

Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part I

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Abstract

The quantum view about metabolism has developed in two stages. First came the somewhat unbalanced vision about the connection of quantum metabolism and bound state formation. The second breakthrough was the discovery of dark matter hierarchy and associated hierarchy of generalized EEGs.

1. *Quantum metabolism and bound state formation*

Topological self-referentiality states that the topological field quanta of the classical fields associated with a material system provide a concrete representation for a theory about the material system. Actually this principle generalizes and implies an entire hierarchy of representations. An important outcome of the topological self-referentiality is that the “buy-now” part of the buy now-pay later mechanism for energy production could be understood as a generation of bound states with binding energy liberated as a usable energy. “Pay later” means that sooner or later thermal noise destroys the bound state.

This observation led to a quantum vision about energy economy in living matter: generation of the macroscopic coherence involving also binding of mental images to larger ones and liberation of a usable energy are different sides of the same coin. Besides, or perhaps even instead, the ordinary metabolism, quantum metabolism should be key element of living matter. Indeed, also ordinary metabolism might be accompanied by the effective over-unity energy production implied by the generation of quantum bound state entanglement: this implies a connection with the claimed over unity phenomena. This should reflect experimentally as apparently miraculous ability of the organism to cope without the use of the metabolic energy. Anomalies of this kind have been indeed observed at the level of neuronal metabolism and nano-biology is just challenging the basic assumptions of the Newtonian biology.

This vision can be criticized for over-emphasizing the formation of bound states: also the transitions to bound states with lower energy, say transitions between cyclotron states, can generate metabolic energy.

2. *Dark matter hierarchy and quantum metabolism*

The new vision about me relies on several new ideas that have emerged during years after writing the first draft of this chapter.

1. There are three different views about macroscopic quantum phases. As large \hbar phases with scaled up quantum lengths, as high T_c superconductor like systems, and as negentropically entangled structures (negentropic entanglement is purely TGD based notion and stabilized by Negentropy Maximization Principle). In this chapter arguments supporting the equivalence of these descriptions are developed.
2. The valence electron pairs with spin 1 instead of spin 0 emerge as natural candidates for the counterparts of Cooper pairs generating negentropic entanglement in long length scales. Spin 1 valence electron pairs would generate the magnetic flux tubes along which they propagate and this web of flux tubes would bind proteins to larger structures. The role of the phase transitions changing the value of Planck constant in quantum biology has been discussed already earlier. The fact that bio-molecules - in particular sugars and phosphate molecules - tend to maximize the number of covalent bonds supports this view.
3. The completely accidental observation that dark nucleon states corresponds under rather natural assumptions to DNA, RNA, tRNA, and amino-acid states and that vertebrate genetic code emerges under natural assumptions, leads to the idea that the dark nuclear physics realization of the genetic machinery is its primary realization and that chemical realization is secondary realization. This suggest that dark nuclei identified as nuclear strings of dark protons serve as templates for DNA, RNA, and amino-acids.
4. This leads to the vision that the basic purpose of metabolic energy is to make possible re-distribution of negentropic entanglement between distant bio-molecules using the reconnection of the magnetic flux tubes generated by spin 1 electron pairs as a control tool. In photosynthesis the incoming photons would suffer a phase transition to dark photons before being absorbed by dark electrons and eventually provide their energy to ATP to be used to re-organize negentropic entanglement assignable to the magnetic flux tubes going via ATP molecule. This picture is inspired also by the vision about DNA as topological quantum computer and leads to a more plausible view about how genetic code is realized.

3. Many-sheeted photo-synthesis

Photosynthesis is a fundamental metabolic function and a many-sheeted model allows to concretize the general ideas about quantum metabolism. What happens in photosynthesis at the level of energy balance seems to be relatively well-understood but the detailed molecular mechanisms remain obscure. Several strange features, such as the appearance of electron pairs, suggest that super-conductivity and atomic and molecular Bose-Einstein condensates are involved. p-Adic length scale hypothesis gives very strong quantitative guidelines in the attempt to understand photosynthesis in many-sheeted space-time, and one ends up to a general view about how Bose-Einstein condensates store metabolic energy as zero point kinetic energy and how this energy is utilized by remote metabolism by generating negative energy MEs. What is so remarkable is that the resulting simple model of photosynthesis is successful both at qualitative and quantitative level.

I have included in this chapter the earlier variant of the quantum model developed before 2007 as such to compare it with the recent view about macroscopic quantum aspects of photosynthesis involving several new ideas. Note that year 2007 is special in the sense that during 2007 the first evidence for the quantal nature of photosynthesis emerged.

1 Introduction

TGD inspired theory of consciousness and the ideas about quantum control allow already now a rather detailed view about conscious brain. There are general theories for qualia, sensory representations, and quantum control based on many-sheeted ionic flow equilibrium. p-Adic space-time sheets serve as correlates for cognitive representations and recently adelic vision has allow to understand imagination in terms of p-adic pseudo constants [K24].

The role of metabolism for quantum consciousness has however remained poorly understood hitherto. There are also other white regions in the map. How motor control is realized: directly from brain level or from magnetic body as the computer sitting at its own terminal metaphor would suggest? And what is the deeper quantum meaning of neurotransmitters and hormones, and so called information molecules in general? If they were only inhibitors, excitators, and modulators, the organisms would not bother to construct so many different information molecules.

The quite recent steps of progress (I am writing this 2015) has finally allowed to a rather detailed answers to these questions.

Before continuing I wish to thank for many people for providing very important stimuli: in fact, the strange synchronies encourage me to think that we all might belong to a greater pattern gradually becoming self-conscious. I would like to mention Lian Sidorov for turning my attention to remote mental actions and bio-photons and for very stimulating discussions and questions. Also the contact by finnish new energy enthusiasts Juha Hartikka, Jukka Kinnunen and Tapio Tammi, came just in right time to allow to realize the connection with some new physics phenomena suggested by new energy technologies. The material sent for year or two ago by Gene Johnson related to brain metabolism turned also to be very invaluable. I do not know who I should thank for the existence of web: without the availability of information about practically anything between Earth and Heaven this kind of convergence of ideas would be completely out of question. Without the encouragement and financial support from Tommi Ullgren I could not have been able to continue my work.

1.1 Dark Matter Hierarchy, Sensory Representations, Motor Action, And Metabolism

Dark matter hierarchy forces a profound reconsideration of brain metabolism and allows to develop a detailed model for how magnetic bodies use biological bodies as sensory receptors and motor instruments [K13] leading among other things to a generalization of the notion of genome.

For ordinary quantum mechanics photons at EEG frequencies correspond to ridiculously small energies. Dark matter hierarchy is accompanied by a hierarchy of EEGs and its generalizations with the scalings of frequencies predicted to come in multiples of integer in the most general case. A strong hypothesis is that they come as powers $r = 2^{k_d}$, where the values of k_d are fixed by Mersenne hypothesis [K13].

The fact that arbitrarily small frequencies can correspond to energies above thermal threshold at higher levels of dark matter hierarchy implies that photons with arbitrarily low frequencies can have sizeable physical effects on matter. This conforms with the findings about the effects of ELF em fields on living matter [K13], and these effects allow to develop a rather detailed model for EEG and identify the parts of EEG correlating with communications of sensory data to the magnetic body and with quantum control performed by the magnetic body [K13].

The implication is that the transfer of energy between magnetic bodies and biological body could be major factor in metabolism. The question is whether the magnetic bodies provide metabolic energy for brain or utilize the metabolic energy provided by brain or both. Time mirror mechanism as a mechanism of intentional action would predict that magnetic body uses the metabolic resources of brain during intentional action. Together with the strange findings about ionic currents through cell membrane suggesting that ionic channels and pumps are actually ionic receptors and the ionic currents through them are only small samples about the net currents, this vision leads to a profoundly new view about brain metabolism. Dark matter hierarchy forces a profound reconsideration of brain metabolism and allows to develop a detailed model for how magnetic bodies use biological bodies as sensory receptors and motor instruments [K13] leading among other things to a generalization of the notion of genome.

The reduction of the hierarchy of Planck constants to a hierarchy of quantum criticalities was already mentioned and finally provides a great vision allowing to ask questions beginning with “Why”.

1.2 New Ideas

After the writing of the first version of this chapter for about decade ago several new ideas have emerged and the challenge is to unify these ideas.

1.2.1 Three different views about living matter as a macroscopic quantum system

There are three different views about how living system manages to be a macroscopic quantum system.

1. The first vision is based on various kinds of super-conductivities [K7]. Electronic super-conductivity is assigned with the cell membrane and plays a key role in the model of cell membrane as a Josephson junction. Furthermore, the effects of ELF em fields on vertebrate brain [K13] suggest that biologically important ions form macroscopic quantum states and cyclotron Bose-Einstein condensates of bosonic ions have been suggested. The TGD based view about atomic nuclei predicts exotic nuclei chemically equivalent with ordinary ones but being bosons rather than fermions. Also these exotic ions could also form cyclotron Bose-Einstein condensates. Large value of Planck constant would guarantee that cyclotron energies proportional to \hbar are above thermal energy.
2. A more precise view about hierarchy of Planck constants as an implication of the enormous vacuum degeneracy of Kähler action has emerged [K16]. According to this view non-standard values of Planck constant are only effective.

As the idea about the hierarchy of Planck constants emerged, I proposed that favored values of Planck constant could come as powers of 2^{11} . This was just a first guess inspired partially by the observation that the mass ratio of proton and electron is $940/.5 = 1880 \sim 2^{11}$. I managed to find indications supporting this hierarchy and also this chapter contains traces of this idea. I became later skeptic but one could actually imagine a mechanism implying this kind of hierarchy. Dark protons with say $r = \hbar/\hbar_0 = 1836 = 4 \times 3^3 \times 17$ would correspond to approximately same Compton length as ordinary electrons. It is natural to assign this value of \hbar also to electrons and this gives Compton length 44.6 Angstroms not far from the p-adic length scale $L(149) \simeq 50$ Angstroms assigned with the lipid layer of cell membrane. The condition that dark proton corresponds to this Compton length gives $r = 1836^2$: the electron Compton length comes now $8.1 \mu\text{m}$, which corresponds to cell size scale. One could continue the resulting hierarchy of Planck constants indefinitely.

3. The notion of negentropic entanglement making sense for rational and even algebraic entanglement probabilities has emerged as a possible characterizer of living matter [K22]. Quantum arithmetics [K36] allows to generalize the notion of rational so that p-adic real correspondence mediated by canonical identification is fixed uniquely and is both continuous and respects symmetries [K36]. One implication is an explanation for Shnoll effect [K3], which could be important also in living matter.

This raises several questions.

1. How high T_c super conductivity based on dark electron pairs and negentropic entanglement relate?
2. Could it be that electron pairs in valence bonds are the carriers of negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig.** 21 in the appendix of this book) and that they generate the magnetic flux tubes as parts of their magnetic bodies? This makes sense only if the valence electron pairs in living matter have spin 1. The Cooper pairs of high T_c super-conductors are indeed known to have spin 1 [?] If this view is correct, biological evolution would favor the maximization of covalent electron pairs and this indeed seems to be the case.
3. Why large \hbar would make possible negentropic entanglement or even force it? Is there some purely number theoretic reason for this?

The progress has occurred in several frontiers.

1.2.2 The most recent progress

The progress which has taken place during period 2014-2015 has led to a dramatic increase of understanding concerning ZEO [K37], NMP [K22], hierarchy of Planck constants and dark matter [K40], the notion of self [K24, K30], and p-adic physics as physics of cognition [K24].

1. Weak form of NMP [K22] and ZEO based view about state function reduction has led to the detailed identification of self as a sequence of state function reductions at same boundary of CD (Zeno effect) [K4, K34] and led to the identification of sensory-motor cycle and its generalizations as a kind of Karma's cycle in which subselves representing mental image die and re-incarnate as time reversals at the opposite boundary of corresponding CD. The death of sensory mental image means generation of motor mental image or vice versa. The predicted existence of time reversed mental images serves as a test for the theory [K24].
2. Hierarchy of Planck constants has been assigned with a hierarchy of quantum criticalities, and phase transitions increasing h_{eff} and negentropy take place spontaneously as self dies and re-incarnates as time reversed mental image in the first reduction to the opposite boundary of CD [K40, K22]. Although the death of self is like picking fruit from tree (NE is generated), selves do not want to die and in order to satisfy the demands of NMP must generate negentropy by refining their mental images by in their respective Karma's cycles. Conscious entities can also steal negentropic entanglement by eating other conscious entities. A more neutral manner to express is to talk about metabolism, which can be energy metabolism but also other kinds of metabolisms providing the system with negentropy. This view about metabolism emerged already earlier [K41] but only the precise formulation of the notion using ZEO, weak form of NMP, and the vision about hierarchy of quantum criticalities allowed the detailed understanding.

This framework allows even to consider answers to questions about origin of ethics and moral [K34].

3. Also the understanding of p-adic physics as physics as physics of cognition has developed dramatically with the advent of adelic vision about TGD in which all number fields appear democratically. Together with the understanding of strong form of holography stating that string world sheets and partonic 2-surfaces (briefly 2-surfaces) serve as space-time genes this leads to a beautiful view about how number theoretical universality is realized by algebraic

continuation of the 2-surfaces to space-time surfaces. One can even understand imagination in this framework: pure imagination not realizable in real world corresponds to collections of 2-surfaces continuable to p-adic space-time surface (pseudo constants make this possible) but not to real space-time surfaces.

1.2.3 Genetic code and dark nucleon states

New realization of the genetic code in terms of dark proton sequences identified as dark nucleons was discovered [L2, K19].

1. The states of dark proton are in natural one-one correspondence with DNA, RNA, tRNA, and amino-acids and vertebrate genetic code is realized in a natural manner. Dark nucleons realized DNA codons as entangled quark triplets. The effective chemical formula $H_{1.5}O$ for water in atto-second time scale supports this view [K12]. How the notion of dark nucleon relates to negentropic entanglement of electrons? Could dark electron pairs and dark nucleons correspond to the same value of Planck constant? Could both dark protons and dark electrons play a key role in metabolism.
2. The simplest guess is that DNA strands are accompanied by dark nuclei with one dark proton per DNA nucleotide. The resulting positive charged would stabilize the system by partially neutralizing the negative charge density due to the phosphorylation (2 negative charges per nucleotide). Dark proton sequences could be associated also with other important bio-polymers. If the spins of the dark protons are parallel the dipole magnetic fields give rise to flux tubes connecting the protons and one can assign to the large \hbar protons a macroscopically quantum coherent phase.
3. The natural guess would be that dark nucleus realization of the genetic code induces the biological realization as evolution assigns to dark nucleon sequences DNA, RNA, and amino-acid sequences with 1-1 correlation between dark nucleon state and basic unit of the sequence. The dark realization of genetic code suggest a totally new view about biological evolution as a process, which is analogous to R&D in high tech industry rather than being completely random [K19]. The candidates for new genes could be tested at dark matter level and in the case that they work they would be transcribed to their chemical equivalents.

