EVOLUTION

A Nonlinear Irreversible Quantum Model

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Abstract

Motivated by the postulates :

(a)- Biological systems are compatible with the laws of quantum mechanics.
(B)- Biological systems are order generating systems.
(C)- Evolution is an irreversible transition from stable state to another state which is more structurally stable.

We discuss a definite model in which the life state of an organism, for successive generation, is a Schrodinger type of system which is nonconsevation, nonlinear and irreversible. Vitality, the state variable, is a certain function of biological order.
Biological order, or complexity, is the quantity of information generated by growing organism. Whereas vitality, which is a function of the total energy metabolized by the organism and its life expectancy, is the capacity of the organism to generate biological order. Vitality has the following properties:

i) It increases before adulthood, has a maximum when the organism is adult, decreases afterwards and becomes zero when the organism dies.

ii) It is a periodic function of time with period, A, which is the life span of the organism .

We also discuss evolution within this model. We find that the evolution of a unicellular organism, being a process through which the life state function undertakes negative damping, leads to the increase of total vitality. This means that the evolution of unicellular organism leads to the increase of at least one of the following :-

[A] Life span or cell cycle time.
[B] Biological order or, complexity.
[C] Energy consumption or body size.

1- INTRODUCTION :

A growing concern that the basic premises of the Darwinian theory of evolution, i.e. , random mutational changes and natural selection, are not sufficient to account for the enormous complexity and organization of present day biological systems has been gaining momentum since the mid of this century (Bertalanffy , 1954 ; Waddington , 1968 ; Gould 1982).

In April 1966 at Wistar institute of Anatomy and Biology in Philadelphia, a debate regarding this problem, took place between a group of mathematicians and biologists. The mathematicians charged that if natural selection has to choose from the astronomically large number of the alternative systems by means of the mechanisms described in current evolution theory the chances of producing a creature like ourselves is virtually zero. Eden (1966) who was especially concerned about the elements of randomness, contends that "No currently existing language can tolerate random changes in the symbol sequence which express its sentences. Meaning is almost invariably destroyed. Any changes must be syntactically lawful ones".

Thus all attempts to simulate the evolutionary process on computers have not been successful and the mathematicians concluded that current evolutionary theory is inadequate. It has to supply the programmer with a correct set of rules for " genetic grammaticality " that has a deterministic explanation rather than owing the observed stability of biological systems to selection pressure acting on random variations.

Whyte (1965) suggested that in addition to Darwinian selection there should be an internal selection at molecular, chromosomal and cellular levels, in accordance with their compatibility with internal coordination of the system. Whyte also asserted as some embryologists held, ontogeny is theoretically primary to phylogeny; consequently the synthetic theory can not be regarded as definitive until it has been combined with a theory of ontogeny. Waddington (1968) tried to show that evolution does not depend on random search. He emphasized that what occurs randomly are the mutations on the genome level, however, the output of these changes on the phenotype is not random, i.e. , there are certain operators that map the space of genotypes into a " fitness space" .

Probably, based on Eden's (1966) objection to random search and on his assertion that " No currently existing language can tolerate random changes in the symbol sequences which express its sentences ", Dawkin (1986) Proposed what he called cumulative selection. He clarified the concept by drawing attention to the fact that given a sentence of 28 units the probability that a monkey types it right away(What he calls single-step selection) is negligible. However, if whenever a letter falls in its proper place is preserved so that the next random change acts on the remaining letters then the chance for writing the sentence in this manner, which Dawkins calls cumulative selection, is very much improved. It is obvious that the process of generating a meaningful sentence in Dawkins above mentioned example, is guided by English Language grammar. However since such a grammar or set of rules to guide the evolutionary process have not yet been discovered Dawkins made some reservations as to significance of his example.

Some authors (Bertalanffy, 1954: Eden, 1965) even consider the evolutionary concept of fitness as tautologous, i.e, it restates the fact that only properties of organism that survive to produce offspring do survive. In other words to the question which organisms leave more offspring? The answer will be it is those that leave more offspring. So bertalanffy concluded that if leaving more offspring is the sole measure of evolutionary progress then it is difficult to see why evolution has progressed from the level of rabbits or even from bacteria.

