About the recent findings of Michael Levin's group

February 1, 2024

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Abstract

It seems that the findings of Michael Levin's group are revolutionizing biology. The Darwinian vision of life as a struggle for existence is being replaced by life as survival based on cooperation, where conscious collective intelligence plays a key role. Control hierarchies are suggestive. The findings also challenge genetic determinism and suggest that membrane potential serves as a control tool of epigenesis during the embryonic stage. The findings suggest that life forms can be artificially created for various purposes: the applications in medicine can only be guessed at.

The most recent findings of Levin's group are highly interesting from the TGD point of view. The first finding is that it is possible to generate non-standard phenotypes also in the case of human cells, that structure implies function and there are only discrete number structures. Second finding is that the population of embryos behaves in an unexpected manner: the larger the number of embryos, the better the chances of embryos to recover from external harmful perturbations. One could argue that the communications between embryos based on Ca^{++} can explain this in terms of standard physics. A more radical view is that new quantum physics with long length scale quantum coherence is needed. This view would suggests the emergence of collective intelligence and consciousness.

Contents

1 Introduction

I watched a video discussing two articles just published in Nature (thanks to Marko Manninen for the links). Besides Michael Levin present was Gizem Gumuskaya from the team behind the

first article [I1] "Motile Living Biobots Self-Construct from Adult Human Somatic Progenitor Seed Cells". Also Angela Tung from the team behind the second article [I2] "Embryos assist morphogenesis of others through calcium and ATP signaling mechanisms in collective teratogen resistance" participated in the discussion.

It seems that the findings of Levin's group [I3, I4, I5] are really revolutionizing biology. The Darwinian vision of life as a struggle for existence is being replaced by life as survival based on cooperation, where conscious collective intelligence plays a key role. The findings suggest that life forms can be artificially created for various purposes: the applications in medicine can only be guessed at.

I have written a couple of articles [L1, L3, L7] about the observations of Levin's team. These ideas are emerging outside of biology as well: I have considered Gershing's vision of self-building machines from a TGD perspective in the article [L6].

A brief summary of the approach and findings of Levin's team [I3, I4, I5] is in order.

1.1 Epigenesis as means to produce new phenotypes

Instead of genetic engineering, epigenesis would serve as means to produce new phenotypes.

1. Epigenesis can produce completely different outcomes even though the genes are the same: genetic determinism must be given up. Electric fields of the cell membranes in the embryonic stage control epigenesis, but in the adult phase they no longer have an effect. Different phenotypes can be produced in a controlled manner. How epigenesis is realized under the control of electric fields is a mystery.

2. In the approach of Levin's team, there is no need to construct new genomes as in genetic engineering: the same end result, the phenotype, can be achieved with several genomes. Genetic determinism, i.e. the idea that the whole organism is encoded in genes, would be simply wrong. The protein-coding parts of the genes determine the protein level, but the phenotype would be determined by morphogenesis, which would be based on epigenesis.

   A fascinating question is how independent the phenotype actually is on the genome. This kind of independence would be analogous to the substrate independence of AI based consciousness. In TGD this would conform with the idea that the magnetic body (MB) is the boss and controls the biological body so that the genetic code would be basically a code used by communication and control signals.

3. Epigenesis means that the same basic genome can code for a wide variety of mRNA molecules, which in turn code for proteins: even an mRNA chain does not determine proteins unambiguously, but can be split into parts (slicing), some of which determine a protein. This makes cell differentiation possible, only a small fraction of the genes is expressed, just like only a small part of the modules of a word processing program are in active use.

   The realization of epigenesis relies on chemical modifications of DNA, such as DNA methylation and histone modification, which prevent normal gene transcription locally. Epigenetic expression can vary even on a time scale of hours. On the other hand, epigenetic modifications can be passed on to subsequent generations. What controls epigenesis is not understood. It is not even clear what epigenesis should include: should one just say that epigenetic is all that is not genetic. The notion of morphogenetic code emerges naturally.