1.2.4 New ideas related to metabolism

Also new ideas related to metabolism have emerged at the same time when evidence for quantal aspects of photosynthesis has been emerging [I43, I34, I33, I14].

1. Negentropic entanglement (NE) leads also to the idea about energy metabolism and negentropy transfer as different sides of the same coin. The model for DNA as topological in turn suggest that $ADP \rightarrow ATP$ and its reverse can be interpreted as a standardized reconnection process re-organizing connections between distant molecules connected by magnetic flux tubes by the relay defined by ATP molecule. Metabolic energy would - or at least could - go to the re-organization of the flux tube connections and therefore of the negentropic quantum entanglement. The question is how to fuse this vision with the hypothesis about metabolic currencies as differences of zero point kinetic energies for space-time sheets.
2. The radiation from Sun defines the fundamental metabolic currency. Solar radiation cannot be said to negentropic since negentropic entanglement is a 2-particle property. Solar photons could possess a large value of \hbar or - more plausibly - suffer at the magnetic body of the living system a phase transition increasing the value of \hbar . Could the absorption of large \hbar photons arriving from Sun or from magnetic body by electrons generate spin 1 valence electron pairs or provide the metabolic energy needed to re-arrange the flux tube connections between distant molecules by $ADP + P_i \rightarrow ATP$ process?

The identification of $h_{eff} = n \times h$ with gravitational Planck constant $\hbar_{gr} = GMm/v_0$, where v_0 has dimensions of velocity is highly attractive, and in the case of dark cyclotron radiation implies that the cyclotron frequency spectrum is universal and does not depend on the mass of the particle

with mass m . This suggests the identification of the ordinary photons resulting from these photons by h_{eff} changing phase transition as bio-photons with energy spectrum in visible and UV (and thus in the region of molecular transition frequencies) [K38]. This would provide for the magnetic body the fundamental control and communication mechanism and the long sought for connection with bio-chemistry. Quantum gravitational coherence would play fundamental role in living matter: not that the gravitational Compton lengths of particles are given by $\lambda_{gr} = GM/v_0$ and are universal.

The latest step of progress has been already mentioned. One can understand how the weak form of NMP forces metabolism as a manner for self to stay alive (something rather trivial to understand in the context of everyday life but far from trivial when one can explain it using only the concepts of physics, even allowing some new physics!). Also homeostasis can be seen as a collection of mechanisms making possible for self to stay at given level of quantum criticality: living systems are dancers on the rope!

Living systems need NE but in what form they get it? This is still poorly understood question.

1. NE could effectively reduce to single particle property and be between parts of nutrient molecules. The somewhat poorly understood high energy phosphate bond is a good candidate in this respect. Even elementary particles consisting of pairs of wormhole contacts connected by magnetic flux tube and strings could carry quite an impressive entanglement negentropy characterized by the p-adic prime labelling the particle. For instance, electron would carry almost 127 bits of entanglement negentropy [K24, K9]. For the neutrinos this negentropy would be even higher, and this forces to reconsider the old idea about cognitive neutrinos as carriers of information. For this option NE would be kind of information carrying substance.
2. NE could be between the particle (of nutrient molecule) and large gravitational dark mass M_D and assignable to the flux tubes connecting the particle with this dark mass and assignable to flux tubes connecting particle to the dark mass M_D . This leads to a beautiful model for bio-photons as dark cyclotron photons and predicts for them universal energy spectrum in the range of energies for molecular transitions.

This would make possible large $h_{eff} = h_{gr}$ [K41, K40]. One could even speak of dark gravitational Mother Gaia. For this option NE would be relationship to dark gravitational Mother Gaia and the transfer of NE would be transfer of the other end of flux tube contact to MG.

There are two separate anomalies in the solar system supporting the existence of a spherical layer consisting of dark mass and with radius equal to the distance of Moon from Earth [K31]. The first anomaly is so called Flyby anomaly and second one involves a periodic variation of both the value of the measured Newton's constant at the surface of Earth and of the length of the day. The period is about 6 years and TGD predicts it correctly.

3. Both options might well make sense but it is still an open question whether one should select between them or not. It might be also possible to transform long length scale NE to short scale NE by splitting from U-shaped flux tube pairs carrying long range NE short flux tube pairs by reconnection and carrying NE in short scale.

1.2.5 DNA as a topological quantum computer vision

The vision about DNA as topological quantum computer [K15] has turned out to be very general allowing to imagine several concrete realizations. The essential element is the coding of DNA nucleotides and one can imagine several options.

1. The original proposal for the realization of DNA as TQC is based on the representation of DNA nucleotides A, T, C, G as quarks u, d and their antiquarks and requires scaled up version of QCD [K15]. This idea looks rather outlandish but could be justified by the strange findings of mathematician Barbara Shipman about honeybee dance [A1] and also by the p-adic length scale hierarchy and the hierarchy of Planck constants suggesting scaled variants of QCD like physics also in the length scale range relevant to the living cell.
2. The question whether one could use spin 1 triplet and spin 0 singlet of dark electron pair instead of quarks and their antiquarks to represent codons, is rather obvious. The

problem is that $S = 0$ state for electron pair however gives rise to vanishing dipole field so that flux tube structure would not be possible. The generation of flux tube structure along which supra currents can flow is however an essential element of the proposed mechanism of super-conductivity.

3. DNA as topological quantum computer hypothesis lead to the hypothesis that it is O=: s to which one must assign the flux tube pair responsible for the representation of the genetic code. Why O= would be in special role? And why should one have a pair of flux tubes? Could this relate to the coding of nucleotides by electron pairs? If there are two parallel flux tubes, one obtains tensor product $3 \times 3 = 5 + 3 + 1$ of electron triplets at the ends of the flux tubes. Could it be that A, T, C, and G are represented in terms of 3 and 1 and that the breaking of rotational invariance implies mixing of singlet and $S_z = 0$ state of triplet so that nucleotides and their conjugates could correspond to the resulting two pairs related by reflection.
4. $ATP \rightarrow ADP + P_i$ would correspond to the reconnection of the flux tubes of the flux tube pair with hydrogen bonds associated with two water molecules. The flux tubes would split and end to water molecules containing valence electron pair so the negentropic entanglement might not be totally lost. The reverse process would create flux tube connection labelled by the spin state equivalent of A, T, C, or G.

1.2.6 What happens to the second law of thermodynamics?

The possibility of negentropic entanglement raises the question about the fate of the second law of thermodynamics. I have already earlier considered a maximally pessimistic generalization of second law but it now clear that it does not rest on a sound basis.

Apparently NMP states just the opposite of second law. This is not the case however since NMP is about entanglement negentropy and second law about ensemble entropy. It is however easy to imagine that the generation of NE in thermal ensemble breaks second law. This process however generates dark matter, and if one limits second law to processes in with permanent generation of dark matter does not occur, second law should hold true.

Concerning life second law and NMP are diametrical opposites of each other. In the world governed by second law alone life is thermodynamical fluctuation. In the world governed by NMP life is unavoidable since quantum criticality is reduced gradually but weak form of NMP allows the analogs of thermodynamical fluctuations in which negentropy does not increase. Weak form of NMP however allows also negentropy gains larger than those allowed by strong form of NMP.

1.3 Many-Sheeted Photosynthesis

Photosynthesis is a fundamental metabolic function and a many-sheeted model allows to concretize the general ideas about quantum metabolism. What happens in photosynthesis at the level of energy balance seems to be relatively well-understood [I38, I32] but the detailed molecular mechanisms remain obscure. Several strange features, such as the appearance of electron pairs, suggest that super-conductivity and atomic and molecular Bose-Einstein condensates are involved. p-Adic length scale hypothesis gives very strong quantitative guidelines in the attempt to understand photosynthesis in many-sheeted space-time, and one ends up to a general view about how Bose-Einstein condensates store metabolic energy as zero point kinetic energy and how this energy is utilized by remote metabolism by generating negative energy MEs. What is so remarkable is that the resulting simple model of photosynthesis is successful both at qualitative and quantitative level.

I have included in this chapter the earlier variant of the quantum model developed before 2007 as such to compare it with the recent view about macroscopic quantum aspects of photosynthesis involving several new ideas. Note that year 2007 is special in the sense that during 2007 the first evidence for the quantal nature of photosynthesis emerged. 2015 is the year of the most recent updating.imoleph

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at <http://tgdtheory.fi/tgdglossary.pdf> [L5].

2 General View About Sensory Representations, Motor Control, And Metabolism

The following summarizes the general after dark matter revolution vision about sensory representations, motor control, and brain metabolism.

2.1 General Vision About Living Matter As A Macroscopic Quantum System

The assumptions below summarize the general vision achieved before the dark matter revolution. The picture is consistent with the findings of Libet about strange time delays of consciousness [J5, J1] discussed in the article “Time, Space-time and Consciousness” in [L1] and chapter [K35].

1. Magnetic bodies forming a hierarchy are the fundamental volitional agents transforming intentions to actions. Intentions are represented by p-adic MEs transformed to negative energy MEs representing the desire about particular activity communicated to the lower level magnetic bodies in the geometric past and eventually to the material body. Each negative energy ME in the cascade represents a desire to realize some submodule in motor program. Eventually the cascade of negative energy MEs ends up to the glial cells serving as metabolic sources. The desired action is generated in terms of neural communications and of positive energy MEs both representing classical communications to the geometric future. The desire in question could be a desire to perform a particular motor action, a desire to direct attention or select among sensory percepts (binocular rivalry [K24] is the standard example), or a desire to remember something. Sensory perception, motor action, and memory would thus be based on essentially the same basic mechanism. The population inverted many-sheeted laser system providing the energy source in brain or body would consist of bosonic ions or of Cooper pairs of fermionic ions in excited cyclotron states.
2. Sensory representations are realized at the magnetic bodies associated with the sensory organs and sensory mental images are shared with the personal magnetic body by negative energy em MEs. Brain constructs only symbolic and cognitive representations, writes the sensory music to notes. The mental images defined by these representations can be shared by personal magnetic body or magnetic bodies associated with the sensory organs in a similar manner. Also classical communications to the personal magnetic body are possible. A tree like structure with the root represented by sensory mental images and branches and leaves represented by various symbolic and cognitive mental images results.

The selective entanglement by negative energy MEs allows to understand the active aspects of sensory experience involving direction of attention and selection between percepts at various levels. In the case of motor actions, the negative energy MEs received from magnetic body communicate the desires of the magnetic bodies about motor actions to be performed and the response by positive energy MEs would realize these desires as nerve pulse patterns.

3. Positive energy interior MEs lie along interior of magnetic flux tubes of the personal magnetic body. These MEs could relate to the classical communication of the symbolic representations constructed from the data processed in the brain to the magnetic body. Sensory perception and memory differ only is that the time scale involved is different. Declarative memory corresponds to negative energy MEs sent from a point of the personal magnetic body at the distance $L = cT$ to the material body and reflected back as positive energy MEs. Thus the material body serves as the mirror unlike in the original variant of the mirror mechanism of memory. The distance $L = cT$ along magnetic flux proportional to the transverse area S of the flux tube $L \propto S$ tubes codes for the temporal distance to the geometric past by transforming it to cyclotron frequency scale.

2.2 A General View About Quantum Control, Coordination And Communication Inspired By Dark Matter Hierarchy

The general vision about motor action is roughly the following. The dark matter hierarchy with levels labelled by the increasing values of Planck constant defines a hierarchy of intentional agents.

The original vision was that intentions are realized as p-adic space-time sheets transformed to real ones as intention is transformed to desire.

This view have been modified since the phase transition between different number fields is not a mathematically sound notion, and it is better to talk about imagination. The starting point is strong holography allowing to continue string world sheets and partonic 2-surfaces parametrized by numbers in an algebraic extension of rationals (briefly 2-surfaces) to space-time surfaces and code the physics using the data at the 2-surfaces. Algebraic universality is achieved by algebraic continuation to various number fields.

Pure imagination as non-realizable imagination corresponds to 2-surfaces continuable to p-adic space-time surfaces (p-adic pseudo constants) but not allowing a continuation to real space-time surface. In state function reduction to the opposite boundary of CD state function reduction selects the 2-surfaces, which allow a continuation to real space-time surfaces. This corresponds to a realization of intention as action. During state function reduction sequences at the same boundary super position of 2-surfaces receive contributions, which can correspond also to pure imagination. One could perhaps interpret this as a development of intentions. Sensory perception and motor action are time reversals of each other.

Negative energy MEs serving as space-time correlates for dark photons and also dark variants weak bosons and gluons are good candidates for the representations of these desires. A natural guess is that the desires are communicated from given level of dark matter to the next level below it and ultimately the level of ordinary matter represented by the biological body is reached and the signal induces various neural and other activities realizing the desired motor actions. Each level has a lot of freedom to decide about the details of that part of motor action for which it is responsible.

Motor action is an iterative top-down process, a gradual build-up of a four-dimensional space-time statue representing the motor action starting from a rough sketch and adding gradually the details. This view is consistent with how we experience motor control: what happens is that we decide to move hand, rather than initiating consciously some complex neuronal activity in brain leading to the raising of the hand. We need not know how the motor action happens in order to initiate it.

The control signals from the magnetic body must enter to structures with high connectivity and very probably be very simple and symbolic. A reference wave generating complex hologram would be an over-simplified example about an initiator of a complex control action proceeding gradually to the lower levels of hierarchy by similar simple signals. Of course, some linguistic structure based on, say, amplitude modulation is required to avoid interference of the undesired signals with the bio-control. Various gap junction connected structures are a good guess for the relay stations the control commands from the magnetic bodies. Thus gap junction connected neuron groups, astrocytes, and the walls of arteries and perhaps even capillaries are good candidates for receivers at the level of brain. At the level of body various organs, epithelial tissues, walls of arteries, and also skin could be the mediators of the generalized motor actions during sleep.

2.2.1 Dark matter hierarchy and motor control

The following general overview about quantum communication and control emerges from the model for EEG hierarchy as correlate for dark matter hierarchy discussed in detail in [K13], and from the implications of the model of DNA as topological quantum computer [K15, K17, K2]. Consider first general assumptions about how motor actions would be controlled from magnetic body.