Furthermore, from Dawrin onwards, evolutionists have realized that if we arrange all our available fossils in chronological order, they do not form a smooth sequence of gradual change. Most evolutionists, following Dawrin, have assumed that this is mainly because the fossils record is imperfect as we thought. May be the gaps are a true reflection of what really happened, rather than being an imperfect fossil record. They suggested that evolution, may be, in some sense go in sudden bursts, punctuating long periods of stasis. Now accepting this punctuationistic pattern of evolutionary change necessitates in turn explaining why evolution occurred in this particular manner.

A radically different view which tries to overcome some of the above mentioned inconsistencies of neo-Dawrinism was proposed by McClendon (1980). Hc compared biological evolution with the chemical evolution of isotopes. From the comparison he concluded that the forces which drive biological evolution are intrinsic property of matter. In other words the evolution of novel, more complex organisms, from lower ones precedes adaptation and selection.

The question whether evolution is a random process or an intrinsic property of matter is related to a deeper level of reality which concern the nature of life. The nature of life has been the subject of heated debate, full with emotions, for centuries. The controversy culminated in present times to what may be called reductionism anti-reductionism dichotomy. Reductionists claim that biological phenomena are explainable in terms of physico-chemical laws, in practice the law of quantum mechanics. Antireductionists oppose this position and maintain that biological phenomena are autonomous and are irreducible to physics. If we accept the reductionists claim it will be difficult to explain why biological systems behave so differently from inanimate systems if they are both governed by the same set of laws. Likewise anti-reductionists are facing the fact that in the vast literature of biophysics or biochemistry there is no shred of evidence that the laws of physics are violated which implies the dependence of biological phenomena on physico-chemical laws.

To overcome this dilemma in order to pave the way for tackling the problem of evolution we need a physical theory of general

biology. We believe that the basic assumptions for such a theory were given by Pattee (1968) when he proposed that :

A- Both living and non-living forms of matter obey precisely the same physical laws .

B- Living states of matter are distinguishable from non-living states of matter only by the potential for evolution.

Starting from these assumptions, limiting our considerations to the laws of quantum mechanics, there are two possibilities for understanding life phenomenon based on the limitations we impose on the domain of quantum theory :

A'- If we assume that the potential domain of quantum theory coincides with the domain of present day linear reversible quantum mechanics then we are left with no other alternative, due to the second assumption, than rejecting the dependence of life on laws and consequently try to reveal its mystery in terms of constraints, e.g non intergrable or measurement control constraints (Pattee 1990).

Of course Pattee did not assume that the domain of existing physical theory is closed. However, Pattee (1965) envisaged the development of physical theory in a particular manner when he said " Notice that assumption A does not imply that all aspects of physical theory have been formulated, but only that whatevertheories we currently accept must apply equally to living as well as nonliving matter". Thus according to Pattee's program the evolution of physical or quantum theory is a continuous homogeneous process and not a hierarchical one. Such a view excludes the possibility that the potential domain of quantum theory which may account for life phenomenon may contain the set of present day quantum mechanics as a subset, i.e., Special case. This possibility which Pattee excludes is the only savior for his assumptions from contradiction as he did refer to some physicists who feel that his assumptions are contradictory (Pattee 1968).

B'- If we assume that the potential domain of quantum theory is wider than present day linear reversible quantum mechanics then there is room for a nonlinear irreversible quantum mechanics. This is particularly evident if we conceive evolution as an irreversible transition from structurally stable state to another which is more structurally stable.

Since the development of any scientific theory, in this case quantum theory, is an open question and we can not claim a priori that that the potential domain of the theory coincides with its present day existing boundaries, we shall take the view that life phenomenon, or at least evolution, is a nonlinear irreversible quantum phenomenon which is not reducible to present day linear reversible quantum mechanics. The irreducibility to the wave function is imposed by the second assumption which necessitates the distinction between animate and inanimate matter. However the proposed life state function cannot be quantum mechanical, i.e., Schrodinger type of system, and at the same time irreducible to the wave function. Unless, somehow, it admits a limiting transition to the wave function.This amounts to saying that linear reversible quantum mechanics is a subset or aspecial case of nonlinear irreversible quantum mechanics, so that reversibility is derivable from irreversibility and not vice versa .