1.2 Membrane potential as a new control level during embryonic stage

1. Already the earlier observations of Levin's team demonstrated that there is a completely new level of control that has been ignored before: the electric fields associated with the cell membrane, which are central to neuroscience but ignored in biology. Only the embryonic stage is sensitive to the effects of the electric fields so that these electric fields can control epigenesis only during this stage. The vision is that there is a multi-level control hierarchy above the genes that could extend even to the population level.

   For instance, in the case of frogs it is possible to induce dramatic modifications of the phenotype such as several heads or no head at all. These modifications are stable and inherited by the next generations.

2. This inspires the idea of creating life forms, biobots, but without applying genetic engineering. Only epigenesis is utilized and has been controlled by manipulating the electric fields of the cell membrane in different ways, for example chemically or using external electric and magnetic fields at the scale of the embryo.

1.3 From frog embryos to human cells and populations of embryos

Earlier simple life forms such as frog embryos were studied, but now human cells have been the target and the earlier observations are made also now.

1. In the past, xenobots were studied as artificial life forms built from frog cells. For example, cells taken from epithelial tissue can be used. The important thing is that the system is sensitive to the control of the electric field of the cell membrane only in the embryonic stage and the genetic expression stabilizes after that.

2. Now anthrobots [I1] have been studied as artificial life forms formed from human cells. The spheroid shape group of cells generated under normal conditions is transformed by external stimuli so that the usually inward-directed cilia point outward and the structure can move with their help. Embryo is turned inside-out.

3. The population formed by the embryos has also been studied [I2] and unexpected collective effects have been observed. The collective survives a perturbation better than a mere individual. The vision of vulgar Darwinism about life as a struggle for existence (to which also our materialistic view of society relies on) is simply wrong.

2 TGD view of the findings

Consider now a summary of what has been observed from the TGD perspective.

2.1 Structure determines function

It seems that at the level of the organism, the 3-D structure determines the function and that these functions are a discrete set in the studied situations. This is highly non-trivial but in line with the TGD vision, which differs from the standard physics in the sense that holography is realized at the space-time level.

3-D surfaces in $H = M^4 \times CP_2$ identified as a generalization of point-like particles of quantum field theories is the starting point of TGD. The 4-D spacetime surface is determined from the 3-D surface providing holographic data and is therefore analogous to the Bohr orbit. The almost deterministic Bohr orbit is analogous to the notion of function of biology, a genetic program determined the structure having 3-D holographic data as a counterpart. Quantum states are superpositions of these Bohr orbit-like space-time surfaces.

What distinguishes TGD from other quantum theories is that there is no path integral so that one avoids the usual divergences and classical physics becomes an exact part of the theory.

In particular, the fact that there seems to be a very small number of different structures and associated functions conforms with holography.

At the quantum level, biological functions are time evolutions that obey statistical determinism. What distinguishes biosystems from deterministic computers is that statistical determinism can be violated because quantum coherence in all scales is possible. Quantum coherence in time scales longer than say the EEG periods implies this violation. This is what makes matter alive. An interesting question is whether this violation can take place also for ordinary computers.

2.2 Cells behaviour depends on the size of the population

1. A surprising result of [I2] is that cells behave differently depending on the size of the population. Furthermore, cells, embryos, etc... are cooperative social beings helping each other to survive. For example, in a population, a single cell recovers from damages much better than a solitary cell. This happens only if the entire population has experienced the same perturbation. Cells survive better in a larger population and develop differently in them.

2. This strongly suggests the presence of collective consciousness and intelligence, which is much more than what is thought to be, for example, the swarm intelligence of AI systems. The magnetic body (MB) as a conscious entity could provide the TGD realization of collective intelligence and produce a hierarchy of levels of consciousness. The bigger the population, the larger the value h_{eff} as a measure of algebraic complexity and quantum coherence scale also at the level of the individual: this would explain why the increase in population size makes individuals smarter too.

3. When a single cell of the population is damaged, it generates a Ca^{++} wave that spreads to the environment and induces ATP production and Ca^{++} secretion. This involves the transfer of information, which makes it possible for the population to react as a coherent entity, a kind of life form. If the Ca^{++} wave or the generation of ATP is blocked, the embryos behave as if they were alone.

