Bioinformation and Twistor Theory in Biology

Yi-Fang Chang

ABSTRACT

First, bioinformation and possible entropy decrease in biology are discussed. Complex biology provides a wide region for research of possible entropy decrease in various isolated systems, for example, membrane, enzyme and molecular self-assembly, etc. Next, quantum theory in NeuroQuantology is searched. Third, we research applications of twistor and its extensions in biology, which may describe some biological duality, and propose specially the twistor model of DNA.

Key Words: biology, neurobiology, quantum theory, bioinformation, entropy, twistor, DNA

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1. Introduction

Biomechanics investigates the mechanical properties of bone, cartilage, ligament, tendon, muscle, the neuro-musculo-skeletal system, and biomaterials, etc (Fung *et al.,* 1972; Fung, 1981; Nigg *et al.,* 1999). Usual blood as an incompressible non-newtonian fluid applies hydrodynamics (Burton, 1965; Rushmer, 1970; Caro *et al.,* 1978), and is related with biorheology (Blair, 1974). Bone corresponds to a classical linear elastic theory (Cowin, 1981). Biomembrances are researched from mechanics and thermodynamics (Evans, 1980). Therefore, scalar and vector are applied widely in biology and neurobiology.

Based on the inseparability and correlativity of the biological systems, we proposed the nonlinear whole biology and four basic hypotheses (Chang, 2012b). It may unify reductionism and holism, structuralism and functionalism. In this paper, we discuss bioinformation and possible entropy decrease in biology, and quantum theory in NeuroQuantology, and research twistor in biology and propose the twistor model of DNA.

2. Bioinformation and Entropy Decrease in Biology

Gu (2003) published a book *Radiation and Bioinformation*. Bioinformation by means of physical technology is a development of life science. In this book entropy as a function of the mean photon number N increases for the chaotic field and the random-phase coherent state. But, the dynamics of entropy S(t) decreases for the chaotic state and the random-phase coherent state, and S(t) increases and then decreases for the mixture of two coherent states. The calculations of entropy are used by formula

$$S = -\sum_i R_i \ln R_i , \qquad (1)$$

and the time-dependent mean photon number is:

Corresponding author: Yi-Fang Chang
Address: Department of Physics, Yunnan University, Kunming, 650091, China.
e-mail ✉ yifangch@sina.com
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$$N(t) = [P\,|\,\alpha_1\,|^2 + (1-P)\,|\,\alpha_2\,|^2]\mu(t). \quad (2)$$

Here an exponential decay of the mean photon number is characterized by $\mu(t)$.

The Jaynes-Cummings model can describe the dynamic and statistical aspects of a system consisting of a two-level atom and a single mode of the radiation field. In this model field entropy S(t) in the different time scale increases and is oscillations in Figures 3.10, 3.11 and 3.13 (Gu, 2003). Field entropy S(t) as a function of the dimensionless time fluctuates in Figures 3.19 and 3.28 (Gu, 2003). But, they are not increase always, and are not often tend to maximum entropy.

Biophoton emission is a universal phenomenon of living system (Gu, 2003), and is necessarily a quantum phenomenon. Theoretical explanation for DNA as a source of biophoton emission has been presented by Popp et al (1994). Based on its quantum theory, the order-growth dynamics of the exciplex system is investigated in terms of determinism, statistics and information theory, and the theoretical results agree well with the experiments. This indicates that biophoton emission may serve as a potential measure of organizational order (Gu, 2003). This is related with the time evolution of entropy of living system, whose entropy may decrease (Gu, 2003). Biophotonics is essentially quantum theory. Popp (1997) searched biophoton emission of the human body.

Usual second law of thermodynamics points out that entropy increases always in isolated system. But, we proposed that if various internal complex mechanism and interactions cannot be neglected, entropy decrease in an isolated system is possible under some conditions (Chang, 1997, 2005, 2012c, 2013a, b, 2015c), for example, self-organized structure, whose formation should decrease entropy.

Complex biology provides a wide region for research of possible entropy decrease in various isolated systems, which has different levels in biological systems, for example, membrane, enzyme, adenosine triphosphats (ATP) and molecular motor, etc (Chang, 2013a).

Schrödinger (1944) in book *What Is Life? The Physical Aspects of the Living Cell* pointed out that "an organism feeds with negative entropy (negentropy)". But, usual entropy S cannot be negative. We think, an essence of negative entropy should be that an organism feeds food which is an open system, then produces some internal metabolism and entropy decrease, so that life possesses lower entropy and order. The after eat food should be an isolated system.