1. Massless extremals (MEs, topological light rays) serve as correlates for coherent states and Bose-Einstein condensates of dark bosons. Neutral massless extremals could be responsible for signals related to control, coordination and communication. Also charged and colored MEs are predicted but their role has not yet been firmly established. Negative energy MEs would be related to motor control and positive energy MEs to communication of sensory data. Zero energy ontology, which has become the cornerstone of quantum TGD [K11, K10], justifies the notion of negative energy ME.
2. Magnetic body has an onion like hierarchical structure and its layers receive sensory information from biological body and perform motor control. The matter at the layers of magnetic body corresponds to the value of Planck constant which is so large that cyclotron energies

are above thermal energy. A fractal hierarchy of analogs of EEG is involved with these communications. The frequencies involved correspond to harmonics of cyclotron frequencies for biologically important ions and to differences and sums of these with Josephson frequencies associated with Josephson junctions defined by the magnetic flux tubes carrying dark supra currents. Magnetic flux tube refers in the following to ordinary or “wormhole” magnetic flux tube since it is not yet clear which of them of these options if not both are realized [K15]. Flux tubes bind the biological molecules to a weblike structure and are responsible for the macroscopic quantum coherence of living matter.

3. Negative energy control signals from the magnetic body initiate topological quantum computation like processes whose outcome is expressed as four-dimensional self-organization patterns relying basically on gene transcription inducing motor responses in a very general sense. It is also possible that the outcome is expressed as an electromagnetic signal generated by intronic portion of the DNA representing a call of TQC subprogram. The experimental work of Peter Gariaev suggests that polarization coding of DNA sequences is involved with the sub-program calls and TGD provides a model for how this could take place [K15].
4. Harmonics of cyclotron frequencies relate to the control of the biological body by the magnetic body and could be assigned with the magnetic flux sheets going through DNA since it is genome where protein synthesis is initiated and is thus the optimal intermediate step in the cellular control. Differences and sums of harmonics of cyclotron frequencies and Josephson frequencies would be involved with communication of sensory data.
5. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. A good guess is that in this case magnetic flux quanta are hollow cylindrical structures parallel to the cell membrane associated proteins serving as Josephson junctions. Also magnetic flux tubes parallel to axon serving as as templates for axons could define communication lines connecting cell membranes to the cellular magnetic body. Also synaptic contacts should involve similar magnetic flux quanta connecting them to neuronal magnetic body.
6. In DNA as topological quantum computer vision magnetic flux tubes as carriers of supra currents of dark variants of charged particles and connecting cell interior and exterior define braid strands. The quantum phase transitions changing the value of Planck constant and thus length of flux tubes would be fundamental building element bio-control in the scale of biological body and involved with both bio-catalysis and higher biological functions at nanoscale (molecular motors) and in the scale of cells and organs.
7. This picture would explain why the temperature of brain must be in the narrow range 36-37 K to guarantee optimal functionality of the organism [K13]. If interior superconductivity is lost, magnetic body receives sensory data but is paralyzed since its desires cannot be realized. If boundary superconductivity is lost, magnetic body can move but is blind.

There are also additional hypothesis which are natural in TGD framework but whose necessity is not yet clear.

1. In the length scales below the weak length scale L_w also charged weak bosons behave as massless particles and the exchange of virtual W bosons makes in principle possible a non-local charge transfer. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei can become charged via the emission of dark W boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy.
2. Besides neutral massless extremals (MEs) TGD predicts also charged MEs obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). W ME would represent an exchange of virtual W boson giving rise to em current. Charged massless extremals could be seen as correlates for non-local quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color

charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K18]. The exchange of W bosons appears in an active role in TGD inspired model [L2], [L2] of cold fusion, biofusion [C1], and plasma electrolysis [D3]. The exchange of exotic W : s between nuclei would give rise to exotic nuclei. For instance, chemically equivalent bosonic counterparts of biological important fermionic ions such as Na^+ , K^+ , Cl^- could be generated and could form Bose-Einstein cyclotron condensates at magnetic flux tubes. Whether biologically important ions can have exotic nuclei having mass number differing from expected could be easily tested.

3. The second non-local quantum control mechanism relies on em charge entanglement. Charge entanglement could involve a superposition of pairs ordinary ions/atoms and exotic ions connected by a W massless extremal joining magnetic body and biological body. In quantum jump this state would be reduced to exotic charge state with some probability increasing with the strength of the classical W field. The successful proposal for the protein folding code relying on the assumption that wobble base pairing corresponds to charge entanglement between quark and antiquark (superposition of uu_c and dd_c pairs forming a pion like state) at the ends of the magnetic flux tube connecting tRNA with $N - H$ group of amino-acid backbone [K2].
4. These non-local quantal mechanisms can induce or change electromagnetic polarization in turn inducing ordinary charge flows and in this manner make possible quantum control of nervous system by magnetic body. The generation of nerve pulse could rely on the spontaneous state function reduction occurring for charge entangled state reducing the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior and inducing voltage pulse generating DC supra current [K27]. Also remote mental interactions, in particular telekinesis, might rely on this mechanism. Of course, the interactions between magnetic body and biological body are essentially remote mental interactions.

In the introduction the latest progress in relating hierarchy of Planck constants to a hierarchy of quantum criticalities has been mentioned [K42, K40] and its biological meaning was discussed.

2.2.2 What conditions the sensory projectors to the magnetic body must satisfy?

General constraints for a rather detailed and testable models for the hierarchy of sensory canvases (magnetic bodies) and for the system projecting sensory data to it. An especially important new element is the model for the generation of ELF MEs acting as sensory projectors.

The projectors to the sensory canvas should satisfy several constraints.

1. Sensory projectors should correspond to magnetic flux quantum structures (tubes or sheets). The magnetic flux tube structures would be to those of Earth's magnetic field plus possibly those generated by the magnetic structures and would have fixed directions by anchoring to the large scale Earth's magnetic field.
2. Projectors must be able to bind neurally represented features to the point of the sensory canvas they project. Binding would be achieved the magnetic flux quanta traverse through synaptic contacts of a larger number of firing neurons.
3. There must exist a fixed frame of reference which does not rotate when head or body rotates or moves in the scale of magnetic body much larger than the corresponding body part. The directions of Earth's magnetic and gravitational fields fix naturally this kind of reference frame. Red blood cells and pyramidal cells are magnetic structures and define naturally compass needles allowing to construct sensory representation providing information about the orientation and configuration of the body with respect to this preferred coordinate frame.
4. The fundamental exterior-interior division of the sensory experience to the bodily sensations and percepts about external world or body as seen by external observer should correspond to fundamentally different sensory representations. Blood-brain barrier is an excellent candidate for the representation of this separation at the level of brain. Neuronal consciousness

would represent outsider's cognitive view about the external world and body whereas blood consciousness would represent insider's view about body.

Astrocytes define the analog of a skeleton for neurons having endfeet to the synaptic contacts and might play key role in the binding. Hence astrocytes might act as higher level sensory organs integrating the sensory input of synchronously firing neuron groups. The myelination of axons by oligodendrites is usually regarded merely as an insulation allowing to achieve rapid neuronal communications through long distances. Myelin sheaths could also serve as sensory receptors scanning for nerve pulse activity along axon.

2.2.3 Communications and energy transfer at cellular level

The communication and energy transfer at cellular level could rely on Bose-Einstein condensed and coherent photons at the lowest level of dark matter hierarchy. MEs defining single sheeted covering of M^4 with lengths given by typical distance between red blood cells and ordinary cells would define the space-time correlates for these photons. The wavelength range involved would cover visible wave lengths so that the identification as bio-photons [K6], [I41] might make sense.

At higher levels of the dark matter hierarchy MEs would have $r = \hbar/\hbar_0 = 2^{k_a}$ if Mersenne hypothesis holds true. Each of them would carry the energy $E = \hbar_0\omega$ of a visible photon, so that the relationship $E_k = \hbar(k)\omega = r\hbar_0\omega$ would have a space-time correlate. Their decay to ordinary photons by de-coherence would produce r ordinary photons. This would make possible coherent liberation of large amounts of energy and momentum.

Besides chemical signalling genuine quantum communication based on bound state entanglement between red blood cell colony and neurons can be considered. Charged entanglement induced by W MEs is one option and state function reduction of this entanglement inducing deviation from charge equilibrium could induce Ca^{++} waves just as it would induce nerve pulses. The blood cell colony, the activated synchronically firing group of neurons, and astrocytes could entangle to form single quantum system and communication would be a cellular variant of telepathy. The entanglement of the blood cells with the synchronically firing neuron groups could be crucial for the assignment of features represented by neuron groups to the points of the magnetic sensory canvases.

Charged entanglement between magnetic body of some gland and corresponding hormones carried by blood flow represents a possible example of quantum communications. Hormone would be like an old fashioned postman but the letters would contain quantum links to the quantum web. Nerve pulse transmission would be a more modern communication method involving electronic transfer along axons: postman mechanism would be realized only at synaptic contacts. Quantum links could ultimately refer to the primary sensory input at the level of sensory organs so that sensory input would be associated with cognitive mental images produced by the neural activity. Besides carrying the quantum links, neural transmitters would induce neuronal chemical qualia at the synapse.

2.2.4 Emergence of symbols at molecular level and new view about hydrogen bond, water, and bio-catalysts

The hierarchy of dark matter leads to novel ideas about what distinguishes living matter from ordinary matter. The emergence of symbols and symbolic dynamics and what might be called "molecular sex" could be a fundamental step in the process and I have considered two visions for how this would take place.

1. First vision

First vision is relies on the model of DNA as TQC based on braids and has quite close contact with empirical reality [K5, K15, K17]. In this case DNA nucleotides are analogous to colors of braid strands and base pairing corresponds to molecular sex for DNA molecules. The color of braid strand implies long ranged highly selective interactions between DNA and distant molecules, such as lipids of the lipid layer of cell membrane or amino-acids. Free amino-acids inherit the colors of the first two nucleotides in the codon XYZ whereas the color of the third nucleotide corresponds to a quantum superposition of colors for codons coding for the amino-acid: this defines the quantum counterpart of wobble base pairing. Amino-acids can be divided into amino-acids and their conjugates analogous to opposite sexes and generalized base pairing determines the

interactions of the amino-acids to a high degree. Hydrogen bond can be identified as a special case of flux tube. There are also flux tubes connecting acceptors of hydrogen bonds acting as plugs in the connection lines formed by the magnetic flux tubes and Y corresponds to this kind of plug at the level of amino-acids.

In the recent conceptual framework The molecular sex could indeed interpreted as pairing of n space-time sheet of two n -fold coverings which are singular in the sense that the sheets co-incide at the ends of CD. This brings in n discrete degrees of freedom and these degrees of freedom would be central in living matter and give rise to symbolic dynamics almost independent of the material substrate. The n -sheets would be associated with magnetic flux tubes.

One of the implications is a proposal for a code for protein folding [K2]. In the light of afterthought this proposal looks involves possibly un-necessarily strong assumptions - such as the identification of flux tubes in terms of hydrogen bonds - and it would be better to just talk about n -sheeted magnetic flux tubes as basic correlates of attention and avoid too detailed identifications. There is no absolute need to reduce these new degrees of freedom to ordinary biochemistry or vice versa.

With this reservations in mind let us summarize the model.

1. Hydrogen bonds play a key role in bio-catalysis but are not understood completely satisfactorily in the standard chemistry. Hence the basic question is whether hydrogen bonds can be regarded as or are accompanied by short (wormhole) magnetic flux tubes: note that the subject-object asymmetry of directed attention would correspond to donor-acceptor asymmetry of they hydrogen bond. If this is the case, the identification of the magnetic flux tube connection as a generalized hydrogen bond becomes natural. At least the atoms able to form hydrogen bonds could form flux tube contacts so that the model would be very predictive and would conform with the known important role of hydrogen bonds in bio-catalysis.
2. The fact that hydrogen bonds connect base pairs suggests a generalization of the notion of base pairing stating that under some conditions amino-acids coded by XYZ and UY_cV can behave like base pairs. These amino-acic pairs correspond to pairs of amino-acid residues which are hydrophilic *resp.* hydrophobic and hydrophobic residue do not form hydrogen bonds in general. These flux tubes would thus be more general and in general long. The model for DNA as topological quantum computer requires this kind of flux tubes and they would in general connect atoms or molecules which act as acceptors in hydrogen bonding: O = atom in amino-acid and aromatic ring are basic examples.
3. If one assumes that both $N-H$ and $O =$ associated with the constant part of the amino-acid can act as flux tube terminals and represent Z and Y nucleotides of the codon XYZ coding for the amino-acid, one obtains $Y = Z$ pairing of $O = -O =$ flux tubes are allowed and $Y = Z_c$ pairing if only hydrogen bond like pairings are allowed. Direct check shows that $Y = Z$ pairing is surprisingly successful.

The phase transitions changing Planck constant change the length of flux tube and these phase transitions could be a main tool of bio-catalysis. The contraction of flux tubes connecting biomolecules brings them near to each other and this explains why they are able to find each other in miraculous manner (see **Fig.** <http://tgdtheory.fi/appfigures/fluxtubedynamics.jpg> or **Fig. ??** in the appendix of this book). Also a detailed understanding about DNA as topological quantum computer emerges [K15]: the acceptors of hydrogen bond (aromatic rings, $O =$ atoms, ...) serve as fundamental plugs at which flux tubes terminate and continue further. Also a direct connection with the basic metabolic process $ATP \rightarrow ADP + P_i$ emerges: this process can be identified as temporary splitting of the flux tube implied by the reconnection process between the flux tube connection the $O =$ atoms of second and third phosphate of ATP and hydrogen bond connecting two water molecule. Flux tube connections would also provide an explanation for the properties of gel phase in cell interior and the phase transitions changing Planck constant would induce the phase transitions of gel phase (say gel-sol transition) [K27] suggested to be a basic mechanism behind various biological functions in molecular and cell scale [I44].

2. Second vision

The mathematical realization for the hierarchy of Planck constants leads to a generalization of the notion of imbedding space and this leads to four kinds of phases resulting as combinations of

phases with increased or reduced unit of spin and quantum numbers associated with CP_2 degrees of freedom. Each phase corresponds to its own Planck constant and is characterized by a discrete symmetry group.

Especially interesting are phases with a maximal value of Planck constant involving charge fractionization and increase of spin unit. The free electron pairs of aromatic cycle are reasonable candidates for dark electrons of this kind. This means that one can consider variants of hydrogen atom with a fractional electron charge and the obvious idea is that the values of fractional charge would define “names” and their “conjugate names”. Thermal stability poses strong constraints since atomic and molecular energy scales are reduced as Planck constant increases.

The notion of fractional electron inspires the notion of “half” hydrogen bond for which electron has a fractionized fermion number. The full hydrogen bond would be formed in the fusion of half hydrogen bonds and give rise to a structure analogous to a full electron shell expected to be especially stable. Catalyst sites might correspond to half hydrogen bonds and the basic recognition mechanism could be the fusion of half bond and its conjugate to form a full hydrogen bond. One could speak about “molecular sex”. The sequences of half bonds would represent words so that molecules would have names. Also interpretation as quantum computer codes might make sense.

The problem of this vision is the lack of direct contact with experimental facts and for this reason it will not be discussed in the sequel.

