Dynamics of Organisms in Environment

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1. The Role of Environment in Shaping Electronic Structure

The electronic structure of atoms, molecules and crystals is a well-established area of quantum physics and chemistry which provides an understanding the structure and behavior of "inorganic" matter, and was/is a basis for 20-th century high technologies including lasers, semiconductor technologies, quantum sensors, etc . While "organic" matter and its components is the foundation of living nature, their current understanding in terms of standard biochemistry and molecular biology is still quite limited and misses an in-depth dynamics which would be critical in understanding the organisms growth and development and their dynamics in an active environment. That understanding would open new opportunities in in-depth understanding of new synthetic biology, and hopefully in design and synthesis of *next-generation* drugs.

This paper is the very first step in this direction. Its focus is on electronic structure of cells and organisms and its dynamics in the environment. Another focus is on how the electronic structure and its dynamics impact the structure, functions and behavior of organisms in environment. In the sect. 2 we present the electronic shell model for cells and organisms and discuss the cell and organism properties that follow from that model. In sect. 3 and 4 we discuss the mechanism of incremental build-up of molecular and organismic structures. In the sect. 5 we discuss and analyze a number of examples and applications of the model. The conclusions and future plans are presented in the Sect.6.

1.1 Electronic structure of atoms, molecules, and crystals

Electronic structure used to be ignored in discussion of organisms growth and development mechanisms. Meanwhile life activities are fundamentally impossible without red-ox-driven metabolism and formation of chemical bonds which involves electrons and their wave (quantum) properties. Chemical bonding is a typical quantum phenomenon, a result of quantum interference of electronic wavefunctions of interacting atoms.

Electrons in atoms and molecules are universally organized into *shells* of various spatial forms and binding energies. Each free atom has a specific electronic structure which is based on *electronic shells,* ring-like spatial structures of *specific* shape; they are known as *s, p, d, f, etc shells* and correspond electron orbital momentum l=0,1,2,3,.. respectively. Each shell has a specific number of electrons. Shells with maximal number electrons are *closed* shells and chemically *stable,* and the shells with less than maximal number are *open* and usually chemically *active*. The shells with minimal number of electrons are typical electron *donors,* whereas the shell with almost filled shells are typical electron *acceptors,* two very different classes in terms of behavior. The shells also can be viewed as spatial layers. An atom can have as many as *seven shells,* each of which holds only a certain number of electrons. The shells, in sequence from the closest to the furthest from the nucleus, hold a maximum of $2n^2$ = 2, 8, 18, 32, 50, 72, and 98 electrons respectively for n=1, 2, 3, 4, 5, 6, 7. The binding energy of the shell electrons gets smaller and smaller, and spatial properties (shapes and flexibility) get richer and richer.

All nature structures are built from atoms and molecules. Such an architecture is a *fundamental* property of atoms, and it is a basis for *Periodic System* of elements, a classification of atoms based on their electronic structure. For example, the *groups* of the *Periodic System* are the atoms with the same type of external electrons (actually, electronic states). An atom size gets determined by the radii of its external electron shell and typically is less than 1 *nm* size. In some media (e.g., polar liquids such as liquid ammonia) electron orbital may have 10-100 nm size. In some metals as well as in superconductors (at low temperatures), electron orbital may have a macroscopic size. So, for molecules, crystals and organisms, the electron shell size needs to be *evaluated properly* depending on specific environment the particle is in.

In the *realistic* environment (as opposed to *free* space), two extra components emerge: *vertical symmetry* (due to the *gravity force*) and *back/forward asymmetry*. They transform the spherical electronic shells into *environment-specific* electronic shells. That is the *foundation* of environment-specific electronic architecture of cells and organisms. The environment of *spherical* symmetry is typical for 3D media such as sea/ocean and air. Moving of simple spherical species into other media such as ground-based media caused further transformation and adaptation of the free-atom electronic shells to the new reality. Which caused the emergence of asymmetrical organism *forms* typical for plants and animals. The emergence of mirror asymmetry relative to a vertical plane (left-right symmetry) for animals is due to their *relocation capability* which is not available for plants with their fixed locations.