Membrane is one of basic biologic framework. The biologic membranes as the base of bioenergetics may choose a direction self-motion. The cell membrane and ferment show a control for direction. A permeable membrane is namely the Maxwell demon, which may be entropy decrease. Samal et al (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, and inputs continuously the metabolized matter, and removes the metabolized outcome. ATP provides energy, and lead that living body shows the macroscopic order. Enzyme as catalysis relates closely to electronic move. While electron always moves, which correspond to quantum mechanics and quantum biology.

Semiconductor may control a voltaic direction, which is analogy with the biologic membranes. Therefore, the semiconductor theory may be applied to the biologic membranes, which should have the corresponding heat effect, light effect, electric and magnetic effect, and the similar Hall effect, etc.

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. Animals sleep and awake periodically in chronobiology, which should be a period of entropy increase and decrease. The emergence and formation of living individual are more due to internal interactions. The growth of a cuvette baby in test tube should be a classical isolated system at least in a certain time. Generally, many biological and chemical changes in test tube are all the isolated systems. The homeostatic organisms are the internal interaction with auto-adjustment, which keep small entropy, so entropy cannot increase continuously. For any living system if its entropy increases always, it will necessarily tend to death.

Generally, biological evolutions are increases of complexity and bioinformation. They correspond to entropy decrease. In an evolutional 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. If

the biosystem is isolated at a certain time, the second law of thermodynamics will be violated.

Although the total entropy for whole system must be positive and should increase, but, so long as different entropy states for any systems exist, entropy should decrease in transformation process from a higher entropy state to a lower entropy state (in Fig. 1 from A to B), for example, from chaos to order, from awake to sleep, from war to peace and so on. If this system is isolated, it will correct and develop the second law of thermodynamics (Chang, 2015c).

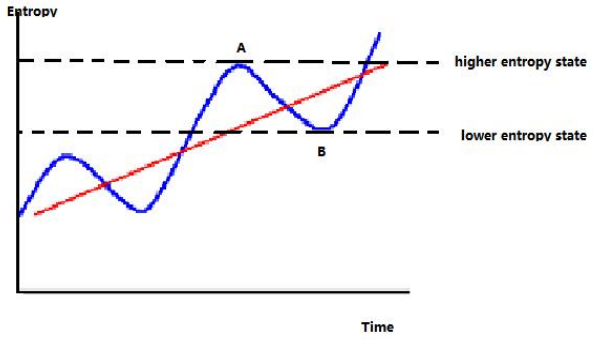

Figure 1. Transformation processes between states with higher entropy and lower entropy.

Entropy decrease is a change of entropy dS extended from the positive number to the entire real axis included negative number, dS(+R,0)→(+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 $dS + id\tilde{S}$, whose meaning is possibly that dS represent quantity of change, and $d\tilde{S}$ represents undulate of change. They can correspond to vectors and the life index on heartbeat, breath, blood pressure and so on.

Self-Assembly is a process by which disordered parts build an ordered structure through local interaction, which must be entropy decrease. Molecular self-assembly is an autonomous process that forms molecules or polymer under non-external influence is nanostructure technology. Crane (1950) proposed two basic principles of molecular self-assembly. Further, Adleman (1994), Winfree, et al. (1998) and Ignatova et al. (2008) discussed the self-assembly of DNA structures by the molecular and DNA computation.

3. Quantum Theory in NeutoQuantology

Neurobiology applies widely quantum mechanics, and forms a new word: NeuroQuantology. Tarlacı (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 (Tarlacı, 2010b). Erol (2010) researched basics and concise relations between Schrödinger wave equation and consciousness/mind. Khrennikov et al. (2014) searched the quantum model for psychological measurements from the projection postulate to interference of mental observables represented as positive operator valued measures. Grandpierre et al. (2014) proposed the universal principle of biology: determinism, quantum physics and spontaneity.

According to basic thinking of *NeuroQuantology*, we assumed that A-T and G-C are the basic quantum of DNA, or assume nucleic acid has five types of base quantum: A, T, G, C and U, but usual case A-T, G-C form double, therefore, we proposed the extensive quantum theory of DNA (Chang, 2014). For RNA the basic quantum elements are the corresponding A-U and G-C. The corresponding quantum theory and its many mathematical methods are applied to DNA and molecular biology. From this we discussed symmetry and supersymmetry of DNA, and the quantum theory and equations of DNA. Further, we researched the string theory of DNA and general biological string. Some solutions and functions of these theories may describe probably DNA, biological things and their motions (Chang, 2014). In biology physical basis for protein folding is due to covalent bonding, hydrogen bonding, ionic bonding, Van der Waals forces, and hydrophobic interaction that is the tendency for non-polar molecules to gather near each other, away from water molecules. It is obvious difference with usual tendency for disorder of mixture. Different enzymes possess the special active sites, and lock-and-key vs. induced-fit mechanism. Enzymes, Anfinsen principle and self-assembly should be entropy decrease. In Anfinsen experiment a protein will be denaturing for add urea from its tertiary structure to primary structure, and for remove urea from its primary structure to tertiary structure. In eukaryotes transcription, regulation, modification, translation and replication, etc., are very complex and fine processes, and these never are all the simple tendency of disorder with entropy increase. ATP synthase is a very small biological rotary motor (Capaldi *et al.,* 2002), which and kinesin motor protein correspond to entropy decrease in biology