2.3 Some Mechanisms Liberating Metabolic Energy And Connection With Free Energy Phenomena

In this section possible mechanism liberating metabolic energy are discussed. All these mechanisms can be combined with time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig. ??** in the appendix of this book).

It must be admitted that the recent view about the real purpose of metabolism is as negentropy transfer and it is not clear whether a liberation of energy necessarily accompanies the process. I do not understand well enough the relationship of NMP with second law to be able to answer this question. It seems that when the generation of dark matter is allowed, second law ceases to hold.

Certainly the feed of negentropic entanglement is accompanied by that of dark energy and if this dark energy is transformed by living matter to ordinary energy with standard value of Planck constant, entropy is produced very effectively. The reduction of the length of magnetic flux tube is one of the basic processes taking place at molecular length scales and corresponds to a reduction of h_{eff} being therefore dissipative so that the ordered energy is transformed to non-ordered form. The dissipation would be basically due to the fact that living systems at all levels of the hierarchy do their best to stay at their level of criticality since the phase transition increasing h_{eff} means death of the self.

2.3.1 Some mechanisms liberating metabolic energy

In the earlier approach metabolism as liberation of ordered energy assumed to carry information was in a central role. In the recent view this essentially thermodynamical approach is replaced by that inspired by NMP: metabolism is seen basically transform of negentropic entanglement (NE). I have already discussed briefly the options for how the nature of transferred NE (either short distance NE or long distance NE).

Several mechanisms liberating metabolic energy are possible and very probably many of them are important.

1. The dropping of ions from space-time sheet to a larger one liberates energy. The liberated energy is essentially the difference of the zero point kinetic energies associated with the space-time sheets. Zero point kinetic energy derives from Uncertainty Principle: the smaller the box where particle is forced to move, the higher the momentum uncertainty and the larger the zero point kinetic energy.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to

the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

2. The ion dropped to a magnetic flux tube can have very high cyclotron energy gradually dissipated as ELF MEs when the ion drops from the cyclotron state with magnetic quantum number $n \simeq f_h/f_{ELF} \gg 1$ by a stepwise process $n \rightarrow n - 1 \rightarrow n - 2 \dots$ to the ground state. The energy liberated in this process can be utilized by magnetic bodies at various levels of dark matter hierarchy. The mechanism is emission of negative energy dark photons inducing a coherent dropping of ions to lower cyclotron states. Magnetic bodies could share a considerable portion of metabolic energy used in brain.
3. A variant of this mechanism involves dropping of a photon BE condensed at ME parallel to a linear structure and having a frequency which is multiple of f_h to a magnetic flux tube transversal to the linear structure and its absorption by a super-conducting ion. Also this mechanism generates ELF MEs with a fixed f_h/f_{ELF} ratio for a given ion at the super-conducting magnetic flux tube.

2.3.2 Liberation of metabolic energy via the formation of bound states

The formation of bound states liberates also energy. At the level of conscious experience the formation of bound states corresponds to a fusion of mental images to higher level mental images and a loss of consciousness at the level of fusing selves. Sharing of mental images corresponds to fusion of sub-selves of two unentangled selves to single sub-self. The sharing of mental images is allowed only by the TGD based definition of subsystem relying on the notion of length scale resolution. For instance, the fusion of left and right visual fields to single visual field would give rise to stereo vision in this manner.

Binding energy could be liberated as coherent photons at some level of the dark matter hierarchy and utilized for metabolic purposes. The beautiful aspect of this mechanism is that the liberation of metabolic energy is accompanied by the generation of higher level mental images, and the higher the amount of energy liberated, the longer lasting the mental image is. The value of Planck constant is even more important since the de-coherence time is expected to be proportional to \hbar .

1. Gravitational binding energies for blocks of water in the biologically most interesting length scale range $L(151) = 10 \text{ nm} - L(167) = 2.5 \text{ } \mu\text{m}$ correspond to frequencies in ELF range. The immense spin glass degeneracy implied by space-time surfaces differing only by classical gravitational energy encourages to think that the generation of gravitationally bound states generates ELF MEs. The objection is that the energy of one ELF ME is quite too low and that one needs large number of ELF MEs to achieve statistical reliability for the sensory representations.
2. The role of the metabolism in the generation of the bound state entanglement suggests that the natural energy scale is in the range of molecular and atomic binding energies. Bound state energies are typically measured in electron volts from the bond energy of hydrogen bond. At DNA level the generation of hydrogen bonds correlate gives rise to generation of projector MEs. If so, hydrogen bonds connecting blood and cellular liquid to cluster would be responsible for the generation of the hydrogen bonds. This is consistent with the idea that water liquid crystals amplify and represent. There is however no obvious mechanism for the generation of ELF MEs.
3. The formation of water clusters is also a good candidate for the mechanism generating bound states and could play crucial role in the metabolism. The binding energy .485 eV of hydrogen bond which is very near to the energy associated with the p-adic length scale $L(163)$ is expected to define the length of ME generated in this process. This process could be especially important at DNA level.

2.3.3 Liberation of zero point kinetic energy in dropping of ions to larger space-time sheets as a source of metabolic energy

In TGD the simplest manner to liberate usable energy is the dropping of ions from the atomic space-time sheets to super conducting space-time sheets. Since the difference of the zero point kinetic energies is inversely proportional to the mass of the ion, proton is optimal in this respect. The energy liberated when the proton drops from the atomic space-time sheet to much larger space-time sheet is about $3\pi^2/2m_p a^2 \simeq .4932$ eV for $a = L(137) = L(151)/128 = .78$ Angstrom and very near to the metabolic energy liberated when single ATP molecule is utilized. This energy is also amazingly near to the energy $E = 2\pi/L(163) = .4921$ eV defined by the p-adic length scale $L(163)$ defining one of the miracle length scales associated with Gaussian Mersennes. With the scaling $L(151) = 10$ nm $\rightarrow xL(151)$, $x = 1.002$, allowed by experimental uncertainties these energies are identical.

The dropping of the protons from the atomic to the super-conducting space-time sheets explains also the strange findings of Irving Langmuir [D2] and the over unity energy production in water hydrolysis (also involved with the utilization of ATP!). In the generation of single ATP molecule 3 protons are accelerated in the electric field generated by the liberation of the metabolic energy. These observations do not leave much freedom of choice: the flow of protons between super-conducting and atomic space-time sheets is the basic mechanism of the energy economy in the living matter: energy is liberated when the proton drops to the atomic space-time sheet and the charging of the energy batteries means that the protons are kicked back to the atomic space-time sheets.

Fractality suggests that also other ionic flows define similar cycles in smaller energy scales and ATP cycle takes only care of the most roughest energy metabolism. For instance, the dropping of Ca^{++} ion would give rise to energy of in various biologically important ions would liberate energy of about .01 eV if proton liberates energy of .5 eV. The corresponding photon wave length is about 100 microns. The excitation of high n cyclotron states is possible also now and the generation of ELF MEs at multiples of cyclotron frequencies could give rise to sensory representations and contribute to EEG.

2.3.4 Connection with free energy anomalies

1. Anomalies discovered by Langmuir

The first class of anomalies is known more than a century and were discovered by the nobel chemist Irving Langmuir [D2] while developing the first electric lamps based on electrode consisting of tungsten wires. Langmuir made three discoveries which have been forgotten since then, perhaps because they are very difficult to understand in the framework of existing chemistry.

1. The first observation was that the heating of tungsten wire in vacuum to get rid of the gas inside it liberated practically unlimited amount of gas. Langmuir stopped the process when an amount of gas equivalent with 7000 volumes of tungsten wire had been evaporated. The question Langmuir posed himself was "Where this gas comes". I do not know whether Langmuir found any satisfactory answer but a very attractive possibility is that the heating allows the transfer of gas ions from super-conducting magnetic flux tubes to the atomic space-time sheets. This would indeed imply that the tungsten wire could act as effectively endless source of gas.
2. The second observation of Langmuir was that the energy liberated in the electrolysis of water to hydrogen and oxygen in presence of electric current in electric voltage in Volt range liberated energy which was by a factor of order 10^3 higher than the energy deduced from the binding energy of the hydrogen molecule. This suggests strongly that the electrolysis somehow generated bound states and that binding energy was liberated. The simplest explanation would be the dropping of ions to the magnetic flux tubes by a process in which they emit the difference of zero point kinetic energies for initial space-time sheet and magnetic flux tube as the kinetic energy as a photon emitted in the process. The energy could also be liberated when the magnetic field penetrates to matter, say metal, implying that the hydrogen atoms

collide with the atoms of the metal. The basic function of the electric voltage and electron current in this process would be the splitting of the bonds binding hydrogen to the water.

One can consider also the possibility that the binding of the hydrogen atoms to hydrogen molecules did not occur as two-particle process but involved the formation of water clusters and the liberation the binding energy.

Similar process might be involved with the generation of ATP which involves acceleration of hydrogen ions in membrane potential. Therefore the energy liberated in generation of ATP would be many orders of magnitude higher than expected and could give rise to generation of bound states as well as generation of MEs projecting to the sensory magnetic canvas.

3. The third strange observation of Langmuir was that the heat conductivity of the hydrogen gas created in the lamp was anomalously high. This could be understood if the hydrogen atoms or ion propagating along magnetic flux tubes during the conduction of the gas hydrogen ions liberated their energy when the magnetic field penetrated to a target material forcing hydrogen atoms to collide with the atoms of the material.

2. Strange properties of Brown's gas

There is also a connection with the strange properties of the so called Brown's gas discovered by Prof. Yul Brown [J7]. Brown's gas results in the electrolysis of water using electric current running between oppositely charged plates in a voltage which is below 1.7 V. What is believed to occur is the electrolysis of water to oxygen and hydrogen atoms. The flame of hydrogen resulting in the electrolysis appears to have low temperature. When the flame is directed to a metal, it melts and one of the applications is welding of metals. The temperature of the metal remains the melting temperature during the melting. The process involves a liberation of energies which are several times higher than expected on basic of the binding energy of hydrogen atoms to oxygen and the electric power fed to the system.

The TGD based explanation would be that hydrogen atoms and/or ions drop at larger space-time sheets such as magnetic flux tubes of Earth and get additional kinetic energy as the increment of the zero point kinetic energy resulting from the localization inside space-time sheet. The estimates for the molecular weight of Brown's gas are consistent with the molecular weight of H_2O but also with the atomic weight of oxygen in a good approximation. If Earth's magnetic field penetrates to the atomic space-time sheets of the metal, then the hydrogen atoms flowing along magnetic flux tubes enter to the atomic space-time sheet of metal and collisions with the atoms of metal lattice occur and heat it and induce a phase transition leading to the melting of the metal. The liberation of the zero point kinetic energy means effective over-unity energy production in case that the ions at the magnetic flux tubes interact with a matter with the binding energy being liberated. If this interpretation is correct, living matter would construct the sensory representations using the same mechanism that explains the strange properties of Brown's gas.

3. Biefeld-Brown effect

Also Biefeld-Brown effect allows explanation as a recoil effect in many-sheeted space-time. For long time ago T. T. Brown observed [H1, H2, H3] that when capacitor plates are loaded with opposite charges by coupling the capacitor to a voltage source, it jumps to the direction of the second plate. The magnitude of the effect depends on the voltage and begins to decrease above some critical voltage and eventually changes its sign. What is strange is that neither energy nor momentum conservation do not seem to hold true if one assumes that only electric energy is liberated: momentum and energy simply seem to appear from nowhere.

The explanation is in terms of a recoil effect in many-sheeted space-time. When the voltage is coupled on, the ions with opposite charges rush to the capacitor plates. By their inertia some of them leak to larger space-time sheets (the mechanism of auroras and breakdown of superconductivity is essentially the same [K8]). The difference of the binding energies is liberated as additional kinetic energy and momentum of the dropped ion and the recoil momentum is obtained from the elementary text book formulas $E_f = E_i + \Delta E$, $E = p^2/2m$ as

$$\Delta p = -p_i \left(\sqrt{1 + \frac{\Delta E}{E_i}} - 1 \right) ,$$

where ΔE denotes the difference in zero point kinetic energies for a charged particle of mass m and subscripts i and f refer to initial and final states of the charged particle. These recoil momenta are absorbed by the entire system and give rise to a recoil effect if the recoil momenta from the plates do not exactly compensate each other. This is not expected to happen since the positive and negative charge carriers have widely different momenta due to the widely different masses and different velocities.

For definiteness assume that there are only electrons and ions of single type; that they drop to single space-time sheet only; and that capacitor plates have opposite charges during loading so that ionic and electronic currents are of opposite sign at the capacitor plates during loading. Under these assumptions the ratio of the momenta is

$$\frac{p_i(e)}{p_i(I)} = \frac{m_e n_I}{m_I n_e} ,$$

where $n(e)$ ($n(I)$) refers to the density of the electrons (ions). Combining this with the previous equation, one has

$$\frac{\Delta p(e)}{\Delta p(I)} = - \frac{m_e n_I}{m_I n_e} \frac{\left(\sqrt{1 + \frac{\Delta E(e)}{E_i(e)}} - 1 \right)}{\left(\sqrt{1 + \frac{\Delta E(I)}{E_i(I)}} - 1 \right)} .$$

When several ions are present, one must construct a more elaborate model. Also an effect tending to change the mutual distance of the plates is predicted.

The effect is proportional to the charge of the capacitor plate and thus to the voltage but depends on voltage in nonlinear manner. since the recoil momenta due to electrons and ions depend on non-linear manner on voltage. The change of the sign of the effect when voltage increases should be due to the fact that the velocities gained by ions and electrons depend on the voltage in different manners. The electronic band structure of the conductor could play an important role in the effect.

This mechanism is obviously ideal mechanism of locomotion in living matter and it would be surprising if bio-systems would not have invented it.

2.4 The Challenges Posed By The New Ideas

After writing the first draft of this chapter for more than decade ago several new insights and ideas have emerged. Therefore I decided to try to fuse these new ideas with the older vision. This required re-organization of the entire chapter and I was also forced to split it into two parts separating the stuff strictly related to metabolism. As usual there was also some obsolete stuff related to assumptions which in hindsight look ad hoc. Few years after writing this section I realized that many fresh ideas have emerged and it seems that also this section needs updating.

2.4.1 Unification of different views about how living matter is macroscopic quantum system

The identification of dark matter realized a hierarchy of phases labeled by the value of Planck constant [K16], the idea that negentropic entanglement possible for algebraic entanglement probabilities characterizes living matter [K22], and living matter as super-conductor [K7] are three separate ideas of TGD inspired theory of quantum biology and it now seems possible to unify these ideas.

1. The view about hierarchy of Planck constants has simplified considerably. One can speak about effective value of Planck constant and identify the integer characterizing the number of sheets of the local covering of imbedding space allowing a convenient description for the fact that the correspondence between canonical momentum densities and generalized velocities defined as time derivatives of the imbedding space coordinates is one-to-many.