1.2 Environment and the Hellman-Feynman theorem

The critical role of electronic stat*e* of a cell/organism is due to the fact that it is electron state that *determines* a spatial arrangement of atoms, a kind of "hard copy" of the electronic state. Any change of electronic state *causes* a proper rearrangement of the atomic structure of the molecule. So, the molecular rearrangements *follow* the change in the electronic state. This statement is the Hellman-Feynman theorem formulated independently by H. Hellman (1937) and R. Feynman (1939) .

We also add that an electronic state is not only a *controlling template* for molecular architecture; it is also its *interface* to the external (environmental) electromagnetic field (EMF). In other words, the response of a molecular structure to the EMF occurs via the molecule's electronic state. So, according to the Hellman-Feynman theorem, environmental EMF *changes* the electronic state of the matter, and thus *controls* the dynamics of molecular rearrangements.

The described in the literature and observed "aggressive" nature of living matter (Vernadsky), its "unlimited" growth and propagation, can be explained by the activity of its electronic state. Indeed, an excited electronic state typically has a "doubled" structure with a nodal/dividing plane between two "halves". According to Hellman-Feynman theorem, such a doubled electronic state selectively attaches the environmental building components thus transforming the environmental material into the copies of the "seed" structure. So via its electronic state, the seed aggressively transforms the environmental material into the seed copies. In other words, life driven by the EMF (from Sun and Earth itself) transforms the environmental material into specific living forms via the seed's electronic state. In this process, the seeds aggressively compete for environmental material.

1.3 Principles of molecular structure build-up

Molecules basically have a similar *shell* architecture, and can be described in terms of a *ground* state with tightly-bound electrons and *many excited* states of various spatial shapes depending on configuration of the molecule. For example, benzene molecule C_6H_6 has an almost spherical ground *electronic state* (Σ-state) and many *excited* Π-states of various shapes.

Crystals are built as 3D arrays of *identical* elementary cells each one consisting of single atom or many atoms, and their electronic structure also follows the mentioned fundamental rule: the ground shell/band with tightly-bound electrons and a number of shells/bands with less-bound electrons or unfilled by electrons shells/bands; the term 'band' has to do with the structure of energy spectrum of a crystal. Some crystals have certain properties similar to the ones of cells and organisms, for example, floating crystals.

We believe that the electronic structure of cells and multi-cellular organisms (being built from atoms and molecules) *can not* be based on totally different principles. Electronic states is a *fundamental* feature of matter, and so electronic structure of atoms, molecules, cells, and organisms should have similar *fundamental* properties if they are placed in similar environments. We also believe that *adaptation* (or flexibility) as the fundamental property of living matter can be understood only in terms of its electronic structure that has a unique feature of *mixing* electronic states in new environments thus providing actually *unlimited* possibilities to build various shapes and forms. Victor Weisskopf [W75] has suggested that only quantum mechanisms allow for reasonable description of spatial architecture and temporal rhythms in nature.

2. Shell Model and Organism Architecture

2.1 Electronic structure and behavior of cells and organisms in environment

We extend and apply the *shell model* to the *electronic structure and architecture* of a cell and an organism viewed as large molecules or *aperiodic* crystals. Like in the case of an atom, the cell/organism shell model includes a core with tightly-bound electrons and the external shells with less-bound electrons similar to the shells of the simplest H atom:

$$1s^2 - 2s^2 2p^6 - 3s^2 3p^6 3d^{10} - 4s^2 4p^6 4d^{10} 4f^{14}, \text{ etc.}$$

When placed in the environment with axial symmetry (gravity), the spherical architecture typical for free atom electrons gets transformed into electronic architecture with *axial symmetry;* the core shell located at the ground plane (gravity) becomes the center of the growth from the ground plane up, a kind of foundation of the growing organism. The former free-atom peripheral ring-like shells become a part of *vertical architecture* with the highest shell similar to the highest (most remote) electronic shell in atom. This shell is a source of *least-bound* electrons which can effectively interact with the environment. The whole vertical architecture of the electronic shells may be thought of as a foundation of a spinal system of organisms with the shell structures and functions emerged due to interaction with environment and handling stimuli from that environment. The shells with *lower* energy are always *closed* ones (analogues of the closed *s, p, d, f,* etc shells in atoms), and their participation in cell/organism dynamics is generally *minimal.* The *open* shells, in particular, the most external one is active in metabolism and interactions with the environment. There are as well the empty, normally non-populated electronic shells, which in some situations may be involved in interactions with the environment driving changes in metabolism, brain dynamics, and somatic functions.

