decrease in isolated system.

Ashby (1956) pointed out that two substances such as ammonia and hydrogen in a gaseous state can be mixed to form a solid. Similarly, about twenty different types of amino acids present in microorganisms can gather together to form a new reproductive process. It is commonly understood that solids are more orderly than gases, such that the entropy of a solid is less than the entropy of the same material in its gaseous state. Microorganisms should likewise represent a more orderly state than the amino acids from which they are formed. The Belousov-Zhabotinski reaction in chemistry shows a period change that occurs automatically, at least during specific time intervals. Within any microscopic region, the Pauli Exclusion Principle may spontaneously produce a more orderly state.

In a biological self-organizing process, some isolated systems may spontaneously proceed toward the orderly states. Prigogine and Stengers (1984) have discussed such a case: Under particular circumstance, such as when Dictyostelium discoideum experiences a lack of nutrition, solitary cells will spontaneously unite to form a larger cell cluster. In such a case, the cells and nutrition-liquid together may be regarded as an isolated system. Jantsch (1979) pointed out that when different types of sponge and water are mixed within a uniform suspension, they rest for a few hours and then automatically separate into different types. More interestingly, when a small hydra is cut into its individual cells, the individual cells spontaneously evolve to form cell-clusters. Some cell clusters are malformations, but other cell clusters will eventually become a normal hydra.

The auto-control mechanism in an isolated system may produce a degree of order. If it does not need the input energy, at least in a given time interval, the auto-control will act like a type of Maxwell demon, which is just a type of internal interactions. Ordering is the formation of structure through the self-organization from a disordered state. The emergence and self-organization of biology and human all depend mainly on self-interaction, because only sunlight cannot produce spontaneously biology on Earth, at least, they cannot evolve some higher living body.

In an evolutorial process with long time, life forms a nonlinear complex and complete system with multi-levels: gene, cell, tissue, organ, system, individual, population, community, ecosystem, bio-sphere. In the nonlinear whole biology the fourth hypothesis is namely the extensive environmental biology. For various levels in isolated systems usual entropy increase, but entropy possibly decrease under some conditions with internal interactions, which has possibly different levels in biological systems, for example, membrane, enzyme, and adenosine triphosphats (ATP) and molecular motor, etc.

Membrane is one of basic biologic framework. The biologic membranes may choose a direction self-motion. Samal and Geckeler (2001) investigated an unexpected solute aggregation for DNA, etc., in water on dilution, which violates the second law of thermodynamics. The cell membrane is a barrier with selectivity, on which the ion channel exists. For cell it inputs continuously the metabolized matter, and removes the metabolized outcome. ATP provides energy,
and lead that living body shows the macroscopic order. A permeable membrane is namely the Maxwell demon, which may be entropy decrease.

The life energy originates mainly from the photosynthesis, which compounds ATP by light, and translates into the chemical energy. ATP hydrolyzed is an exergonic reaction, and the glycolysis may again produce ATP, which is an endothermic process. The both opposite processes must include an entropy decrease. Further, we should investigate large function of chlorophyll and enzyme, and their thermodynamics, in particular, in which internal interactions and entropy.

In a word, biology is a wide region for research of entropy decrease in various isolated systems.

### 3. Moderate input negative entropy flow for open system

In the dissipative structure theory, the total change of entropy for an open nonequilibrium system is a formula (3), in which \( \Delta S \geq 0 \) is the entropy production inside the system, and \( \Delta S^e \) is the entropy flow, which may be positive or negative, such \( \Delta S^e = \Delta S^+ - \Delta S^- \). Therefore, the total entropy can decrease when input entropy flow is negative, and is given as

\[
S = S_0 + \Delta S = S_0 + \Delta S^+ + \Delta S^- > 0 \quad (5)
\]

which and the entropy production are always positive. Then the maximum entropy is

\[
S_{\text{max}} = S_0 + \Delta S^+ + \Delta S^- \geq S_0 \geq dS^e > 0 \quad (6)
\]

The maximum entropy defines a quantitative range of moderate degree on input negative entropy flow for any open system, whose absolute value is always greater than zero, but the total entropy can never become negative.

The general goal for input negative entropy flow is: (a) an existing order structure is kept, such that negative entropy flow equals entropy production, and the total entropy is invariance so that \( dS=0 \) and \( S=S_0 = \text{constant} \). And (b) it allows for internal entropy fluctuations, which imply the construction of a new order structure. In the second case, it is common for \( dS^e = 0 \) and \( dS^- > dS^+ \), so that the total entropy decrease and \( dS<0 \).

Under the condition defined in equation (6), an input value of negative entropy flow can be neither excessively large nor small. Excessively small values prohibit the existence of a dissipative structure and do not achieve the threshold value for transformation to a new order structure. Conversely, if the excessively large values are beyond the sustained power of the system itself or the particular circumstances governing the system, it will break various stabilities. Therefore, the moderate degree on input negative entropy flow includes a control of open degree in system and a selection of input time. The input negative entropy flow is determined by the internal conditions of system and is restricted by the external circumstances.