In fact, it seems that the time derivatives in the interiors can have this kind of multi-valued relationship to canonical momentum densities. The space-time surfaces would be multi-branched and could be seen as surfaces in the covering space of the imbedding space. The space-like 3-surfaces at the ends of space-time sheets, at light-like boundaries of CD and the

light-like 3-surfaces at which the signature of the induced metric changes would be analogous to the points at which a cut of analytic function begins: origin for \sqrt{z} is the simplest example about this. The branching of the space-time surfaces would take place at these 3-surfaces. The branching would be n_1 -fold at space-like 3-surfaces for each branch emerging in n_2 -fold branching at light-like 3-surfaces. At partonic 2-surfaces $n = n_1 n_2$ branches of the space-time sheet would degenerate to single one. That the branchings occur at two kinds of 3-surfaces corresponds to the effective 2-dimensionality forced by strong form of holography in turn forced by the strong form of general coordinate invariance.

This brings strongly in mind stacks of branes and one can expect similar mathematical structures such as appearance of dynamical gauge group $U(n)$ having interpretation in terms of finite measurement resolution and characterizing inclusion of hyper-finite factors of type II_1 with included factor defining analogs of local gauge transformations generating states equivalent within measurement resolution.

2. The idea about living matter as something residing in the intersection of real and p-adic worlds - intersection of matter and cognition- is very powerful [K24, K22]. One implication is the notion of negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) possible for rational or quantum rational [K36] entanglement probabilities (and also entanglement coefficients but in larger algebraic extension). Negentropic entanglement is not generic but is favored and stabilized by NMP. The natural idea is that negentropic entanglement at molecular level distinguishes between living and inanimate matter.

Also bound state entanglement is stable under NMP but in general entropic. Negentropic entanglement can be however stable even when binding energy is formally negative. The natural crazy idea is that so called high energy phosphate bond formally corresponds to negative binding energy and carries entanglement negentropy. This leads to the idea that energy metabolism is basically about transfer of conscious information or quantum communication meaning re-arrangement of the magnetic flux tubes connecting distance molecules serving as a correlate and a pre-requisite for negentropic entanglement.

What could be the carriers of the negentropic entanglement in living matter?

1. The first guess is that they are electrons of electron pair with a vanishing spin. The geometric size of an electron pair assignable to a valence bond cannot however scale like \hbar . One can however assign the large value of \hbar to the magnetic body of the electron pair. The larger the value of \hbar , the larger the magnetic body. Support for the fundamental role of electrons in biology comes from the observation that the time scale associated with electron's CD is .1 second and corresponds to the fundamental biorhythm [K13].
2. Another key hypothesis is that electronic super-conductivity [K7] is a key aspect of living matter and this suggests that the electron pairs associated with covalent bonds and having large \hbar are responsible for this super-conductivity and that negentropic entanglement characterizes large \hbar phase. This suggests a connection between several ideas: dark matter hierarchy as hierarchy of Planck constants, bio-systems as super-conductors, negentropic entanglement characterizer of living matter, and metabolism as transfer of negentropic entanglement in some sense.

This looks nice but one encounters a difficulty. For ordinary atoms the spin of electron pair in the valence bond however vanishes so that also the dipole contribution to the magnetic field of the pair vanishes. This does not favor the idea about electrons pairs forming a Bose-Einstein condensate connected by flux tubes to a larger structure.

1. Could one assume that dark valence electrons pair to form $S = 1$ states in living matter so that the resulting magnetic field would be dipole field in the lowest order and the flux tubes would naturally connect electron pairs in the direction of the flux tubes to larger quantum coherent structures and one would obtain super-conductor? This idea is not so unrealistic as it looks first since spin 1 states are indeed assumed in the model of high T_c super-conductivity. These states couple to orbital angular momentum $L = 1$ to form $J=2$ Cooper pairs [K7].

Electronic Cooper pairs at valence bonds could generate the magnetic body. The flux tubes of the magnetic body would in turn bind the proteins to quantum coherent larger scale structures. By their small mass as measured in the protein mass scale electron pairs would obey a very swift dynamics whereas the the much slower dynamics of proteins would be determined by the electromagnetic forces due to them. Electronic super-conducting phases could control the protein dynamics in the sense that quantum jumps for the macroscopic quantum state of super-conducting electrons would induce large scale conformational changes.

2. The second guess is based on the idea that the electron pairs form a super-conductor like macroscopic quantum phase made possible by the overlap of the wave functions for large values of \hbar . Negentropic entanglement could be between the members of electron pairs and between the pairs themselves. The latter option make possible quantum communications involving entanglement between distance biomolecules at the ends of the magnetic flux tubes connecting them. This clearly favors bio-molecules possessing maximal number of electron pairs since the density of electron pairs is maximized in this manner.
3. Especially important transformations would be the phase transitions reducing or increasing \hbar . They would induce the scaling of flux tube lengths and compression or extension of the protein system such as cytosol [K5].
4. Suppose that electrons with dark magnetic flux tubes with size scale of Compton length proportional to \hbar and having negentropic entanglement characterize bio-molecules but not the molecules of inanimate matter for which electron pairs at valence bonds have vanishing spin. In this framework metabolic energy could help to generate negentropic entanglement or make possible the re-organization of the negentropic entanglement using $ADP + P_i \rightarrow ATP$ process as a manner to reconnect the magnetic flux tubes serving as correlates for this entanglement. The latter option looks more plausible. The ageing of the organism could basically mean a loss of negentropic entanglement implied by the loss of spin 1 electron pairs associated with the valence bonds.
5. The photons of sun-light should arrive along magnetic flux tubes with large value of Planck constant. They could leave Sun as large \hbar photons or transform to such in Earth's magnetosphere. The latter option is more plausible. The simplest option is that they provide the dark metabolic energy needed to manipulate the negentropic entanglement between bio-molecules.

If this view is on the correct track, biological evolution would tend to maximize the number of negentropic covalent electron pairs and simple checks show that basic biomolecules indeed tend to maximize this number and phosphates crucial for metabolism are especially negentropic. Also the idea about peptides as information molecules conforms with the idea about electron pairs as carriers of negentropic entanglement. Peptides are also molecules of emotion and this suggests that the large \hbar negentropic entanglement is crucial for understanding emotions. One can naturally assign positive emotions to the generation of negentropic entanglement and negative emotions to its loss.

2.4.2 Generalization of second law and living systems

In TGD Universe the generalization of negentropic entanglement is possible and forced by NMP [K22]. Does this mean that second law is lost? One can argue that this is not the case and experimental evidence supports this view. For a given CD the entanglement can be negentropic below the time scale characterizing it. Above this time scale ensemble description is necessary and second law holds true and is basically due to the non-determinism of quantum jump just as it is for the ordinary entanglement. Years after writing the above lines I must add an important restriction: second law holds if matter is not transformed to dark matter permanently during process considered.

Perhaps it was conformism which led to a proposal what I called pessimistic view. A more pessimistic view is that the generation of negentropic entanglement is accompanied by generation of a compensating entropic entanglement somewhere else. Few years later this idea looks ad hoc.

One could say that living matter would differ from inanimate matter in that it has discovered dump pit. One can try to formulate this conjecture more precisely and try to identify the mechanism generating the entropic entanglement.

1. If the end products of biological processing are molecules characterized by the ordinary value of Planck constant, the entanglement assignable with them - in particular covalent electron pairs - is entropic. One could interpret the transformation of negentropic electronic entanglement to entropic one as a realization of the strong form of Second Law. In photosynthesis involving photons from Sun would induce a phase transition increasing the Planck constant for the pairs and making them negentropic again. Biological death would mean the transformation of spin 1 negentropic electron pairs to ordinary spin 0 entropic electron pairs. The basic difference between bio-chemistry and ordinary one would be the presence of these spin 1 pairs of electrons.
2. One can also consider the possibility that also the end products of metabolism have non-standard value of Planck constant and that only the bio-molecules containing un-paired electrons-that is free radicals (see <http://tinyurl.com/5p5jan>) [I15] such as O_2 are entropic. Free radicals are known to cause damage to DNA and believe to be responsible for degenerative diseases, cancer, and senescence. The reason is that they are very reactive and reaction induce formation of electron pairs. This would induce transformation of large \hbar electron pairs in living matter to ordinary electrons pairs with the unpaired electrons of free radical and would tend to reduce the negentropy. This might happen in cell respiration believed to produce CO_2 and H_2O as “wastes”. The attribute “waste” would apply naturally if the valence electron pairs are ordinary ones for CO_2 and H_2O . One can however imagine also the transformation of these electrons to electron pairs with larg \hbar in chemical reactions so that the situation remains unclear.
3. One can also wonder what is the Planck constant the valence electron pairs of the ordinary water. Could it be large and could the water resulting as the end product of metabolism have ordinary value of Planck constant?

2.4.3 Realizations of the genetic code

TGD suggests several realizations of the genetic code [K19, K33, K1, K44]. This would conform with what we know about information society in which there is a proliferation of codes basically due to the fact that the basic feature of computers is that they are able to emulate each other and with the fact that living matter is basically information processor.

1. I discovered one new realization of the genetic code by accident as I constructed a model for dark proton and observed that the states of dark proton are in one-one correspondence with the DNA, RNA, tRNA, and amino-acids [K19, L2]. DNA sequences would correspond to dark nuclei realizes as strings formed from dark proton sequences. They would be accompanied by magnetic flux tubes generated the magnetic fields of dark protons if their spins are along the flux tube direction. The observation that water obeys the effective chemical formula $H_{1.5}$ in atto-second time scale suggests that 1/4 of protons of water are dark [K12].
2. The vision about DNA as topological quantum computer is very general [K15]. The essential element is the coding of DNA nucleotides and one can imagine several options. One realization is based on the representation of DNA nucleotides A, T, C, G as quarks u, d and their antiquarks and requires scaled up version of QCD. If quark pairs are unavoidable, one must understand how the correspondence of A, T, C, G with quarks and antiquarks emerges.

Second option would be use spin 1 triplet and spin 0 singlet formed from two dark electron pairs with mixing of singlet and $S_z = 0$ state of triplet. The pair of electron pairs would be assigned to a pair of magnetic flux tubes emanating from $O =$. This option would allow unification of DNA as topological quantum computer conjecture with the conjectures about dark high T_c super-conductivity and negentropic entanglement. Now one should understand the coding of A, T, C, G by the pairs of electron pairs. Basically one should understand two correspondences: the correspondence of dark protons with DNA, RNA, tRNA, and amino-acids inducing genetic code and the correspondence of pairs of electron pairs with these.

3. One can also imagine codes based on field patterns and dynamical realizations of the genetic codes [K19, K33, K1, K44].

4. During 2014 I developed a model of music harmony and genetic code [K26] predicting a realization of genetic codes using 3-chords which can be assigned with the 20 triangles at the surface of icosahedron and 4 triangles at the surface of tetrahedron. The harmony is characterized by a Hamiltonian cycle at icosahedron representing 12 notes of the 12-note scale. The model predicts standard genetic code and its modification corresponding to icosahedron and tetrahedron, which are either disjoint or glued together along a common triable. In the new code to 2 additional amino-acids appear. It is known that standard code is not quite unique (wobble phenomenon), and the predicted two codes might be assigned to the two strands of DNA: maybe they could be seen as different dialects of language.

At the level of magnetic body there would be 256 different bio-harmonies, whose interpretation as molecular moods might make sense. The realization of the bioharmony could be in terms of 3-chord sequences represented as sound or dark photons. The natural definition of harmony could be as a condition that the subsequent DNAs/amino-acids correspond to chords which are o nearest neighbors as triangles at the surface of icosahedron. It is relatively easy to code random chord sequences using MIDI language and they sound rather harmonious.

2.4.4 Flux tubes and DNA

The model of DNA as topological quantum computer gives useful guide lines in the attempt to form a vision about flux tubes. It was assumed that braid strands defined by “wormhole magnetic” flux tubes join nucleotides to lipids and can continue through the nuclear or cell membrane but are split during TQC. The hydrophilic ends of lipids attach to water molecules and self-organization patterns for the water flow in gel phase induce a 2-D flow in the lipid layer which is liquid crystal defining TQC programs at the classical level as braidings. The flow indeed induces braiding if one assumes that during topological computation the connection through the cell membrane is split and reconnected after the halting of TQC.

The challenge is to understand microscopically how the flux tube joins DNA nucleotide to the phospholipid [I30]. Certainly the points at which the flux tubes attach should be completely standard plugs and the formation of polypeptide bonds is an excellent guide line here. Recall that phospholipid, the TQC dancer, has two hydrophobic legs and head. Each leg has at the hydrophilic end $O=C-O-C$ part joining it to glyceride connected to monophosphate group in turn connected to a hydrophilic residue R. The most often appearing residues are serine, inositol, ethanolamine, and choline. Only three of these appear in large quantities and there is asymmetry between cell exterior and interior.

1. *Are the flux tubes beginning from $O=$: s special?*

Let us denote by $= O_1$ and $= O_2$ the two oxygens (maybe analogs of right and left hemispheres!) in question.

1. The proposal is that DNA nucleotide and $= O_1$ are connected by a flux tube: the asymmetry between right and left lipid legs should determine which of the legs is “left leg” and which $O =$ is the “left brain hemisphere”. $= O_2$, the “holistic right brain hemisphere”, connects in turn to the flux tube coming from the other symmetrically situated $= O_2$ at the outer surface of the second lipid layer. Besides this $= O_1$ and $= O_2$ are connected by a flux tube serving as switch on both sides of the membrane.
2. During TQC the short $O = -O =$ flux tube would experience reconnection with a flux tube acting as hydrogen bond between water molecules so that the connection is split and $O =$: s form hydrogen bonds. The reversal of this reconnection creates the connection again and halts the computation. The lipid residue R couples with the flow of the liquid in gel phase. Since $= O$ is in question the quark or antiquark or a pair of electron pairs at the end can correspond to the DNA nucleotide in question. The necessary complete correlation between quark and antiquark charges at the ends of flux tubes associated with $= O_1$ and $= O_2$ might be understood as being due to the minimization of Coulomb interaction energy. In the case of pair of electron pairs the correlation could come from the minimization of the magnetic energy.

3. If one is ready to accept magnetic flux tubes between all acceptors then the aromatic rings of nucleotides known to be acceptors could be connected by a flux tube to the $O =$ atom of the lipid or to some intermediate $O =$ atom. The phosphate groups associated with nucleotides of DNA strand contain also $= O$, which could act as a plug to which the flux tube from the nucleotide is attached. The detailed charge structure of the aromatic ring(s) should determine the quark-nucleotide correspondence. The connection line to the lipid could involve several intermediate $O =$ plugs and the first plug in the series would be the $O =$ atom of the monophosphate of the nucleotide.