In a crystal, *spatial* shells follow the *periodic* architecture of the specific crystal with the crystal *core* (internal electrons) made up from the electron cores of component atoms, and the crystal *valence* electrons made up from the valence electron orbitals (Bloch wavefunctions) of the component atoms. The core electrons (shells) normally are not involved in any collective, crystal-wide functions, whereas the *valence* electrons are crystal-wide and are actively involved in the interaction with the environment. They form a *responsive* shell/layer interface crystal-environment. When environment gets changed from free space to the space with the interface plane (ground) and vertical gravity force, the *core* shell becomes the most c*lose* to the ground plane and forms the foundation of the growing organism. The *meso-shells* are located in the "middle" of the organism's vertical with the later in development layers/organs located at periphery of the organism. The *exo-shell s* are located at the top of the organism vertical architecture and include the interface organs (eyes, ears) and signal storage and processing organs (such as brain's neocortex). In organisms, legs and similar relocation devices get developed "later" as *external*, purely environment-oriented facilities.

2.2 Cellular and multicellular electronic orbitals

Like the interacting atoms create molecules and crystals, the interacting cells create tissues an organisms. Like the atom's valence electrons are responsible for formation of molecules and crystals, similarly, cell's valence (metabolic or red-ox) electrons are responsible for formation of tissues, organs, and the organism. In this process, molecular and crystal electronic orbitals (bands) get naturally transformed into cellular and multicellular electronic orbitals ("bands"). Like in the case of atoms and molecules, *integrity* and *stability* of cells/organisms in environment is fundamentally due to the *discrete* nature of their *quantum states* and in particular to their electronic shells. The 'valence' (metabolic or red-ox) electrons form the *cellular orbitals* which directly respond to the environmental effects.

Cells with *closed,* i.e. totally filled, electronic shells or bands are very stable (like noble gas atoms), whereas cells with *open,* i.e. partially-filled electronic shells or bands can easily interact with other cells and are sensitive to the environment impact (like the atoms of the first few groups of the Periodic System). In the *asymmetrical* environment, cell's electronic states get *mixed* forming *hybridized states* of specific spatial shapes adapted to the environment; this also includes a specific *temporal* dynamic [W75], the one visible for example in neuron and axon dynamics. The *collective* electronic states/orbitals of tissues and organs, the electronic *densities and currents,* can be visualized as the *electrical* (or better electromagnetic) *framework* of the tissue or organ. Its *temporal* dynamics or *beatings* gives a possible explanation for *pulsations and rhythms* observed in organs as well as electron current/density traffic visible in the electroencephalograms (EEG), electrocardiograms (ECG), and electromiograms (EMG). A cell lowest energy electronic shell, an analogue of $1s^2$-shell of atoms, is its *electronic core.* Its hard copy can be associated with the nucleolus and the nucleus. Cell's external electron shells/rings can be associated with the cytoplasm's ring-like structures such as organelles, endoplasmic reticulum (ER), centrioles, etc.

2.3 Cell response dynamics

The signal/stimulus from environment always propagates to the cell core; it gets modified by the core/genetic structure (the core update is also possible) and then propagates back to the cell periphery through the cytoplasm triggering there the appropriate, driven by the core and by the environment, update of synthesis processes.

Thus, within the proposed model, *cells and organisms* get grown and built up as a response to environmental challenges by *populating* the potentially available electronic states within the fundamental electronic shell/layer architecture . Both the organism's shells and components supplied by the environment participate in building the new external shell/layer, which creates new spatial degrees of freedom and expand the adaptation capabilities of the organism to the environmental challenges. Generally, *simple* environments create *simple* organisms built around one or a few electronic structure shells. *Complex* environments create *complex* organisms built around many shells/layers. Thus environment *shapes* the architecture of the shells, and so the molecular structure of the organism.

Within the proposed model, the *genetic* component related to the core of a cell/organism is a *dynamic* part of that process and gets built-up gradually in the long-term, *phylogenetic time frame*. Its core is due to the *permanent* components of the environment, while the peripheral elements are due to the *variable* components of the environment - variable atmosphere composition, temperature, pressure, solar activities, etc.