   Communication need not involve mere chemical signals, as the standard biology would predict. It is not understood how the mere presence of other individuals helps in the healing process.

4. What could be this unknown means of communication? This brings to mind the observations of Blackman and other pioneers: ELF radiation at the cyclotron frequency of Ca^{++} in the case of mammals affected both behavior and brain physiology. In the TGD framework, the generation of a Ca^{++} wave could correspond to the communication induced with the help of Ca^{++} ions to a certain layer of the system's magnetic body. Communication would take place at the cyclotron frequency and its multiples, which in Blackman's experiments was 15 Hz and would indicate the presence of an endogenous magnetic field of .2 Gauss, which is 2/5 of the nominal value of the Earth's magnetic field.

   Ca^{++} waves could act like neurotransmitters are believed to do, that is by activating communication lines from cells to the MB. The embryos would become a coherent unit through these connections. The MB would control the entire system. Quantum entanglement in the scale of MB would be present making the population a coherent unit: mere classical communications are not enough.

5. A nerve impulse would do the same between neurotransmitters. Here one should think critically about the previous TGD view of the role of nerve impulses. According to the TGD view of brain [L2], nerve pulses do not correspond to fundamental communications. Rather, neurotransmitters would simply connect the magnetic flux tubes associated with pre- and postsynaptic neurons to form one long channel along which dark photons with large h_{eff} would propagate from the sensory organs to the cortex and from cortex to the MB.

   A more general alternative would be that dark photons signals to the hierarchy of layers of the MB of the brain take place also from the activated neurons along the neural pathway and not only from the cortical neurons. The activated neurons, the neuronal pathway, would have a quantum coherent and quantum entangled entity at the level of MB and define an association chain at the level of conscious experience. Neuronal synchrony would relate closely to this quantum coherence.

2.3 Morphogenetic code

The proposed communications should involve a morphogenetic code, which is not understood.

1. TGD inspires the idea that the genetic code as a universal code defines also the morphogenetic code [L3, L4]. Dark codons of DNA, RNA,.. and their counterparts would be realized as dark proton triplets in various scales. Dark genes with N codons would correspond to 3N dark protons. Communications would rely on dark 3N-photons (N would correspond to the number of codons of gene) as analogs of bound states of 3N dark photons would realize the genetic code in the sense that that they would induce 3N-resonant transitions between dark genes as dark 3N-protons.

2. Also the communications between dark and ordinary information molecules would rely on the resonance mechanism. The idea that dark genes are mere copies of ordinary genes does not

look attractive. Actually, dark DNA, RNA, etc could be almost independent of their chemical variants and participate in quantum information processing not directly visible at the level of ordinary biomatter. Only in the communications with ordinary gene or its part, dark information molecules could transform to a state corresponding to the ordinary information molecule or its part.

3. The realization of the genetic code could be universal and could correspond to the so-called icosa tetrahedral tessellation of the hyperbolic 3-space and it would appear in all scales, not only in biology [L5].

2.4 Hierachy of collective intelligences

Levin proposes that collective intelligence is present in several scales. TGD predicts the existence of several scale hierarchies based on a new view of spacetime and a number-theoretic vision of TGD as dual to geometric vision.

I have built a model for the birth of language [K1] based on the observation that the appearance of a few crucial genes was crucial for the emergence of language. The proposal is that this meant the appearance of a layer of MB with a considerably larger h_{eff}. A collective level of consciousness on a much larger scale was born. Language would make possible the communication between individuals and promote the birth of these larger collectively conscious structures. Language in human society would have a role similar to that of Ca^{++} waves in the collective behavior of embryos [I2].

Somewhat surprisingly, Levin does not speak at all about the possible role of quantum theory in biology. I think it would be important to build a bridge from the observations of Levin's group to the models of quantum biology. The team's findings force us to take quantum coherence at long scales seriously.

Typically, theories of consciousness do not have much to say about this aspect. One reason, of course, is that standard quantum theory doesn't have much to say.

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