What is the impact of this view on the long lived controversy between reductionsists (mechanists) and anti reductionists (vitalists) ? It seems that, according to this solution, both mechanists and vitalists are partly correct. The mechanists are correct as far as they conceive life as aquantum phenomenon but they are not correct in claiming life reduction to present day linear reversible quantum mechanics. On the other hand the vitalists are correct when they oppose reducing life phenomenon to present day quantum mechanics but they are not correct in seeking life laws that are independent of quantum mechanics. Thus bearing in mind Pattee's assumptions we shall introduce the following as basic postulates for our model :

(a) Biological systems are compatible with the laws of quantum mechanics.
(B) Biological systems are order generating systems .

(c) Evolution is an irreversible transition from structurally stable state to another state which is more structurally stable.

We also introduce "vitality", a function of the total energy metabolized by the organism and life expectancy, as a function of biological information. Whereby biological information is regarded as a measure of biological order or complexity. We require the vitality function to have the following properties :

i) It increase before adulthood, has a maximum when the organism is adult decreases afterwards and becomes zero when the organism dies.

ii) It is a periodic function of time with period A, which is the life span of the organism.

Consequently our system of postulates and conception of the vitality function satisfy the requirement that the life state of the organism can be described by a life state function which is a Schrodinger type of system, structurally stable, irreversible, has vitality as a state variable and admits a limiting transition to the wave function. We have confined, at this preliminary stage, our model to the evolution of unicellular organisms. It is found that evolution, being a process through which the life state function undertakes negative damping, leads to the increase of total vitality. The increase of total vitality means the increase of at least one of the following :

[A] Life span or cell cycle time.
[B] biological order or complexity.
[C] Energy consumption or body size.

It is notable that in previous work the author (Elshiekh, 1987) disclosed some of these ideas :

2.1- A model for Biological Order.

Definitions:-

2.11: Biological order, or biological complexity, is the quantity of information, I(t), generated by a growing organism at time t ; where t is measured from the moment of initial growth .

2.12: Vitality, v(t); it is the capacity of the growing organism to generate biological order.

Information biologists may not have yet been able to calculate the information, I(t), assigned to a growing organism. However from common physiological observation, at least qualitatively, the growing organism generates increasingly more information, I(t), for $0 \leq t \leq \alpha$; where α is the time when the organism is fully grown, i.e., adult. Afterwards biological information, I(t), decrease for $t > \alpha$. So it seems plausible to assume that I(t) has the following general properties :

$$\begin{aligned} &I'(0) > 0 \\ &I'(\alpha) = 0 \\ &I''(\alpha) < 0 \end{aligned} \qquad (1)$$

So that the growing organism has maximum amount of information at adulthood. Now we shall construct a function v(t), so that the relation :

$$I(t) = X[v(t)] \qquad (2)$$

is valid for the general properties of I(t). I.e., relations (I) .

Let E(t) be the energy growth function defined as the energy available for the organism to support its growth, where t is the time measured from the moment of initial growth. For each organism we take F(t) to be defined by :

$$F(t) = (A - t)^a = 1^a \qquad (3)$$

Where A is the life span of the organism, a is a positive parameter that depends upon the species of the organism and l is the life expectancy of the organism. We shall call the function F(t) life factor. The The vitality function v(t), is then defined by :

$$v(t) = E(t)\ F(t) \quad = \quad E(t)\,(A-t)^{a} \qquad (4)$$

then $v(A) = 0$

From Medawar (1945) and Bertalanffy (1957) we can deduce that the energy growth function, E(t), for some classes of organisms, is given by :

$$E(t) \quad = \quad be^{Rt} \qquad t \leq \alpha \qquad (5)$$

Where b and R are positive constants which depend on the species of the organism and α is the time, or age of the organism, when it is fully grown, i.e., adult. For the period $\alpha \leq t \leq A$ we make the simple extension that metabolic rate, $\frac{dE}{dt}$ remains constant at its value when $t = \alpha$
then,