(Chang, 2013a). Posttranslational quality control (Wickner *et al.,* 1999) is namely an auto-control as Maxwell molecular demon. Many proteins in the cell may be a huge array of functions and structures.

Based on the extensive quantum theory of biology (Chang, 2012a) and NeuroQuantology, the Schrödinger equation with the linear potential may become the Bessel equation. Its solutions are Bessel functions, and may form the double helical structure of DNA in three dimensional spaces. From this model we predicted the discrete bound energy spectrum of DNA (Chang, 2015a). By using the entangled state representations of Bessel function (Fan *et al.,* 2006) the investigations of formulation of DNA are easier, in which A-T and G-C are entangled each other. Moreover, we discussed some solutions of quantum mechanics and their meaning, and researched the entangled state of neurobiology by the extensive quantum method and the nonlinear theory. New experiments shown that the quantum entangled state should be a new fifth interaction, for its verification neuroscience will possibly take a very important role (Chang, 2015a).

Greene (2015) discussed macroscopic quantum superposition in a human life-form, and discovered the open gate into the quantum world. Jansen (2015) studied measurement problem in quantum mechanics, which predicts future outcomes with multiple potentialities but only one realization, would resemble the general prediction problem in life and science and thereby loses its weird aspects. Mender (2015) discussed quantum photosynthesis by which energy harvesting in "brainless" plants and green algae is identified as the root non-trivially quantum process powering neural correlates of consciousness in humans and other "brainy" animals. Life is a series of experiences and responses woven in the chain of causality that builds the knowledge system in the universe, a complex system altogether. Bhutkar (2015) proposed a corresponding quantum field model. Norman (2015) searched quantum unconscious pre-space as a psychoanalytic/neuroscientific analysis of the cognitive science of Elio Conte the hard problem of consciousness, new approaches and directions.

Based on topological biology and structural biology, and combined the extensive quantum biology (Chang, 2012a) and general biological string, we proposed that Calabi-Yau manifolds can provide a mathematical method to be applied to biology. Some Calabi-Yau spaces may possibly describe the biological spatial structures, in particular, in NeuroQuantology. In biology usual Calabi-Yau manifolds are also smaller and cannot be observed except microscope. It is used to superstring and brane, so may also describe some biological strings, and biological branes, etc. Further, this may combine the extensive graph theory, which includes five types of the basic elements: various solid lines, dotted lines, wavy lines, and vertices, fields. Variegated Calabi-Yau manifolds and superstring-branes correspond to multiformity of biological structures (Chang, 2015b).

Quantum mechanics is based on Schrödinger wave function with linear superposition of vectors in a Hilbert space. Then Schrödinger equation developed to Dirac equations, Klein-Gordon equation, etc. Further, we should research tensor and spinor in biology and neurobiology

In neural system there are neuron and neuroglia which has three types (Kettenmann *et al.,* 1995): astrocyte (including fibrous astrocyte, protoplasmic astrocyte and radial glia), microglia and oligodendrocyte whose structures have intrafascicular cells, satellite cells and node of Ranvier, etc. Schwann cell may form myelin. Quantal synaptic potential determines quantum releases, and corresponds to vesicle release and presynaptic release of neurotransmitter (Bruns *et al.,* 1995).

Life science applied topology and morphological genology, special DNA by knot theory. Marvin, et al. (1966) discussed the topology of DNA from the small filamentous bacteriphage fd. Kamp et al. (1986) summarized a biotopology in past, present and future. Baumgartner, et al. (1992), proposed that the biological way may find an optimum structure topology. Its generalization is the topobiology. Femtobiology is related with dynamics of torsion on DNA cell (Saxena *et al.,* 2004). Neural network (Christopher, 1996) is a simplify model of neural system, whose mathematics corresponds to graph, matrix and tensor.