The control of cell/organism structure occurs via its electronic state (accordingly to the Hellman-Feynman theorem), so that the cell/organism's "hard copy" always *follows* the changes in its electronic state. An environment with *complex* spatial and temporal stimuli/challenges causes the corresponding changes in the electronic shells of an organism, and so each shell acquires a specific spatial architecture under environment control. Similarly to atomic *p,d,f, etc* electronic shells, the *higher* shells are more *flexible* and *rich spatially* and so may acquire a highly sophisticated *spatial and temporal architecture* under the proper environment control. See, for example, spatial shapes of various atomic electronic states here . The most external, easily-bound electrons (shell) are involved in the metabolic processes (so called *red-ox* electrons), whereas internal electrons form a dense, tightly-bound *core*.

Like in atoms, the core excitation requires a relatively high energy, and the core gets involved in the organism dynamics only under strong pressure from the environment; in this case, due to release of large energy and initiating powerful electronic currents, other shells get involved in organism dynamics - often, causing many unexpected phenomena such as kundalini. See also an interesting article[K79] on kundalini by Gopi Krishna). Due to its flexibility it is the external shell that establishes the *interface* with the environment. Usually, the environment-driven changes or adaptations are related to the *exo*-layers of an organism, whereas the *meso*- and *endo*-layers and structures are much less involved, in particular, the endo core shell.

Response structures and functions in a cell. In environment, molecules display an activity which is an excitation of "valence" electrons with possible rearrangement of atoms in the molecule and with optional de-excitation by emission of photons and/or by radiationless relaxation via excitation of *soft* molecular vibrational and rotational modes. In cells, the environment excites metabolic (red-ox) electrons which may cause rearrangements of the cell's internals and optional de-excitation by emission of photons (EM signals) to other cells around. The internal rearrangement (as a response to the environment stimuli) may include a multi-step chromosomes rearrangement including separation and division. Like in molecules, the *anti-bonding* electronic states of cells are critical for division and its dynamics. Thus *metabolic red-ox electrons* directly interface environment and mediate the response dynamics. Those electrons occupy the cell-wide orbitals and are the "front line" of the cell/organism interaction with the environment. They sense changes and respond by *building* the proper structures and by *integrating* those into coherent cellular response.

Integration of *environmental effects.* The proposed model introduces a universal mechanism of interaction living matter with environment via the electronic shells interaction with environment. The basic step is the *incremental* building up a new layer. For example, in the womb, an embryo goes through the stages of fish, amphibian, and mammals. This can be viewed as a sequential population of electronic shells of ever increasing complexity and potentiality. So, this mechanism introduces a *layered architecture,* roughly the endo, meso, and ecto-layers that correspond to core structure of the organism, its connective infrastructure and the external interface layer. Each one though has also a fine structure due to the specific environmental interaction. Certainly, the genetic component is always there introducing the contribution of the phylogenetic history of the species.

DNA-driven model and its extension. The proposed model extends and complements the DNA-driven model of an organism by providing a *multi-scale* (in space and in time) and multi-level *infrastructure* for an organism development in the *active* environment, an aspect of organism dynamics that was very much neglected in DNA model. The DNA-driven model focuses on genetic information and its transfer between the various molecules such as DNA, RNA, and proteins. The proposed model focuses on the electronic cell/organism *infrastructure* and its close relationships with the environment. The genetic information then comes in as a transferred *seed* and gets built-up (updated) as a result of the cell/organism interaction with environment. The seed is basically related to *geological,* large-scale time frame; in that sense, it is *not* quite a "pre-specified" control code, rather the result of accumulation of long-term inputs from the environment such as temperature, pressure, atmosphere composition, solar activities, etc.

The universal *layered architecture of the matter* can be naturally related to building the matter under electronic shells control. Everything - solids, plants, animals, etc. get organized and built by their electronic shells control. From electronic structure viewpoint, an organism can be viewed as large molecule or *aperiodic* crystal, so its electronic shells and their hard copies may be of macroscopic size - like in the case of crystals. The tree annual rings, onion, cabbage, fish visible layered structure, and many many other are examples of that universal infrastructure.