There is a strong temptation to assume that subset of XYP molecules, $X = A, G, T, C$, $Y = M, D, T$ act as standard plugs with X and phosphates connected by flux tubes to a string. This would make it possible to engineer braid strands from standard pieces connected by standard plugs. DNA nucleotide XMP would have flux tube connection to the aromatic ring of X and the $O =$ of last P would be connected to next plug of the communication line. If so, a close connection with metabolism and topological quantum computation would emerge.

1. Phosphorylation [I31] would be an absolutely essential for both metabolism and buildup of connection lines acting as braid strands. Phosphorylation is indeed known to be the basic step activating enzymes. In eukaryotes the phosphorylation takes place amino-acids most often for ser but also thr, and trp with aromatic rings are phosphorylated. Mitochondrions have specialized to produce ATP in oxidative phosphorylation from ADP and photosynthesis produces ATP. All these activities could be seen as a production of standard plugs for braid strands making possible directed attention and quantum information processing at molecular level.
2. As already noticed, $O = -O =$ flux tubes could also act as switches inducing a shortcut of the flux tube connection by reconnecting with a hydrogen bond connecting two water molecules. This is an essential step in the model for how DNA acts as topological quantum computer. De-phosphorylation might be standard manner to realize this process.
3. This picture would fit with the fact that XYP molecules, in particular AMP, ADP, and ATP, appear in bio-molecules involved with varying functions such as signalling, control, and metabolism. $= O$ might act as a universal plug to which flux tubes from electronegative atoms of information molecules can attach their flux tubes. This would also provide a concrete realization of the idea that information molecules (neurotransmitters, hormones) are analogous to links in Internet [K27]: they would not represent the information but establish a communication channel. The magnetic flux tube associated with the information molecule would connect it to another cell and by the join to $= O$ plug having flux tube to another cell, say to its nucleus, would create a communication or control channel.

2. DNA as topological quantum computer hypothesis and electronic super-conductivity

The vision about DNA as topological quantum computer is very general. The essential element is the coding of DNA nucleotides and one can imagine several options.

1. One realization is based on the representation of DNA nucleotides A, T, C, G as quarks u , d and their antiquarks and requires scaled up version of QCD. The motivation for this realization came from the observation of Barbara Shipman that the mathematical description of honeybee dance suggests that quarks play a role in living matter [A1].
2. Second option that one can imagine would use spin 1 triplet and spin 0 singlet of dark electron pair. Spin 0 state for electron pair however gives rise to vanishing dipole field so that flux tube structure would not be possible. Can one circumvent this option or are quark pairs unavoidable?
3. DNA as TQC lead to the hypothesis that it is $O=$ to which one must assign the flux tube pair responsible for the representation of the genetic code. Why $O=$ would be in special role?

- (a) If there are two parallel flux tubes, one obtains tensor product $3 \times 3 = 5+3+1$ of electron triplets at the ends of the flux tubes. Could it be that A, T, C, and G are represented in terms of 3 and 1 and the breaking of rotational invariance implies a mixing of singlet and spin 0 state of triplet so that nucleotides and their conjugates could correspond to the resulting two pairs related by reflection?

One can however argue that for $S_z = 0$ states the direction of the magnetic flux tubes is orthogonal to that in other cases. An alternative possibility is that one uses only the four $S_z \neq 0$ states of spin 2 5-multiplet obtained in the tensor product. The breaking of the full rotational symmetry down to $SO(2)$ symmetry around flux tube direction could be used to justify this option.

- (b) The coding would be also consistent with quantum classical correspondence since it would reduce at classical level to a coding in terms of directions of magnetic fields in the two flux tubes: the directions could be parallel and in two directions or antiparallel giving also two options: four altogether. Notice however that one must be able to distinguish between two different configurations in which the directions of magnetic flux are opposite for the flux tubes of the pair. Classically this is achieved if the flux tubes form either a right-handed or left-handed double helix. Double helix could also resolve the problem posed by the fact that in $S_z = 0$ case the flux tubes cannot be parallel to their common axis at the flux tube end.
- (c) This option would allow a unification of DNA as topological quantum computer conjecture with the conjectures about dark high T_c super-conductivity and negentropic entanglement.

$ATP \rightarrow ADP + P_i$ would correspond to the fusion of flux tube pair with two hydrogen bonds associated with water molecules so what they could become short-circuited with water molecules. The reverse process would create flux tube connection labelled by the spin state equivalent of A, T, C, or G. The possibility of 5-plet allows also to consider the possibility of five codons instead of four.

Whatever the correct option is it must explain how the correspondence between A, T, C, G and secondary codons emerges.

1. If the pairs of spin triplet electron pairs appear in the correspondence, one must understand why the spin state of the pair of electron pairs at the O= of the phosphate attached with the DNA nucleotide correlates with the character of the nucleotide. Phosphate has also two O⁻: s containing two electron pairs. Minimization of the magnetic energy is the explanation which is easiest to imagine. Maybe the total magnetic energy of the pair in the magnetic field of the flux tube structure assignable to the nucleotide plus the de-oxyribose preceding it. T and C contain also O= but not A and G. and A and T and C and G are conjugates.

By studying the chemical structure of DNA (see <http://tinyurl.com/yd7b7w98>) [I40] one finds that the pairs AT and CG contain two O=: s which belong either to same nucleotide (to T in A-T) or to different nucleotides (C-G). This suggests the coding in which there are flux tube pairs connecting the two phosphate O=s at the two sides of the double strand and going through the two intermediation O=s. The rule would be that the spin states are conjugates at the ends of the flux tubes. A-T and T-A pairs could correspond to parallel flux tubes with same direction of the flux and G-C and C-G to parallel flux tubes with opposite directions of the magnetic fluxes.

2. If quark pairs are unavoidable, the correspondence of A, T, C, G with quarks and antiquark must relate to quark charges coming as $\pm 2/3, \pm 1/3$. Also in this case the coding mechanism based on the flux tubes connecting O=: s is natural.

The conclusion would be that the original view about secondary realization of genetic code can be replaced with the realization based on spin 1 dark Cooper pairs of electrons between which the entanglement is negentropic. Quark color plays no special role in the model of DNA as topological quantum computer [K15] so that the model remains as such. One implication would be however that the magnetic flux tubes carrying dark electron pairs at their ends could be of astrophysical size.

2.4.5 Challenges

This picture raises challenges. For instance, one should be able to answer the following questions.

1. The basic idea is that the differences of vacuum energies for electrons and protons or their Cooper pairs define fundamental metabolic currencies quantized by p-adic length scale hypothesis. The $ADP \rightarrow ATP$ should thus involve kicking of an electron or proton pair of both to a smaller space-time sheet and its reverse its dropping so that metabolic energy is liberated.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

The challenge is to relate the proposed transfer of electrons and protons between space-time sheets with different p-adic length scale to the proposed general vision. How the short-cut of the flux tube pair gives to two hydrogen bonds in $ATP \rightarrow ADP + P_i$ gives rise to a dropping of electron pair to a larger space-time sheet. At which end this dropping takes place? At the valence bond of water molecule? Could also proton drop? One can say that the electron pair binds ADP and P_i together. Could the dropping cause the splitting of the valence bond?

One could consider instead of dropping a process in which the bond length and thickness is scaled up by a power of two so that zero point kinetic energy is scaled down. This kind of scaling would occur in a process scaling \hbar for flux tubes but this process would not change the energy. If the length of bond is scaled up this process magnetic energy is not affect but cyclotron energy is scaled down since B would scale like $1/\hbar^2$ and cyclotron energy $\hbar B/m$ like $1/\hbar$. The increase of \hbar would liberate cyclotron energy as photons.

2. The sending of negative energy dark photon (phase conjugate photon) to the geometric past as a basic aspect of metabolism should be also understood in detail. How the absorption of the negative energy photon induces the dropping of the electron pair to a larger space-time sheet? How this dropping appears in $ATP \rightarrow ADP + P_i$. Does it destroy the high energy phosphate bond between P_i and ADP. Is it possible to get energy without the mediation of ATP just by sending negative energy photons?
3. One should understand metabolism in terms of dark nucleons and dark electron pairs. 4 protons and 4 electrons involved with the basic step. At the other side of the mitochondrial membrane protons are fused with oxygen to form water molecules and this induces a transfer of protons through the membrane from the other side liberating chemical energy making possible $ADP + P_i \rightarrow ATP$. Again one can make questions.

Could the four protons be dark? Could they form two Cooper pairs or a dark nucleus consisting of four protons? Could also proton Cooper pairs with spin 1 give rise to magnetic flux tubes and protonic super-conductivity or super-fluidity? Are proton spins parallel and along a flux tube associated with dark nucleus? Could also DNA and proteins as polymers involve magnetic flux tubes formed by a sequence of charged particles with spins parallel to the flux tube generating the magnetic field giving rise to the flux tube. This would give a net angular momentum to the flux tube. Could it be that this angular momentum is compensated by a rotational motion and generation of flux tubes generates rotational motion by angular momentum conservation?

3 General Vision About Metabolism

3.1 About Metabolism In General

I summarize the basic facts about blood circulation and red blood cells in the hope of helping the non-biologist reader to get overall view. I hope that the non-professional style of the representation and the unavoidable in-accuracies do not irritate biologists. I introduce also some strange findings and propose how quantum view could allow to understand them.

3.1.1 Cellular respiration

Mitochondria act as power plants of the animal cell. Mitochondria are coded by their own DNA and the DNA is inherited from mother and thus not copied in cloning. If mitochondria contribute to consciousness, as one might suspect, then clones do not experience the world in a similar manner.

ATP is the universal energy currency and TGD based model for ATP generation will be discussed later. Suffice it to say that the energy is transferred to ADP by phosphorylating it in the presence of a suitable ATPase enzyme which usually also catalyzes the transfer of the phosphate molecule from ATP to the client molecule.

Cellular respiration is the basic metabolic process in animals whereas in plants photosynthesis replaces cellular respiration and allows plants to produce glucose used by animals for their metabolism. The basic formula for the respiration is familiar from school days: $C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O$ and tells that one glucose molecule is transformed into carbon-dioxide and water and gives in this process the energy stored in it in the photosynthesis. The actual process is however considerably more complex than this oversimplified representation suggests. There are several forms of cellular respiration. Glycolysis is anaerobic respiration mechanism and converts glucose to pyruvate (in particular in neurons and glia). 2 ATP molecules per one glucose molecule are produced and this is enough for the continuation of the glycolysis which itself requires some energy.

Aerobic respiration involves a further processing of pyruvate which is transported to the mitochondria where it is used in Krebs cycle for synthesizing the high energy compounds whose oxidation leads to the generation of ATP. This process is possible only if cell receives oxygen from blood flow. 30-35 ATP molecules per one glucose molecule are produced in this process [J9]. Also fats function as energy reserves: when oxidized they produce 9 times higher energy yield than pyruvate molecules but the rate of the process is slower by a factor of 1/8. Brain does not utilize fat as an energy reserve: rather, astrocytes store the energy reserves of glucose to glycogen which they both synthesize, store, and catabolize.

Lactase and alcohol fermentation represent further an aerobic respiration mechanisms. Lactase fermentation is utilized by muscle cells and after maximal exercise the overproduction of the lactate acid is responsible for the characteristic muscle pain. Some plants utilize alcohol fermentation.

3.1.2 Blood circulation

Blood circulation could be regarded as a logistics of the living system. Logistics involve the delivery of both energetic and structural components such as glucose molecules, oxygen, and proteins. Blood circulation supports a chemical signalling system based on hormones. Blood acts as a buffering system based on phosphates and proteins and has defensive functions similar to those of immune system. Blood serves also as a reservoir of body heat and blood flow can control the body temperature by convection and conduction mechanisms.

There is a strict separation of the oxygenated and de-oxygenated blood corresponding to pulmonary and systemic flows. The first type of blood vessels are arteries which have walls consisting of smooth muscles which can constrict and dilate and in this manner control the rate of the blood flow. The rate of blood flow depends also on its velocity controllable by the rate of the heart beat. Blood flow is known to be controlled both by hormonal and neural control mechanisms.

Besides arteries there are capillaries which have walls consisting of single layer of cells, endothelium. Capillaries lack the smooth muscle so that the flow to the capillaries must be regulated by precapillary spinners containing smooth muscle and joining arteries to capillaries: their dilation or constriction controls the flow into the capillary. The basic mechanism for transferring molecules from capillaries to cells is diffusion. Lipid soluble molecules like oxygen and carbon monoxide

diffuse through cell membranes automatically whereas water soluble molecules can diffuse only through pores. The size of the pores varies and in brain the pores are very small so that blood brain barrier results.

Oxygen is bound to hemoglobin which is a tetramer of four identical myoglobin proteins. Red blood cells transfer the hemoglobin near cell and oxygen diffuses through the wall of the capillary and through the cell membrane to neuron and eventually reaches the mitochondria. Glucose is the energy carrier molecule transferred by blood and glycolysis and aerobic cellular respiration transform the energy stored in the glucose to ATP.

3.1.3 Red blood cells

Red blood cells, being carriers of oxygen, are expected to be especially important for consciousness. Being not a professional biologist I freely use the popular article [I35] in which besides standard facts also the importance of red blood cells and astrocytes for consciousness is also advocated.

Some poorly understood aspects of the blood flow support the idea that blood behaves like a coherent conscious unit under some conditions.

1. The first, already mentioned, mystery is that a heightened neuronal activity induces a rush of blood cells to the neurally active regions but is accompanied by a very low oxidative metabolism.
2. Second mystery is how the signal about the need for the increased blood flow is mediated to the pre-capillaries to relax smooth muscle when blood is needed. Signalling is up-stream and signalling mechanisms based on the diffusion of chemicals like NO, CO_2 and protons, extracellular K^+ and purines have been proposed but no consensus about the mechanism has been reached. An alternative mechanism is based on direct communication to an appropriate magnetic body which in turn would perform the needed motor action.
3. A further mystery is that red blood cells exhibit a coordinated group response to threats [I42]. In light of this the observation that sea stars have a hemal system with no obvious function and, although possessing no brain, are capable of displaying rather refined intelligent behavior [I35], is rather suggestive.

With these observations as a context, it is interesting to try to interpret basic facts about blood flow.

1. Red blood cells are distinguished by their unique role in the oxygen transport and by their anaerobic metabolism (it would not make sense for red blood cells to consume oxygen molecules!). Red blood cells exhibit many characteristics of prokaryotes and might be called metakaryotes: indeed, at some stage of development mammalian red blood cells eject their nucleus and organelles. It has been found that neural cells can be trained to become red blood cells, which supports the view that the role of blood flow is more than mere logistics. Red blood cells are the only cells which are unable to divide and become cancerous.

If one takes seriously the proposal that magnetic bodies perform quantum control through magnetic flux sheets traversing genomes and receive sensory input via flux quanta associated with proteins traversing cell membranes, this means that red blood cells would communicate only somatosensory input to the respective magnetic body and magnetic and motor control performed through them would be very primitive: perhaps control of motion of blood cell.