$$E(t) = be^{R\alpha} + (t-\alpha)\, bRe^{R\alpha}$$
$$= be^{R\alpha}\{1 + R(t-\alpha)\} \qquad \alpha \leq t \leq A \qquad (6)$$

$$v(t) \quad = be^{Rt}(A-t)^{a} \qquad t \leq \alpha \qquad (7)$$

$$v'(t) \quad = be^{Rt}(A-t)^{a-1}\ \{R(A-t)-a\} \qquad t \leq \alpha \qquad (8)$$

$$v(t) \quad = be^{R\alpha}\{1 + R(t-\alpha)\}(A-t)^{a} \qquad \alpha \leq t \leq A \qquad (9)$$

Then $v(A) = 0$. And $v(t)$ has single maximum for $0 \leq t \leq A$.

To restrict our model further we shall assume that v(t) takes this maximum value at adulthood, i.e. , when $t = \alpha$ so that $v'(\alpha) = 0$ .00 This assumption, determine the value of a :

$$a = R(A - \alpha)$$
$$= E'(\alpha)\, L(\alpha) / E(\alpha) \qquad (10)$$

Note that $a > 0$ as stated earlier since $R > 0$ and $A - \alpha > 0$.

Consequently, in this model, there exists a vitality function v(t) that satisfies the following condition :

It increase before adulthood, has a maximum at adulthood, decrease afterwards and becomes zero when the organism dies .

2.2 - Numerical Example:

Using dimensionless variables we can draw the vitality curve. Let,

$$Rt = x, \qquad AR = c, \qquad R\alpha = c_o \qquad (11)$$

and

$$v(t) = \frac{by}{R^a}, \qquad a = c - c_o, \qquad \text{from eqn (10)}$$

$$y(x) = e^x R^a \left(A - \frac{x}{R}\right)^a = e^x (AR - x)^a = e^x (c - x)^a \qquad (12)$$

$$x \leq R\alpha$$
$$x \leq c_o$$

From (9) :

$$\frac{by(x)}{R^a} = be^{c_o}\left\{1 + R\left(\frac{x}{A} - a\right)\right\}\left[A - \frac{x}{R}\right]^a$$

$$y(x) = R^{a} e^{c_o} (1 + x - c_o) \frac{1}{R} (c - x)^{a}$$

$$= e^{c_o} (1 - c_o + x)(c - x)^{a} \qquad (13)$$

$$\alpha \le \frac{x}{R} \le A$$

$$c_0 \le x \le c$$

Hence

$$y(x) = \begin{cases} e^{x} (c - x)^{c - c_0} & x \le c_o \\ e^{c_o} (1 - c_o + x)(c - x)^{c - c_o} & c_o \le x \le c \end{cases}$$

$c > c_o$, take $c = 8$ and $c_o = 4$

x	0	1	2	3	4	5	6	7	8
y	4096	6482	9590	12562	13759	8845	2620	218.4	0

It is worth mentioning that fig (I) is based on a particular form for the energy growth function, equations (5) and (6) .00 However, it is evident, no matter what energy growth function the organism has, the present model always determines a vitality curve for it.

Now to substantiate relation (2) the function X(v) is constrained so that :

$$X'[v(0)]\, v'(0) > 0$$

$$\text{for} \quad X'[v(0)] > 0 \qquad (14)$$

$$X'[v(\alpha)]\, v'(\alpha) = 0$$

$$X''(v)\, v'^{2} + X'(v) v''\big|_{t=\alpha} < 0$$

$$\text{for} \quad X'[v(\alpha)] > 0$$

To obtain these conditions we have used $v'(\alpha) = 0$ and $v''(\alpha)<0$. Noting that $v'(0) > 0$ we see that conditions (14) are consistent with function $X(x)$ that increase for $x > 0$ from a vanishing value at $x = 0$. We have thus established that biological information, $I(t)$, is a function of vitality, or inversely we can say that vitality is a function of biological information which is measure of biological order.