4. Twistor in Biology and Twistor Model of DNA

Twistor is proposed by Penrose (1967). It is a new type of algebra by description for Minkowski space-time, in terms of which it is possible to

express any conformal covariant or Poincaré covariant operation. The elements of the algebra (twistors) are combined according to tensor-type rules, but they differ from tensors or spinors in that they describe locational properties in addition to directional ones. The representation of a null line by a pair of two-component spinors, one of which defines the direction of the line and the other, its moment about the origin, gives the simplest type of twistor, with four complex components.

Penrose, et al. (1972) proposed twistor theory as an approach to the quantisation of fields and space-time. Penrose (1968) searched nonlinear gravitons and curved twistor theory. Twistor space is a parameter space-time with complex structure. Twistor is:

$$Z_\alpha = (\lambda_A, \overline{\mu}^{\dot{A}}),\ \overline{Z}^\alpha = (\mu^A, \overline{\lambda}_{\dot{A}}). \quad (3)$$

Here a pair of two-component spinors is:

$$Z^A_{;1} = (\omega^\alpha, \overline{\pi}_{\dot{\beta}}),\ Z^A_{;2} = (\lambda^\alpha, \overline{\eta}_{\dot{\beta}}). \quad (4)$$

A 4-dimensional point is represented by 3-dimensional complex space, i.e., complex number in twistor. It is applied to quantization and curved space-time.

Penrose and Rindler (1986) discussed spinor and twistor methods in space-time geometry. Twistor theory offers a new approach to the synthesis of quantum theory and relativity. Twistors for flat space-time are the SU(2,2) spinors of the twofold covering group O(2,4) of the conformal group. Penrose's basic relations are (Penrose et al. 1986):

$$\omega^\alpha = iz^{\alpha\dot{\beta}}\overline{\pi}_{\dot{\beta}},\ \ \overline{\omega}^{\dot{\alpha}} = -i\pi_\beta \overline{z}^{\beta\dot{\alpha}}. \quad (5)$$

They describe the momentum and angular momentum structure of zero-rest-mass particles. Space-time points arise as secondary concepts corresponding to linear sets in twistor space. Twistors are represented in two-component spinor terms. The generalisation to curved space can be accomplished in three ways; i) local twistors, a conformally invariant calculus, ii) global twistors, and iii) asymptotic twistors which provide the framework for an S-matrix approach in asymptotically flat space-times.

Further, Hayashi (1978) discussed general relativity as gauge field theory in curved twistor space. Penrose (1999) summarized the central programme of twistor theory, which includes twistor quantization, self-dual and anti-self-dual fields, helicity 3/2 fields and the vacuum equations, etc. Twistor may relate with string, superstring and supersymmetry (Delduc *et al.,* 1993; Galperin *et al.,* 1993; Bars, 2004), twistor space (Berkovits, 2004; Roiban *et al.,* 2004), twistor transform in d dimensions and a unifying role for twistors (Bars *et al.,* 2006), particles and superparticles, instanton and gauge field, etc. Bandos, et al. (2000) even proposed supertwistors. The variables of supertwistors are:

$$Z^I_L = (\lambda^\alpha_L, \mu^{\dot{\alpha}}_L, \psi^A_L),\ Z^I_R = (\lambda^\alpha_R, \mu^{\dot{\alpha}}_R, \psi^A_R). \quad (6)$$

These are a pair equation of three variables. Generally, these are n pair equations of m variables. Fedoruk, et al. (2007) researched unification of various string models from twistor, and twistor string, etc (Fedoruk et al. 2009).

It is well-known that space-time depends on matter and its movement in general relativity. Interactions between biological elements of different levels determine biological structures and shapes. For example, in DNA "horizontal" hydrogen bond interaction connects A-T, and "vertical" stacking interaction connects C-G (Gu 2003). Bena et al. (2005a, 2005b) elucidated the one-loop twistor-space structure corresponding to momentum-space maximally helicity-violating diagrams, and use the "holomorphic anomaly" to define modified differential operators which can be used to probe the twistor-space structure of one-loop amplitudes. Bena et al. (2005b) searched loops in twistor space, and twistor transform in d dimensions and a unifying role for twistors. We applied the loop quantum theory to biology, and proposed the model of protein folding and lungs, and obtain four approximate conclusions (Chang, 2012b). Further, it may combine twistor.