In particular, all living bodies are complex open systems. For either case, their
entropies can be neither overly large nor small, and the input negative entropy must have a period. For any open system, a rational combination between the input period and the input amount of negative entropy flow is guaranteed for either a stable structure or for the continual transformation to newer ordered structures. The moderate degree of input negative entropy flow is a universal scientific law. It is suitable for human, any living system and the dissipative structure, and for various natural and social systems.

Eigen proposed the hypercycle theory, which discussed self-organization of matter and the evolution of biological macromolecules (Eigen, 1973). It is in order to model prebiotic evolution governed by the Darwinian principles of competition between species and mutations, and leads to a new level of evolution. Here cooperative behaviors are reflected by intrinsically nonlinear reaction mechanisms. The hypercycle theory may find important applications in fields other than biomolecules.

4. Thermodynamics of physiology and emotion, and possible entropy decrease in various practices

In physiology, increased metabolism and an emotional state of being upset should be characterized by larger entropy. Conversely, decreased metabolism and easy conscience or a calm and good-natured emotional state should be characterized by smaller entropy. The immunity of an organism increases for positive emotions, but metabolism and body-temperature show a remarkable increase for a nervous state and negative emotions increase an organism’s susceptibility to various diseases.

Anomalous cognition (AC) is defined as a form of information transfer in which all known sensorial stimuli are absent. Lantz et al. (1994) have reported testing sender condition and target types in AC experiments. There is a difference between static and dynamic target material. Entropy is defined as a measure of uncertainty or lack of information about a system. The data from both of these studies were analyzed with regard to the gradient of Shannon’s entropy of the targets. May et al. (1994) were able to compute the entropy and its mathematical gradient for each target in these experiments. AC was more pronounced when targets underwent massive changes in energy or entropy in a very short period of time. In addition, dynamic targets produced better results in the Ganzfeld than did static targets, a result that is suggestive of changes of entropy.

Lumsden-Cook (2005a) has previously considered emotion as a possible factor in mind-matter/PK interactions. Two studies were conducted that examined how emotional states of anger and elation mediated the outputs of Random Even Generator (REG). These studies provide some support for the idea that affective states might influence REG activity. He also presented the results of two experiments investigating how emotional states can influence micro-psychokinetic functioning that may facilitate mind-matter interactions (Lumsden-Cook, 2005b). Changes of emotion are often sudden, such that their description may be an example of catastrophe theory, which was proposed by Tom (1983) and was developed and applied by Zeeman, Arnold, Poston, Steward and Gillmore, et al.

NeuroQuantology investigates consistently quantum neurobiology since 2003. Shan (2003) proposed a possible quantum basis of panpsychism. Pratt (2003) searched consciousness, causality and quantum physics. Tarlaci (2005) discussed quantum brain dynamics, general quantum neurodynamics, quantum field theory and consciousness. Tarlaci (2010a) proved we need quantum physics for cognitive neuroscience, and researched the probabilistic quantum thinking and obtained experimental results that are of basic significance in the fields of neuroscience and of psychology (Tarlaci, 2010c). Erol (2010a, b) researched the basics and concise relations between Schrödinger wave equation and consciousness/mind, and the quantum entanglement as fundamentals and relations with consciousness/mind. Tarlaci (2010b) discussed a historical view of the relation between quantum mechanics and the brain from a NeuroQuantologic perspective, and is assumed to be a quantum mechanical many-body system interacting with the macroscopic neuron system.

We proposed quantitatively the extended quantum theory and the extended quantum biology (Chang, 2002; 2012a), in which the formulations are the same with the quantum mechanics and only quantum constant h is different for various general cases. We discussed the neural synergetics, and derive
quantitatively the Lorenz equations and
Lorenz model of brain, whose two wings
correspond to two hemispheres of brain, and
two hemispheres jump about, which describes
thinking. It shows that life lies in cooperation
in chaos. The neural synergetics possesses
three levels: structure, activity and thinking on
brain. Based on the quantum and nonlinear
neurobiology, we researched the soliton-chaos
double solutions of the nonlinear equation,
and their possible meaning. Combining some
known theories in neurobiology and the elastic
hypothesis of memory, etc., the physical
neurobiology is proposed (Chang, 2013a).

Bernroide (2003) discussed quantum-
neurodynamics and the relation to conscious
experience. Vimal (2009 a, b; 2010a, b)
researched systematically the subjective
experience aspect of consciousness as an
integration of classical, quantum and
subquantum concepts for emergence
hypothesis, and discussed a theory of
everything as introduction of consciousness in
Schrödinger equation, standard model, and
loop quantum gravity and string theory and
unification of experiences with fundamental
forces.

Landsberg defined “disorder” as the
entropy normalized to the maximum entropy,
which is that of the equiprobable distribution,
corresponding to a completely random system.
A living being as a whole represents an
extremely orderly state of being and must be
an open system for long-time. A living being’s
death represents a transformation to a state of
total disorder, while sickness is a state of local
disorder and a state of recovering from
sickness is marked by a return to the higher
order of health. The order parameters are thus
health targets. But, for a short-time Qigong
and some states attained during religious
practices, for example Buddhist and Taoist
meditation, may be considered isolated
systems that are characterized by entropy
decreases.