Blood cells would correspond to $k_{em} = 1$ level of dark matter hierarchy assigned to prokaryotes. $k_{em} = 1$ and flux quantization for planar flux sheets of thickness $L(169) = 5 \mu\text{m}$, lower bound for the size of cell nucleus, would give length of $\lambda L(169) = 5 \text{ cm}$ for $\lambda \simeq 2000$. Blood cells could perhaps organize to thread like structures parallel to the blood veins.

2. Red blood cells and their hemolymphatic counterparts contain iron and are good candidates for magneto-receptors [J4, J10]. The orientation of the magnetic structures with Earth's magnetic field and the fact that liquid codes the direction of the gravitational field to pressure gradient define a good candidate for a preferred coordinate system used already by honeybees containing magnetite and ferritin in their abdomens [I36]. Red blood cells could serve as

compasses and code for the orientation of the body with respect to the magnetic field and gravitational fields and a grid of blood cells could code for the local variations of the magnetic field making possible navigation using magnetic field. This information could be represented at the $k_{em} = 1$ somatosensory magnetic body assignable to the blood flow.

3. The velocity of the blood flow in capillaries is about mm/s so that scaling law gives $f = v/L = 1$ kHz, which happens to be the kHz frequency of neural synchrony.
4. Red blood cells exhibit a high capacity for chemiluminescence and it is possible to make red blood cells bioluminescent by genetic engineering. Red blood cells are known to absorb light through the skin and thus might serve as photo-receptors in dermal optics [J11]. In [I35] it is proposed that red blood cells give rise to primitive vision and be responsible for blind sight. Ocular blood vessels are indeed very near to the surface. DNA is believed to generate bio-photons whereas mammalian red blood cells which have no DNA are indeed known to not emit bio-photons [J3]. Perhaps red blood cells “see” the bio-photons generated by DNA: this would conform with the general idea that DNA generates 4-D templates consisting of coherent photons and guiding the biological self-organization.

The large number of mitochondria in the heart muscle, liver and red muscle cell give them their red color. Whether this color is always related to the color of haemoglobin is not clear to me. At least, the idea about a communication system between red blood cells and mitochondria based on red light is worth of demonstrating to be wrong. Unfortunately, I do not know how near the average wave length associated with this red color is to the “miracle wave length” of 640 nm associated with the photons of photosynthesis.

3.2 Cellular Respiration And Photosynthesis

Photosynthesis [I32] in which photon energy is chemically stored and cellular respiration in which it is liberated are the fundamental processes of energy metabolism and in some sense duals of each other.

1. Photosynthesis produces from CO_2 and water in presence of sunlight carbohydrates carrying the metabolic energy and serving also as building bricks of more complex bio-molecules. The photon-dependent part of the process extracts the energy of photons and stores it temporarily to ATP and ADPH. This temporarily stored energy drives both the light-dependent and -independent parts of the process and the surplus energy of ATP and ADPH is stored as a chemical energy of carbohydrates (sugars) produced in the process.
2. In cellular respiration the carbo-hydrades are transformed to carbon monoxide and water and metabolic energy is extracted as the energy of ATP molecules serving as a universal metabolic currency to be used for varying purposes.

Both processes are far from being completely understood and the extreme energy efficiency of these processes leaves room for a macroscopic quantum coherence. TGD proposal is that at the deeper level these processes allow interpretation as a transfer or redistribution of negentropic entanglement. The great challenge would be the interpretation of photosynthesis from this point of view.

3.2.1 Cellular respiration

Cellular respiration (see <http://tinyurl.com/yyvrpb>) [I7] a process which converts the chemical energy of nutrients - typically bio-molecules (hydrogen sulfide is however an exception) - to metabolic energy carried by ATP molecule (see <http://tinyurl.com/clnu4>) [I3]. Besides this also waste products are generated.

Oxidation and redox reaction (see <http://tinyurl.com/ycyetr>) [I26] are the key concepts needed in the description of this process.

1. Oxidation means donation of valence electron so that the oxidation state (see <http://tinyurl.com/ya3yj84a>) [I27] of the atom is changed. Typically the electron is paired with an electron of the receiving atom so that an electron pair assignable with a valence bond is

formed: the oxidation state of the atom increases by one unit. Typically oxygen receives the electron and this has given the name for the process. Reduction is the reverse of this process: atom or molecules donates an electron to the acceptor.

2. A simple example is H_2O containing two valence electron pairs resulting in the oxidation of hydrogen atoms. Second example is CH_4 : Carbon has received four electrons from hydrogens and is thus reduced. For CO_2 carbon has given for electrons so that it is oxidized. In $PO_4C_3H_3$ (phosphate, which is the key molecule in metabolism) phosphorus has given 5 electrons and thus oxidized. Naively would expect that P tends to receive three electrons since this is the number of electrons lacking from the higher electron shell of P .
3. Electron pairs appearing in valence bonds are in general much less active than lonely electrons appearing in the highest electron shell. Molecules or atoms containing unpaired electrons are known as radicals. Molecular oxygen $O_2 = O - O$ crucial for cell respiration contains two unpaired electrons and is stable free radical. It reacts with carbo-hydrates, fats, and proteins and helps to liberate metabolic energy which goes to ATP.

Cellular respiration, which can be seen as a reversal of the photosynthesis, is a stunningly complex process consisting of 4 basic steps.

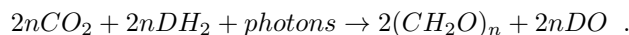
1. At the first step glucose is converted into pyruvate in glycolysis (see <http://tinyurl.com/4rokah6>) [I16] in cytosol. The free energy is released in this process as NADH and ATP. The process requires 2 ATPs as a fuel and produces 4 ATP molecules so that the net gain is 2 ATP molecules. Also 2 NADH molecules carrying metabolic energy are formed. This step precedes also anaerobic respiration.
2. At the next step pyruvate breakdown (pyruvate decarboxylation) in mitochondrion to acetyl-CoA (see <http://tinyurl.com/2wye673>) [I1]. This produces one molecule of NADH and one molecule of CO_2 , which could be seen as waste product.
3. Acetyl-CoA goes through Krebs cycle (see <http://tinyurl.com/hp9go>) [I20]. This process is an oxidation of Acetyl-CoA producing CO_2 and H_2O as “wastes”. In this process the oxygen brought by blood circulation is utilized. In the process NAD is reduced to NADH (see <http://tinyurl.com/2wfrpxj>) [I22] meaning formation of electron pair. Note that NAD and NADH contain two phosphate molecules, which appearing also in ATP.
4. Oxidative phosphorylation via electron transport chain (see <http://tinyurl.com/77zzmakj>) [I13] is the next step in the process. It is electrons rather than electron pairs that are transported in this chain. They are produced in the oxidization of water. In this process ADP receives one phosphate molecule transforming to ATP is the next step in the process. Cytochrome c oxidase (see <http://tinyurl.com/yab2oymh>) [I11] is also involved with the process. O_2 receives four electrons from cytochrome c molecule and is thus oxidized. O_2 then combines with four protons to form two H_2O molecules. Cytochrome c receives its electrons from four NADH molecules transforming to NAD^+ ions. Electron transport chain is involved also with the photosynthesis (see <http://tinyurl.com/r3f6k>).

The change in the membrane potential induces the transfer of 4 protons through membrane and the Coulomb energy liberated in this process drives the F_0F_1 machine acting somewhat like a turbine of a power plant and generating ATP from $ADP + P_i$ in synthesis of ATP (see <http://tinyurl.com/ya5hn5j8>) [I5].

3.2.2 Photosynthesis

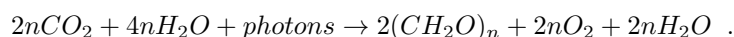
Photosynthesis (see <http://tinyurl.com/r3f6k>) [I32] is performed in plants and algae and interpreted as a process extracting metabolic energy from solar radiation. In the presence of electron donor photosynthesis generates from carbon dioxide CO_2 and photons carbohydrates and oxidized donor. The process consists of two sub-processes: the process extracting the energy needed to drive the process and the process storing solar energy to chemical energy carried by a carbohydrate polymer (sugar).

1. The general equation for photosynthesis is in a schematic form given by



One could say that DH_2 molecules gives its two hydrogen atoms for the carbohydrate and receives oxygen atom from CO_2 molecule in the process. In the initial state the electron donor D is reduced by the two electrons from H_2 . In the final state D is oxidized since it has donated two electrons to O . The elementary step if the process involves two CO_2 and DH_2 molecules and involves the transfer of four protons and electrons.

2. In oxygenic (as opposed to anaerobic) photosynthesis DH_2 is replaced with water molecule. The equation is now however slightly different



The process produces oxygen from carbon di-oxide whereas cell respiration does the opposite.

3. Water can be supplied by some other compound. For instance, arsenite molecule AsO_3^{3-} can replace water:



Photosynthesis takes place in two steps.

1. In the first step light-dependent reactions or light reactions capture the energy of light and store it temporarily to ATP and ADPH molecules.
2. In the second step light-independent reactions store part of the energy of ATP and NADPH to the chemical energy of sugar molecules. This step involves the capture and reduction of carbon dioxide to produce also oxygen necessary for the cellular respiration. The energy stored to the carbohydrates serves as metabolic energy to be used in the cell respiration to generate ATP and NADPH.

This short overall description of course gives only a very rough overall view about extremely complex process. A more detailed description is given in Wikipedia article (see <http://tinyurl.com/r3f6k>) [I32], where also excellent illustrations about the process can be found.

Photosynthesis is performed by plants and algae and involves photosynthetic membranes and organelles known as chloroplasts (see <http://tinyurl.com/dmhoa>) [I9].

1. Chloroplasts capture the light energy and store it to ATP and NADPH in a complex process known as photosynthesis. Chloroplasts contain pigment molecules such as chlorophyll (see <http://tinyurl.com/ycx7nk3>) [I8], carotene and xanthophyll. Chlorophyll gives plant leafs their green color since these wave lengths are not absorbed by the chlorophyll molecules.
2. Chlorophyll molecules contain so called antenna proteins giving rise to a light harvesting complex which absorbs photons from the incoming radiation. The light energy from the antenna proteins is transferred to chlorophyll molecules. Chlorophyll molecules are arranged in and around photosystems embedded in thylakoid membranes of chloroplast.
3. There are two photosystems in which photon absorption takes place: P680 and P700. They are named after the wavelength at which the absorption of light is maximum (680 *resp.* 700 nm).

Photosynthesis gathers the energy needed to drive it from the radiation. In light-dependent reactions that ATP and ADPH needed to drive light dependent reactions are formed. In light-independent reactions part of the energy of ATP and ADPH is stored as the chemical storage as CO_2 is reduced to sugar carrying the energy. Only this part of the process is visible in the general equation for the photosynthesis.

1. *Light-dependent reactions*

Light dependent reactions (see <http://tinyurl.com/ya6ynsxj>) [I21] take place in the thylakoid membranes of chloroplasts (see <http://tinyurl.com/dmhoa>) [I9].

1. There are four protein complexes known as photosystem I and II, cytochrome b₆ complex, and ATP synthase. The first two absorb the photons and donate the resulting energetic electrons. The third generates ATP and fourth ADPH in a sequences of reduction processes generated by electron known as electron transport chain (see <http://tinyurl.com/77zzmak>) [I13]. One can imagine that electron falls down along stairs and loses energy at each step received eventually by ATP and NADPH.
2. What happens that chlorophyll molecule in photosystem II absorbs photon and gives one electron in an excited state with higher energy. The electron is highly unstable and flow through electron transport chain and end up to photosystem I where it absorbs another photon. The final electron acceptor is NADP which transforms to NADPH as it receives proton and electron.
3. Proton gradient over the cell membrane appears as in cell respiration and is used to generate ATP molecule during the first step. The process is catalyzed by ATP synthase also now. Chlorophyll molecule regains the lost electron from water molecule in photolysis releasing O_2 molecule. Also now 2 water molecules and 2 chlorophyll molecules are involved. 4 protons are released in the oxidation of the water molecule.

The so called Z scheme (see <http://tinyurl.com/ybrf248k>) [I32] describes how the light-dependent reactions are thought to occur in thylakoid membranes (see <http://tinyurl.com/7rx984r>) of the chloroplasts to synthesize ATP and NADPH driving the light-independent reactions storing part of the energy of photons chemically to the energy of sugar molecules.

1. Oxygen evolving complex (see <http://tinyurl.com/ycldzc83>) [I32] is not well understood. What this complex does is oxidation of two water molecules to O_2 and 4 protons and 4 electrons. They replace the lost electrons of two chlorophyll molecules. Photosystem II is the enzyme that catalyzes the oxidation of water leading to a production of O_2 and for protons and electrons. What happens in the oxidation of water molecules might relate closely to the TGD inspired proposal that $ATP \rightarrow ADP + P_i$ process involves a reconnection of a flux tubes with hydrogen bond flux tube connecting two water molecules.

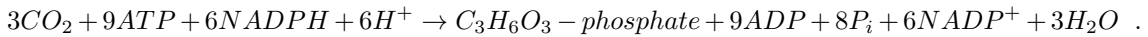
The resulting four electrons which are given to the chlorophyll a molecules to compensate the electrons that they have lost. The four protons are later used to transform $NADP^-$ obtained when electron originating from chlorophyll is absorbed by NADP to NADPH.

2. In photosystem II the electron in chlorophyll a molecule is excited to a higher energy state by photon absorption. The electron is highly unstable and goes down along electron transport chain losing energy produces ATP. Does the production of ATP proceed just as in the case of cell respiration. Four protons, four electrons and one O_2 molecule These would be produced in the first step of the process. One half of the products of the process splitting water molecules would produce ATP and one half would produce....
3. The electron ends down to the photosystem II where it absorbs second photon and goes down to second electron transport chain to be finally absorbed by NADP molecule. $NADP^-$ absorbs proton produced in the oxygen evolving complex to give NADPH. ATP and NADPH drive the electron transport chains.
4. The process must return O_2 molecule and four protons and electrons to two water molecules and this indeed takes place when ATP and ADPH are used. Thus the net effect of the oxidation and reduction of water would be generation of sugar binding the energy of photons to metabolic energy.

It would seem that the pairing of dark electrons occurs when the photons are absorbed by NADP ADP. This would suggests that paired dark electrons appear ADP, P, and NADP. At this stage electrons are not paired. Pairing would occur only when ADPH and ATP and carbohydrate are formed.

2. Light-independent reactions

In light-independent reactions the enzyme RuBisCO captures CO_2 from atmosphere and in process required the newly formed NADPH, known as Calvin-Benson cycle (see <http://tinyurl.com/y1bcy63>) [16], releases there carbon sugars, which are later combined to form sucrose and starch. The overall reaction is



Note that 9 ATP molecules and 6 NADPH energy carrying molecules produced by light dependent reaction are used to drive the overall reaction. The sugars are used to build cellulose, and precursors of lipid and amino-acid synthesis or as a fuel of cellular respiration.