So far, biology applies only twister. Twistor as an extension of scalar, vector, spinor and tensor includes the self-dual Yang-Mills field. We may research generally twistor in biology. Based on complex number and the conformal transformation, twistor is (Penrose *et al.,* 1986):

$$\begin{pmatrix} t+z & x+iy \\ x-iy & t-z \end{pmatrix} = t\sigma_0 + x\sigma_x + y\sigma_y + z\sigma_z. \quad (7)$$

Here using quaternion or Pauli matrices are:

$$\sigma_0 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} = I,\ \sigma_x == \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \quad (8a)$$

$$\sigma_y = \begin{pmatrix} 0 & i \\ -i & 0 \end{pmatrix},\ \sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}. \quad (8b)$$

Twistor (7) is two pair conjugate complex numbers, and includes (t, x, y, z) and Pauli matrices. Its space is C^4. This may relate to relativity. Pauli matrices describe particles with spin 1/2.

Some structures in biology are helix. RNA is a single link structure on A-U and G-C. Here A is adenine and G is guanine, while U is uracil and C is cytosine. It is known that a helical line is:

$$x = a\cos t, y = b\sin t, z = dt\,. \quad (9)$$

Here d is a thread pitch. A form of the complex function is:

$$z = a\cos t + ib\sin t, w = dt\,. \quad (10)$$

The double helix is:

$$z = a\cos(\phi + \begin{matrix} C_1 \\ C_2 \end{matrix}) \text{ and } w = d\phi\,. \quad (11)$$

In complex function $f^{x+iy} = f^x f^{iy}$. When f=e, so $e^x e^{iy}$ is a circle with radius $\rho = e^x$ and $\varphi = y$ (Brown et al. 2009).

Twistor may describe biological extensive string with meander and twister. RNA as a string, and DNA as the double string of the double helix structure on A-T and G-C (here T is thymine) should be able to apply twistor. Therefore, we may research the twistor model described DNA, RNA, etc.

We may transform quaternion or Pauli matrices to other different forms:

1) 1→I=$\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ is unit matrix, and i→C=$\begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$ and $C^2 = -I$. Assume that a new complex positive number j, here j^2=1. Then, let j→B=$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$, B^2 =I, correspond to an inversion operator. k=ij→A=$\begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix}$=CB, here $A^2 = I$ and ji=-k→-A. This set (1,i,j,k) is another quaternion, and relates the Clifford fourfold quaternion. It corresponds to that a field is extended to a ring. Such new twistor is:

$$\begin{pmatrix} t+z & x+y \\ x-y & t-z \end{pmatrix} = tI + xB - yC - zA\,. \quad (12)$$

2) We introduce two pair conjugate complex numbers

$$\begin{pmatrix} t+iz & x+iy \\ x-iy & t-iz \end{pmatrix} = tI + xB - iyC - izA\,. \quad (13)$$

This corresponds to two circles.

3) We may add four parameters

$$\begin{pmatrix} at+dz & bx+cy \\ bx-cy & at-dz \end{pmatrix} = atI + bxB - cyC - dzA\,. \quad (14)$$

Such their radii may be different, and may be determined. For DNA they correspond to a diameter 20A and the pitch 34A, etc.

These corresponding relations between new quaternion and DNA (t~A, z~T and x~G, y~C) are symmetry completely. It is usual B-DNA. Other is A-DNA and Z-DNA, etc. New forms of twistor correspond to develop matrix and tensor, etc.

Twistor is developed from general relativity, and may describe the curved space-time. It is also consistent with a basic idea: the matter determines the structure of space in biology (Chang, 2012b). Moreover, A-T(U), C-G in DNA (RNA) all are 2 square matrixes.

Moreover, in biology there is duality. For example, duality and synergy in peptide antibiotic mechanisms by which peptide antibiotics disrupt bacterial DNA synthesis, protein biosynthesis, cell wall biosynthesis, and membrane integrity shown rich diversity, and involved in synergistic relationships with antibiotics and proteins (Mccafferty *et al.,* 2000). Two ideas in theoretical biology, 'decomposition into functions' and 'gluing functions', show a duality. They imply two biologically significant conditions: the existence of cycles in finite graphs and anticipatory diagrams (Haruna *et al.,* 2007). Al-Sady et al (2008) searched mechanistic duality of transcription factor function in phytochrome signaling, and found that PIF3 acts positively as a transcription factor, exclusively requiring its DNA-binding capacity. Twistor and spinor with double components may describe some biological duality, for example, excitatory synapse and inhibitory synapse, and above duality.

5. Conclusion

Biology possesses some characters of whole, self-organization and jump-evolution, etc. An important character of the nonlinear interactions is the formation of self-organization, which should decrease entropy. The second law of

thermodynamics is essentially a science; it should not become a religion.

The twistor model of DNA is probably advantageous to development of DNA computing model (Ignatova *et al.,* 2008). In a word, various mathematical and physical methods apply continuously different aspects in biology, this will accelerate deep development of modern biology.

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