In Buddhist practice, everyone is
expected to face every day in a happy mood
with thanks to Nature. A harmonious
unification of these two activities of the human
mind (body) and spirit can only consist
completely of a normal sound activity. Qigong
requires that one must be calm and good-
natured, which is a more orderly state for a
person. Clinical practices show that the
practice of Qigong causes a reduction in
human metabolism. This reduction seems to
the possibility that human ideas and similar
thought forms also reduce entropy, achieving
an ordering within a living system that could
cure sickness and increase internal immune
system strength. Electroencephalogram (EEG)
of Qigong practitioners displays slow waves
similar to those of children, demonstrating
that the electromagnetic activity of brain cells
is more highly ordered.

In the Chinese traditional practices the
Inducing into Tranquilization and Qigong, and
the “Chan-Ding” in Buddhism are all an
ordering state. In these cases the metabolism
should be entropy decrease in isolated system,
in particular, for the BiGu as a Chinese special
practice. These practice methods all are to
benefit the control of consciousness. Probably,
some ways are propitious to the cure of cancer.

Modern neuroscience believes that when
the brain is stimulated by certain outside
signals, it will produce induced electric
potential, whose scale is related to the degree
of attention. When the signals are stronger the
potential is higher. Conversely, the potential is
lower when the signals are weaker. The
propagation of Qigong inside a body is
analogous to the motion of a superfluid, which
corresponds to a state of lower entropy. The
superfluid equation has a soliton solution,
which may possibly describe this propagation.

5. Some new research on
biothermodynamics
The modern medicine experiments shown that
the restriction of heat absorbed can decrease
the cancer ratio. Based on dS=dU/T, and
\( T=37^\circ C \) is basic invariant, a smaller dU
corresponds to a smaller dS, and \( dU<0 \)
corresponds to \( dS<0 \). It is also consistent with
BiGu, which is also a therapy. Moreover, many
tumor suppressors, for example p53, are
among some internal interactions (Malanga et
al., 1998).

Entropy decrease is a change of entropy
dS extended from the positive number to the
entire real axis included negative number,
\( dS(+R,0)\rightarrow(+R,-R) \). Further, we suppose that
entropy can extend to the plane of complex
number. It corresponds to \( dS \) is a complex
number, whose pure form may be \( dS+idS \),
whose meaning is possibly that \( dS \) represents
quantity of change, and \( dS \) represents
undulate of change. They can correspond to

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vectors and the life index on heartbeat, breath, blood pressure and so on. Moreover, these formulas may combine theories of Schrödinger and Prigogine.

We propose an entropy index of health on human body: \( \frac{dS}{dt} \) should be least, even at period of time, man (woman) can regulate breath, body and ideology, and reach to \( \frac{dS}{dt} < 0 \). This is namely:

\[
\frac{dS_2}{dt} > \frac{dS_1}{dt} > 0 > \frac{dS^-}{dt} > \frac{dS^-}{dt} \tag{7}
\]

i.e., \( dS_2 > dS_1 > 0 > dS^-_1 > dS^-_2 \). \( \tag{8} \)

West and Severini et al., discussed entropy in the cancer cell, and dynamical network entropy in cancer. We assume that entropy decrease as an index of health and therapeutics in biophysics may be applied to investigate cure of disease. It is often propitious to prolong of life for many animals and human practices. This is an order out of chaos (Prigogine et al., 1984), and corresponds also to the balance between yin and yang in the traditional Chinese medicine. We have studied a system of nonlinear whole medicine (Chang, 2012b).

The diabetes mellitus as a typical metabolic disease is short of insulin and the metabolic disturbance. A diet for the patient of diabetes mellitus must determine time and quantity, and it is consistent with the moderate input negative entropy flow for both input time and control of quantity in open system. For an epileptic patient, the activity of the human brain is chaotic rather than periodic, even though breathing, heartbeat, blood circulation and the endocrine system must be periodic.

A famous saying said that Life lies in motion. But, I think Life should lie in a combination between motion and rest, and in a balance between chaos and order.

6. Conclusion
According to the second law of thermodynamics, all systems in Nature will tend to “heat death”. But, various developments in Universe are not always disorder. General biologic systems never are more disorder. The declining process of life is from order to disorder, and entropy increases. The origin, birth and developed process of life must be from disorder to order, and information increases. It should be entropy decrease with internal interactions. Both middle processes are the dissipation structure, and entropy is invariant. This is a total principle, which shows the relation between entropy decrease and life science.

The self-organized order of any organism in isolated system is inevitably a process of entropy decrease, it may hold at least in a certain time. Various biological systems possess very rich and colorful internal interactions; we believe that the biothermodynamics will make with great contribution for the test of development on the thermodynamics of entropy decrease in isolated system.

References