Electronic structure of a cell and its structural components. A cell - as any "large molecule" - has a set of cell-wide electronic states. The *ground* state of an unconstrained cell usually is spatially *symmetrical and compact* and its energy is separated by the *energy gap* from excited states. The excited states are usually spatially extended and may have sophisticated spatial structure depending on the specific electronic state and the cell immediate environment. The excited states always have one or more *nodal* surfaces that divide cell into two or more compartments.

3. Incremental Build-up of Molecular Structures

3.1 The build-up principle

We believe that there hardly are *different* build-up principles for molecules, crystals, and organisms - viewed as large molecules or aperiodic crystals. So, we formulate and discuss the fundamental build-up mechanism based on quantum properties of electrons and apply it for analysis of the process of building molecular structures in cells and organisms. It is well-known the molecules are being built by *selective* attachment of suitable atoms/molecules to the molecular core according to the quantum rules of formation of chemical bonds. The Hellman-Feynman theorem states that molecular rearrangements *follow* the changes in the electronic state. As a result, a molecular "seed" tends to selectively transform the environment's materials to build its *own* copies, a kind of "aggressive" behavior in the local environment. Viruses growth/multiplication is an example of that mechanism.

3.2 Atom-by-atom vs. layer-by-layer build-up dynamics

Usually, a molecular structure build-up mechanism gets formulated in terms of *atom-by-atom* growth. For large complex structures such as crystals involving a multitude of atoms, this is hardly a realistic mechanism: long time required for sequential build-up and strong consistency requirements for each elementary build-up step make that mechanism unlikely. Instead, for complex (bio)structures, the build-up process likely starts with preparing a *whole layer* rather than making it an atom-by-atom process. In fact, the preparation layer can be thought of as a hard copy of electronic shell which is a kind of *integral organizer* for atoms. When a layer is prepared this way, it then gets deposited *as a whole* on the current core. In other words, the layered electronic architecture strongly suggests the layered build-up mechanism.

Thus, we naturally come to the concept of a cell built by (ring) layers. A pre-organized layer becomes a *unit* to build complex molecular structures. The larger cells likely have more and larger layers than smaller cells. If a cell growth is not a random atom-by-atom process, and rather a layer-by-layer build-up, the *coherent light pulse* is expected to be generated (as well as the proper acoustic wave) by the *in-sync deposition/*attachment of each layer. Thus, cell growth is a coherent process and generates the coherent light pulses and related acoustic waves.

A new layer build-up. When a *new layer* is being built-up, the process necessarily includes a contribution from the environment *and* from the existing structure. So, a layer *is* a physical *link* between the existing core and the environment input. This link is a *physical* model of a *relationship or association* between two mentioned components. So the growth process is an *incremental* build-up of a the whole thing (cell or organism) as a *chain* of *linked* layers. Thus, although a layer (e.g., a tree ring) looks like an independent unit structurally, its infrastructure is *distributed* over all other layers. In fact, to select (get access to) the whole layer, a proper environmental signal/pattern linked to the layer needs to be applied; its visible structure does not represent the whole thing/layer. So, a layer is actually a *distributed pattern* that physically links/correlates the specific environmental stimulus and the corresponding (multi-layer) *response* structure.

4. Incremental Build-up of Organisms

4.1 Layered growth of living structures

Growth of living matter and its dynamics is a challenging issue. The existing views and models are quite limited and often are highly schematic. Questions such as what is the *unit* of growth, *what drives* the growth, and *when/why* growth gets stopped are often neglected and need to be properly addressed. We discuss a growth model which focuses on electronic structure and its interaction with the environment. The model views the living matter growth as a *layer-by-layer* growth. It is *not* an *atom-by-atom* growth. A cell/organism can be described as an *aperiodic* crystal [S44], with each layer of *variable composition*. Within a layer though the composition likely does not change significantly. When a living matter is placed in a new asymmetrical environment, the growth gets modified: "old" layers get transformed into "new" layers of specific shapes and composition depending on the new environment.

4.2 Growth, seed, and environment

Growth depends critically on availability of a *seed*. The seed is a *minimal core* to begin a propagation or growth. Growth process cannot start from scratch: a "small" unit cannot be a seed. The seed should have a *unique* structure enough to drive the growth process in the specific way. This probably is a critical element of what is known us as life. For example, a crystal needs a "nucleus" as a seed, and often the seed needs to be introduced artificially. A cell as a complex unit cannot grow without a seed.