The following definitions will be useful in our subsequent considerations

Instantaneous total vitality $$V(t) = \int_0^t v(x)\, dx \qquad (15)$$

Total vitality $$V(A) = \int_0^A v(t)\, dt \qquad (16)$$

Average vitality density for all ages,

$$\bar{v} = \int_0^A \frac{v(t)\ dt}{A} = \frac{V(A)}{A} \qquad (17)$$

Average Instantaneous total vitality,

$$\bar{V}(t) = \int_0^t v(x)\, dx = \bar{v}t \qquad (18)$$

2.3 - Successive Generations:

The model may be usefully employed to discuss vitality for successive generations. We shall essentially be concerned with unicellular organisms particularly those which reproduce by binary fission. For such systems fig (I) represents the average vitality for one generation, i.e , when the organisms dies. However a unicellular organism usually does not die, it starts to divide when it is fully grown. Referring to fig (i) division occurs at time $t = A_1$, Where

$\alpha < A_1 < A$. The parent cell gives birth to two identical daughter cells so that $v(A_1) = 2v(0)$ where $v(0)$ is the initial vitality. Again each daughter cell grows and divides in the same manner. Thus the average vitality function, vitality per unit cell or organism, or successive generations v_g, under constant environmental conditions is a periodic function of time with period A (assuming no confusion we have deleted the subscript from A_1,).
Then,

$$v_g = v(t + nA) = v(t). \qquad (19)$$

Where $n = 1, 2, 3, ..$ is the number of cell divisions or generations. Figure(ii) represents this state of affairs :

Having been fully grown the unicellular organism divides.

If the unicellular organism completes the cell cycle and dies instead of mitoting then fig(i) describes such a situation, i.e. , determines the vitality curve. However for fig (ii) to be possible the organism must divide successively, i.e. , must have a natality rate r(t). Accordingly we shall regard fig(ii) representative for the life state and that vitality, v, and natality, r, are the fundamental biological state variables.

Where,

$$r(t) = \frac{dp}{dt}\Big/p \qquad (20)$$

p is the population size.

Of course the life state of a biological systems being natality or multicell-ulor is affected by factors other than vitality & natality, c.g. environmental factors.
So, how do we justify not incorporating these as separate state variables? The answer is that, within the present model, we assume all effects on the life state caused by such factors to occur by virtue of their effects on vitality and natality only. In other words we assume that vitality and natality are functions of these factors, and the effect of these factors is to be interpreted as a perturbation or a modification of vitality and natality. This is the same argument by which Rosen

(1970) justified why in the kinetics of a chemical reaction we confine the state variables to the rate constants and not incorporating factors such as temperature, pressure and volume as separate state variables.

3.1 - Life State Function:

In search for a plausible modular life state function we introduce the following postulates:

Postulate (b):
Biological systems are order generating systems.

Based on this postulate , i.e. , on the fact that biological systems are order generating systems, and on the fact that vitality, being a function of biological order,is a state variable it is natural, referring to fig.(ii), to represent the life state of the unicellular organism by what we shall call life state function (L). Then,

$$L = L(v) \qquad (21)$$

where $v = v_a$
To complete the definition of L we introduce :

Postulate (a):

Biological systems are compatible with the laws of quantum mechanics.

This postulate derives its strength from the fact that there is no shred of evidence any-where in the vast literature of biochemistry or biophysics that the laws of quantum mechanics are invalid (Elsasser, 1981) and from Von Neumann's mathematical result that there can be no second set of laws independent of quantum mechanics.

Now from postulate (a) and equation(21) it is reasonable to assume that the life state function, L, is a Schrodinger type of system with vitality as a state variable. We shall therefore take for it the simple form :

$$L = L(0)e^{i\Phi/h} \qquad (22)$$

where L(0) is the amplitude, h is planck's constant. Now according to eqn. (21), Φ must be a function of v. Further we must have correct dimensionality. With this in mind we limit our considerations to the concrete example in which Φ is given by:

$$\Phi = \int_0^t E(1-\frac{x}{A})^a \, dx \qquad (23)$$

this completes the definition of L. From equations (4), (15) and(23) we obtain :

$$\Phi = A^{-a} V(t) = A^{-a} \int_o^t v(x)\, dx \qquad (24)$$

$$\therefore \quad L = L(0) \exp. \frac{1}{A^a h} \int_o^t v(x)\, dx$$

$$= L(0) \exp. \frac{1}{A^a h} \int_o^t E(A-x)^a \qquad (25)$$

The life state function, equation (25), has important and desirable features, namely, the differential expression of equation (25) is

$$L'' - \frac{v'}{v} L' + \frac{v^2}{k^2} L = 0 \qquad (26)$$

where $k = h A^a$

Using (21) we can also have:

$$L'' - \frac{(L')^2}{vL'(v)} + \frac{v^2}{k^2} L = 0 \qquad (27)$$

Equation (27) is that of a non-conservative non-linear system which maintains its stability by consuming energy from the surroundings. Consequently the oscillations given by fig. (Ii), Which

we may call vitality oscillations or waves, are self-sustained oscillations and that the system is structurally stable. A result which is compatible with empirical observation. Moreover, it is significant that, using the vitality function, we can determine the life state function without undertaking the impossible task of constructing the Hamiltonian for the whole organism. By so doing we shall gain a new insight and account within our model for some aspects of biological phenomena. Finally, we would also like to emphasize the significance of the periodicity of the life state function by reffering to the enormous efforts that have been made to reveal the oscillatory nature of fundamental biological organization in general and cellular performance in particular, (Goodwin, 1963; Nicolis, 1977; and Yates, 1981).

The Irreversibility of the life function is also evident since the vitality function equation (4) can not accept any substitution of - t for t.

Now using (17):

$$\bar{v} = \text{constant} \qquad (28)$$

$$\bar{v}' = 0 \qquad (29)$$

we shall reduce (26) to the simpler form :-

$$L'' + \frac{\bar{v}^2}{k^2} L = 0 \qquad (30)$$

we note that:

$$\text{Frequency,} \qquad w = \frac{\bar{v}}{k} \qquad (31)$$

$$\text{Wavelength,} \qquad \lambda = \bar{v}A = V(A) \qquad (32)$$

where, from equation (16), V(A) is the total vitality of the system.

4.1 - Evolution:

The life function (25) is constructed to describe the life state under constant environmental conditions. However, we know that environmental conditions do not always remain constant, they change. In doing so the organism interacts and sometimes incorporates these changes and perturbations. The most significant perturbations from an evolutionary point of view are mutational changes. These perturbations induce nonlinearity in the system. Accordingly the system may spiral to a focus due to positive damping in which case the mutation is lethal and the system may extinct. On the other hand the system may exhibit stable periodic solution in the neighborhood of the homogenous solution with greater period due to negative damping in which case the mutation is beneficial. Thus we say that the system has envolved. The terms positive and negative damping are used in electrical engineering in connection with oscillatory phenomena which dissipate and absorb energy respectively. Likewise we use these terms to characterize the dissipation and generation of vitality by the system when it interacts with the environment. Thus, to incorporate evolution in our model, we make the following assumption:

Evolution (mutation, selection, ... etc) of unicellular organism is a process through which the life state function undertakes negative damping.

Result:

The evolution of the unicellular organism leads to the increase of its total vitality, V(A).

Proof :

Let the unicellular organism before evolution be given by:

$$L'' + \omega^2_1 L = 0 \qquad (33)$$

Now assume the system has evolutionized, i.e., equation (33) has undertaken negative damping. The new evolutionized system becomes :

$$L'' + \omega^2_2 L = \varepsilon f(L,L') \qquad (34)$$

Where ε is a small positive parameter that characterizes the smallness of the deviation of $\omega^2_2 L$ from $\omega^2_1 L$. If the deviation is not small we set $\varepsilon = 1$. Biologically the fact that $\varepsilon \neq 0$ accounts for certain generation of vitality which did not exist when $\varepsilon = 0$. Being interested in finding a stable periodic solution in the neighbhod of the homogenous solution, under the condition of negative damping, equation (34) is readily solvable by Krylov and Bogoliubov (1947) asymptotic method for damping oscillation. The solution yields :

$$\omega_2 < \omega_1 \qquad (35)$$

Since, in general, the wavelength,

$$V(A) \alpha \frac{1}{\omega}$$

then,

$$V_2(A) \alpha \frac{1}{\omega_1}, \quad V_1(A) \alpha \frac{1}{\omega_2} \qquad (36)$$

Where $V_1(A)$, $V_2(A)$ are the total vitality of the organism before and after evolution respectively. Equations (35) and (36) yields,

$$V_2(A) > V_1(A) \qquad (37)$$

Which proves our result.