Electronic excitation and growth. We assume that an elementary step of growth is related to electronic excitation of the core/seed. Then the excited electronic state, which is roughly a 'doubled' ground state, according to the Hellman-Feynman theorem, drives the process which produces a 'hard copy' of the excited electronic state. Then, the next step works similarly but with the already "enlarged core" producing even bigger core and so on. On each step, the dynamics and architecture of the excitation is different as the current core is different as well as the environment input/contribution.

Life is obviously based on the idea of *unique* seed, a launchpad of the unique organism. Life is a propagation of the unique unit in space with *(re)configuration* option. So, the *seed-driven* life is a way of unlimited and adaptable to the environment growth of molecular structures. Certainly, the seed itself is more than just DNA. *Polymerization* does *not* need a seed, but generates an unorganized structure. *Stereoregular* polymers produced with Ziegler-Natta catalysts display a partial regular structure and need a surface as a seed to start a stereoregular structure/chain.

5 Discussions and Applications

The introduced concept and generic model being the very first still step open a new dimension in understanding of organism behavior and its dynamics in various environments, and in development of alternative techniques to diagnose and control organism functions. A few following examples illustrate those new opportunities.

5.1 Organism tree and its layers, pair organs, and organ dynamics

Organism dynamics and its layered tree-like structure is a result of coherent growth and development of an organism in the environment - in space and in time - starting from a seed responding to its local control environment and finishing when the organism loses its coherence and gets transformed back to building components for new organisms.

*Pair organs s*uch as eyes, lungs, kidneys, ears are indications to a pairwise symmetry of electronic states of an organism relative to spinal axis. The *hybridized* electronic states and shells may also introduce more complex, e.g., four-lobe and multi-lobe architecture (see, the gallery here). For example, the pair organ eyes may probably have a less developed additional high-level pair - the 3rd eye between the brows and the symmetrical fourth one on the back of head.

5.2 Dynamics of sex (gender)

The gender used to be considered as *the permanent* feature of sexual living creatures, existing *forever* and "*intelligently"* designed to implement the reproduction function. Meanwhile, an increasing number of observations during last few decades indicate that the phenomenon of sex in biological world seems to be much more dynamic (see interesting works by **Geodakian**. Indeed, sex phenomenon seems to emerge in the *challenging* dynamic environments and may be *not necessary* in other, different type of environments.

The possible origin of *sex phenomenon* may not be directly a matter of reproduction. Initially, and possibly in simple environments, the organisms had no at all the "sexual reproduction feature", a kind of generic "sex-free" or asexual organism. Yet, in the *constraints-driven* environment, for example, if food is limited, such a single organism cannot explore the environment effectively comparing with its potentially available "doubled configuration", an original organism dynamically divided (under the applied stress) into two *complementary* and autonomous "halves" each capable of independent exploring the environment for food or other resources. In other words, the challenging environment might force separation of an original species into 2 or more parts *beneficial* in the specific environment. In such a dynamic state the organism gets separated into standalone units when there is a need (and comes back into united state) and has much better chances to survive. This feature though is not forever. It is due to specifically constrained environment, and when the constraints get relaxed (or just gone), the feature may go as well. Another beneficial effect of such (temporal) separation is the possible *cross-fertilization* between the male/female species of different origin.

5.3 Sleep and its fundamental quantum mechanism

As a fundamental phenomenon, the excited states of an organism get populated in the presence of light (daylight) and/or other perturbing factors. There is a certain *threshold* of such excitation, and then the cell/organism stops to respond to the external factors. That can be interpreted as a sleep stage. After certain time, the *relaxation* processes are set up transforming the electronic excitation energy into other suitable (soft) degrees of freedom. When the relaxation is basically over, the cell/organism is ready again to respond ("wake up stage"). This mechanism is *universal* due to its fundamental nature, and so *any* living unit has the sleep stage as a fundamental necessity – possibly in different forms. At organism level, the sleep phenomenon may be thought of as a result of gradual excitation of higher electronic states by day-time activities. When a *saturation* occurs due to filling-in of available states, further excitation and thus responses are not possible any more, and the organism turns itself off from the environment. The excited states have much larger "radii of interaction" comparing with regular states. Due to enhanced interactions with neighboring structures and the environment, *dreams* may be evoked, sometimes with weird spatial, temporal and personal relationships due to highly active interactions. After internal relaxation, possibly via soft modes, the organism is back to normal state ready to respond to the environmental inputs.