Equation (37) proves that the evolution of the unicellular organism leads to the increase of its total vitality. However we need to know what does the increase of total vitality mean ?.

From equation (37), (16) and (14) we obtain :

$$\int_0^{A_2} (E_2\, L_2^a)\, dt \;>\; \int_0^{A_1} (E_1\, L_1^a)\, dt \qquad (38)$$

From (38), also referring to fig (I), the increase of total vitality leads to the increase of at least one of the following :-

[A] Life span or cell cycle time, A.

[B] Biological order or complexity, $v(\alpha)$.

[C] Energy consumption or body size, $E(\alpha)$.

Looking at the phylogenetic evolution of uni-cellular organisms, e.g. , evolution of bacteria, we encounter features such as increase of life span and body size which are in comformity with the present model.

5.1 - Limiting Transition:

The irreducibility of the life function, begin a Schrodinger type of system, necessitates a limiting transition to linear reversible quantum mechanics. Accordingly given the life function we obtain:

$$\frac{-ih}{L}\frac{dL}{dt} \;=\; \frac{E(t)\;(A-t)^a}{A^a} \qquad (39)$$

This looks like Schodinger's equation with a time dependent energy. It therefore appears plausible to characterize inanimate matter with time independent energy on the right-hand-side of this equation.
In order words we need to add " inanimate energy" ε, the energy that the body of the dead organism will have as a lump of matter.

Then (39) will read when modified :

$$\frac{-ih}{L}\frac{dL}{dt} \;=\; \frac{v(t)}{A^a} + \varepsilon \qquad (40)$$

for living organisms, so that :

$$\frac{-ih}{L}\frac{dL}{dt} = \varepsilon \qquad (41)$$

for inanimate matter, in the latter case one may identify $L = \psi$ so that

$$-ih\frac{d\psi}{dt} = \varepsilon\psi \quad ,\text{i.e.,} \quad H\psi = \varepsilon\psi \qquad (42)$$

Where H is the hamiltonian and (42) is Schrodinger's equation.

5.2 - Summary :

We have, within a concrete model, discussed various concepts that relate to the growth, reproduction, vitality, information, biological order, structural stability, irreducbility and evolution of unicellular organisms. We see that our system of postulates and conception of the vitlatiy function necessitate the description of biological evolutionary process by a life state function, a proposed order generating principle, which is nonlinear, nonconesrvative and irreversible Schordinger type of system. Thus random mutational changes generate beneficial mutations because the system is capable to increase its total vitality through negative damping, otherwise the probability of generating beneficial mutations is virtually zero.

The logical structure of our model is based on the view that the total domain of quantum theory is a hierarchical set and not a homogeneous one, so that quantum laws which govern biological phenomena admit limiting transition to linear reversible quantum mechanics. In other words the quantum biological laws contain the physics of inanimate systems, i.e., what is called ordinary laws of physics, as a limiting case. Such a view, of course, has a tremendous impact on the question of reduction. It seems it is no longer significant or relevant to ask whether biology is reducible to physics or vice versa. Because we have reached the limit where the domain of theoretical biology coincides with the domain of theoretical physics. This is simply because we have got one Universe.

It is worth mentioning that the model is potentially capable to account for problems related to ontogeny. e.g. , we can envisage cellular differentiation as a process through which the life state function undertakes negative damping; because the whole organism is usually issued from a single cell, zygote, through successive cellular divisions. Accordingly ontogeny recopitulates phylogeny in the sense that cellular differentiation is also a process of increase of total vitality, i.e., increase of life span or cell cycle time and / or body size.

Finally the present model can easily be generalized to account for multicellular organisms.

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