5.4 Biogenetic law: ontology repeats (recapitulates) phylogeny

The ontogeny is the mother-controlled development/growth, whereas the phylogeny is the environment-controlled development/growth (K.-E. Baer). In the first case, the zygote is under intensive control from the mother. The growth is until the embryo complexity is comparable with the one of the mother. The internal "genetic" information is being integrated into the whole growth/development. Then, the external environment emerges as the control system for the developed organism (with an internal genetic input). However, the evolutionary development that covers 'long' time and many generations is an imaginable logical process normally interrupted by the ontogeny stages; so, the *direct* comparison between the single ontogenetic development and the multi-generation phylogenetic is hardly possible.

During the evolution, with its environmental challenges, the new/extra shells of the phylo-organism get built up making it more complex and better fitted to the environment. Yet, there is a mystery at the ontology stage - why it seemingly reproduces/repeats multi-generation "evolution" at an accelerated pace? One explanation is that the internal zygote development involves the same fundamental electronic shells/states which structurally resemble the phylogenetic stages/structures artificially combined into a single 'long' process considered as phylogenesis. From that artificial viewpoint, the recapitulation is an understandable thing: in both cases the same initial unit (zygote) is involved and the same fundamental stages/shells/structures get involved in the build-up.

The proposed model considers the development as "unfolding" process controlled by the *immediate* environment *and* by the "growing" core of the organism which begins with the minimal core/seed. The mechanism of transformation of external stimuli/signals into layers is universal and applicable to both internal (ontogeny) and external (phylogeny) growth. Thus, internal and external development actually follow the same mechanism and dynamics. Generally, in the development there is no a concept of an *organ* and generally an independent access to an organ (without violating its *dependencies*) is impossible. However, a *specific* input stimulus may link to the corresponding organism-wide *layer*, which does not coincide with a structurally separate organ. Each "layer" indeed has *projections* into all the other layers including the core. That associative link can be thought of as the "holophone" [Longuet-Higgins], a mechanism proposed to explain brain memory and its associative features. Later, the same concept has been extended and applied to the building of control systems ([B03], [Bykovsky])

5.5 Advanced organism dynamics: cell transformations in tissues/organisms

Like some crystals (such as iodine) may directly release (or attach) atoms or molecules avoiding a liquid state (sublimation), multicellular organisms may release (and/or attach) cells into environment. The difference though is that a cell undergoes de-differentiation and then re-differentiation in the new environment. For example, skin cells, e.g., in banana after pilling out, turn out to be in new environment (air) and undergo de-differentiation and then re-differentiation which may change drastically the cell behavior as well as its structure and functions. This phenomenon is essentially universal, so many soft tissues in vegetables and fruits undergo this transformation and in some cases may change into very different cells. Fruit flies may be an example of such cell transformation dynamics, detached cells redifferentiated in the new environment.

6. Conclusions

The proposed model introduces the level of in-depth understanding of organismic dynamics similar to the level of understanding of quantum dynamics of electrons in atoms and molecules. That level of understanding has created the advanced quantum technologies of 20th century - lasers, quantum standards, detectors and memory elements, optical and silicon technologies. So, there are some reasons to expect that in-depth understanding of electron structure and dynamics of cells and organisms would open new dimensions in the next-generation technologies of "organic" and mixed in-silico/organic components and structures.

We summarize our discussion and findings as follows:

- *Structure and dynamics* of cells/organisms is likely due to their electronic shells/layers, counterparts of atomic electron shells, transformed by the specific environment into highly specific shapes and forms
- *Integrity and stability* of cells and organisms is due to quantum nature of shells/layers
- *Growth* of organisms occurs by layers/shells in discrete manner. Each layer is a physical *link* between the environmental stimulus and the current state/core of the growing cell/organism
- Visible layers inside cell/organism cannot be accessed by their *location,* only by applying the proper stimulus, the one used when building the layer; in other words, a layer has projections into *all* other layers.
- *Genetic* info related basically to the *core* contributes into all the mentioned activities; however, it is only *a part* of the driving force, and the "seed" is not just DNA

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