4 TGD Inspired View About Metabolism

The notions of negentropic entanglement, dark matter as phases with non-standard value of (effective) Planck constant, high T_c electronic super-conductivity, and dark protons providing representation of genetic code, are the basic building bricks in TGD based quantum model of living matter. This picture leads also to a quantum model of metabolism having deeper interpretation in terms of a transfer of negentropic entanglement (NE). For quantal aspects of metabolism evidence has been accumulating since 2007 [143].

The deepest question about metabolism is “Why metabolism?”. The thermodynamics based answer is that it means transfer of ordered energy dissipated in the organism. This might be however only partial truth as already discussed. The real answer suggested by NMP and already discussed is that metabolism is responsible for the transfer of NE to the system and energy transfer is more like side effect.

The following represents the view about metabolism as it was for few years ago. This view is by no means meant to be a list of truths carved in stone. The more recent ideas such as the distinction between short range NE and long range NE and the possible transformation of these two kinds of NEs to each other have been already discussed.

The question whether nutrients carry long range NE or short range NE is open. The older vision discussed below assumed that nutrients carry short range NE in the scale of nutrient molecules. In [K41] the proposal that nutrients carry long range NE with dark matter part of Mother Earth is discussed. It is however important to realize that both of these NEs are in principle possible for nutrients that flux tubes carrying long range NE could serve as effective stores of short range NE. There is evidence that even electrons can serve as nutrients: this conforms with the idea that electron as a negentropically entangled pair of two wormhole contacts could carry almost 127 bits of negentropy.

As already explained, there is now some indirect evidence for the existence of the dark Earth [K31] as a spherical layer of dark matter with radius with total mass of order $10^{-4}M_E$, which is same as the radius of Moon’s orbit. It might be possible to resolve these conundrums by a careful analysis of what is known about ATP-ADP process but also a new bright idea might be needed.

4.1 Negentropic Entanglement And Covalent Bond

The great idea is that living matter resides in the intersection real and p-adic worlds- in the intersection of matter and cognition. This would among other things mean that entanglement probabilities are rational or quantum rational.

p-Adic physics leads to the notion of negentropic entanglement possible when entanglement probabilities are rational or quantum rational numbers [K36] (which belong to algebraic extension of rationals by p : th root of unity). One can ask why entanglement probabilities should be restricted in this manner. In non-generic case this is certainly not true. The answer is that Negentropy Maximization Principle [K22] takes care that system ends up to a situation when entanglement is rational or quantum rational.

The natural question is how the quantum rational entanglement is realized in living matter. The basic characteristic of quantum rational entanglement is that it is stable with respect to NMP

just as bound state entanglement. It seems however unnecessary to assume that negentropic entanglement reduces to a bound state entanglement so that one could assign binding energy to it. This suggests that the somewhat fuzzy notion of high energy phosphate bond corresponds to negentropic entanglement and indeed carries what might be called negative binding energy.

This vision leads to the idea that energy metabolism is basically needed for a redistribution of negentropic entanglement and the model for DNA as topological quantum computer leads to a model of $ADP + P_i \rightarrow ATP$ process as a process generating magnetic flux tube connection between two systems A and B by reconnecting two flux tubes short-circuited to water molecules. This short-circuit would take place by a reconnection with a magnetic flux tube assigned with a hydrogen bond (see <http://tinyurl.com/4vvzj>) [I18]. One might interpret this process as assigning to this particular flux tube the negentropy associated with ATP and other molecular nodes associated with the flux tube connection. This assignment might be regarded as information transfer.

4.1.1 Are large \hbar electron pairs in covalent bonds of bio-molecules responsible for negentropic entanglement?

In what degrees of freedom the negentropic entanglement distinguishing biomolecules from the ordinary ones resides? A little thinking leads to a rather obvious first guess. This vision is consistent with other visions about how living matter manages to be a macroscopic quantum system.

1. The only degrees of freedom one can imagine are electronic. The carriers of negentropic entanglement would be paired electrons assignable to covalent bonds. These pairs need not be ordinary spin 0 electron pairs appearing in molecules in vitro which are expected to be able to have only entropic entanglement. Whether the entanglement is assignable to the electrons of the pairs or to pairs of pairs, remains open at this moment, although the latter option is much more attractive.
2. This pairing of electrons is very similar to the formation of Cooper pairs and could be seen as a super-conductivity in atomic or molecular scale. Therefore one obtains a connection with the hypothesis that living matter is high T_c super-conductor [K7].
3. The hierarchy of Planck constants suggests another manner to realize living matter as a super-conductor. This suggests that the outer valence electrons can topologically condense to space-time sheets with non-standard value of Planck constant. As a matter fact, this hypothesis was introduced as the first application of the hierarchy of Planck constants in order to explain the claimed strange properties of so called ORMEs suggesting strongly super-conductivity at room temperature [K7]. These electron pairs were associated with outer shells of atoms. TGD inspired model for high T_c super-conductivity indeed assumes that Cooper pairs correspond to a non-standard value of Cooper pairs but did not yet identify them as valence electron pairs [K7]. Not that a high T_c super conductor Cooper pairs are however formed from unpaired valence electrons (one in the case of copper).

The challenge is to show that negentropic entanglement is possible only for non-standard values of Planck constant characterized by integer - call it n : the number theoretically inspired guess is that the p-adic prime characterizing the quantum rationals involved with negentropic entanglement is a factor of n .

This would mean that three different manners to see living matter as a macroscopic quantum system in TGD Universe would be equivalent. If this picture is accepted, one ends up with a very general vision.

1. All covalent bonds of bio-molecules can be in negentropic state. For their organic counterparts covalent bonds are expected to carry ordinary spin zero electron pairs with entropic entanglement.
2. Negentropic entanglement requires in the most general situation that entanglement probabilities are algebraic numbers and rational entanglement corresponds to the simplest situation. Quantum arithmetic generalization of the notion of rational number however is however the

p-adically favored option. Also quantum rational entanglement is negentropic and characterized by prime p . The following argument suggests that negentropic entanglement requires non-standard value of Planck constant.

It would not be too surprising that the entanglement probabilities were proportional to $1/n$, where n characterizes the Planck constant so that negative entropy would be possible only when p is a factor of n . The two manners to have macroscopic quantum coherence - negentropic entanglement and large \hbar - would not be independent mechanisms but different facets of one and the same mechanism. For $n = 1$ only ordinary entropic entanglement would be possible so that ordinary chemistry would be entropic.

3. How the value of the p-adic prime p characterizing the negentropic entanglement in quantum arithmetics correlates with the value of Planck constant? Could the integer defining \hbar have p as a factor so that the p-adic prime p and the value of \hbar would correlate? Are prime values of n favored?
4. Paired valence electrons would be negentropically entangled. What can one say about the character of this entanglement?
 - (a) For ordinary molecules these electrons pair to spin 0 state. For high T_c super-conductivity electron pairs have spin 1 [K7], and suggest themselves strongly also now.
 - (b) For spin singlet states the entanglement probabilities in spin degrees of freedom are uniquely fixed and equal to $P = 1/2$. For spin 1 states only the state with vanishing spin projection is entangled and the mixing with spin 0 state could give rise to two un-entangled states. Therefore negentropic entanglement in spin degrees freedom is not a plausible source of negentropy and it should therefore be between electron pairs. Also the fact that entanglement should generate long range correlations between distance bio-molecules, suggests the same.
 - (c) The $1/p$ -proportionality of the entanglement probabilities for $p > 2$ requires that the entangled degrees of freedom are not spin degrees of freedom so that entanglement between spatial wave functions remain. The simplest situation involves p state pairs. This however not the only possibility. Even two states is enough. The naive guess is that the n -sheeted character of space-time region gives rise to n -fold degeneracy of states so that entanglement involves sum over n state-pairs and factor $1/n$ emerges naturally.

4.1.2 Is the number of covalent electron pairs maximized in living matter?

If the negentropic entanglement is between electron pairs, the amount of negentropy would depend on the number of electron pairs and one would expect that this number them. This would mean also maximization of the density of Cooper pairs. Also the assumption that the entanglement is between electron pairs favors maximization of the covalent bonds since this maximizes the quantum coherence by magnetic flux tubes. Does this maximization take place in living matter?

1. Carbon and silicon tend maximize the number of covalent bonds since they have maximum number of valence electrons. Glucose (see <http://tinyurl.com/b25mu>) has the chemical formula $C_6H_{12}O_6$ is the basic metabolite and maximizes the number of valence electron pairs per Carbon atom: this number is four. Hence glucose could be interpreted as an optimal carrier of negentropic entanglement.
2. Phosphate is the basic building brick of metabolism. Phosphate having the chemical formula PO_4H_3 is so called oxidation state. Although the formal valence of phosphorus is -3 it behaves in phosphate with valence 5 so that the number of valence electron pairs is as high as 8!

Even more interestingly, quite recently it has been found evidence that oil droplets can be regarded as a primitive life form. The TGD inspired model [L3] [K17] led to the identification of the counterpart of the phosphate as nitroglycerin (see <http://tinyurl.com/y9a23qen>) [I25], which is also an oxidation state maximizing the number of electron pairs.

Also arsenic based life (see <http://tinyurl.com/krg3bs>) [I19] has been suggested and there are even indications for its realization. Arsenic is analogous to phosphorus has been proposed as possible counterpart of phosphorus.

3. Each nucleotide of DNA strand contains phosphate group giving it high negentropy and also *A, T, C, G* have rather high negentropy. For A the number of electron pairs is maximal-24- and G comes next. This might explain why just ATP defines the standard metabolic currency. Note that also GTP (see <http://tinyurl.com/y8ns4mv3>) is used as a source of metabolic energy in protein synthesis.
4. Peptides are often called information molecules and are also known to correlate strongly with emotions and emotional expression so that they have been called molecules of emotion [J2]. Peptides as amino-acid sequences as also hormones, neurotransmitters, hallucinogens, alcohols and other neuro-chemicals contain a large number of covalent electron pairs. This would support the view that the excretion of hormones and all similar compounds is basically a process of sending flux tubes connecting the sender of the signal with the target by negentropic entanglement. The binding of the chemical to the corresponding receptor would build the entanglement bridge having magnetic flux tube as a correlate.

It would be natural to assign to the generation negentropic entanglement positive emotional coloring and negative emotional coloring to its reduction. The re-distribution of negentropic entanglement *d* between biomolecules using metabolic activities could therefore give rise to emotions with both colorings.

There are several questions to be answered.

1. Atomic electrons are at overlapping atomic orbitals but what about spin 1 super-conducting valence electron pairs with large \hbar ? Could it be that these electrons reside in a region where the Coulomb forces by atoms associated with the valence bond compensate each other so that the electron pair sees very small force. Could this make the de-localized electron pairs effectively free? Could the large value of Planck constant provide them the ability to control the distance of the composite atoms?
2. Can one understand high energy phosphate bond from negentropy maximization? Negentropic entanglement could bind particles without binding energy. This of course need not be always the case but could one assign to the electron pairs of phosphate negative binding energy? This negative binding energy could be caused by the Coulomb repulsion between the electron pairs and the stability of phosphate would be due to the negentropic entanglement between the pairs.
3. H_2S (see <http://tinyurl.com/ybeo6sy>) is used as a nutrient by some groups bacteria. H_2S is oxidized just as water. Are the electron pairs of H_2S ordinary or dark? At what step they are transformed to dark electrons if this they are ordinary in H_2S ? Is this transformation a phase transition induced by the presence of the analog of Cooper pair Bose-Einstein condensate (the mechanism would be the analog of stimulated emission). Could this be tested experimentally?

To sum up, the proposed hypothesis could unify three different hypothesis about the origin of macroscopic quantum coherence. The hypothesis that living matter is high T_c electronic super-conductor, the hypothesis that negentropic entanglement is the basic characteristic of living matter, and the hypothesis that dark matter corresponds to a hierarchy of Planck constants realized in terms of effective multi-sheetedness of the imbedding space.

4.1.3 What is the exact role of the solar radiation?

Photons provide the energy in photosynthesis. Do photons also provide negentropic entanglement or only make possible to re-distribute negentropic entanglement? Since the negentropic entanglement is a non-local 2-particle property rather single particle property, the idea that photons would carry negentropic entanglement does not make sense. This would support the minimal assumption that solar photons provide the metabolic energy needed to re-distribute the entanglement: this

indeed requires destruction and reconstruction of highly energetic valence bonds. Of course, this energy could be also realized as a mechanical work.

Large \hbar photons should in question. Are they generated by a phase transition increasing the value of \hbar at relevant magnetic body? What level in the onion-like hierarchy of magnetic bodies this magnetic body corresponds to? Is the magnetic body of the antenna proteins in question? Or is it some higher layer in the hierarchical structure of the magnetic body? Do the photons appear with several values of Planck constant?

4.1.4 How do dark protons and dark electrons relate?

One of the key observations leading to the identification of dark matter as a large \hbar phase was the effective chemical formula $H_{1.5}O$ for water in atto-second time scales [K14]. The explanation was that 1/4: th of protons are dark in this time scale. The portion of dark photons is expected to depend on temperature and pressure and would make water a two-phase system effectively. This could explain the numerous anomalies of water in the temperature range 0-100 C [K14]. In living matter the portion of dark protons could be even higher.

This hypothesis led later to the idea that dark protons form dark nuclei and to the completely unexpected observation that the quantum states of dark protons are in natural correspondence with DNA, RNA, tRNA, and amino-acid molecules and that vertebrate genetic code finds a natural realization [L2, K19]. The fundamental realization of genetic codes would be at the level of dark nuclei consisting of dark proton strings connected by color flux tubes just as ordinary nuclei in TGD inspired model of nuclei. Taking this seriously, one is forced to conclude that also dark protons play a crucial role in living matter. They indeed appear in key role in both photosynthesis and cellular respiration. The challenge is to understand the precise mechanisms involved.

1. The number of both protons and electrons participating to a typical process step is $n = 4$. The oxidation of two water molecules gives O_2 molecule and 4 protons and electrons. Is the reason for number four just this or could four protons form a dark nucleus serving as a counterpart of 4He , which has exceptionally high binding energy. This sequence corresponds to a sequence of four DNA codons. Do this kind of sequences have a special role?
2. One could counter-argue that the high binding energy of 4He like state would require additional binding energy requiring additional metabolic resources. A possible resolution of the problem would be negentropic entanglement allowing binding without binding energy. This would allow also longer dark nuclei proposed to accompany DNA, RNA, and amino-acids. If dark 4-proton nuclear strings are there, could they be associated with pairs of water molecules and could hydrogen bonds accompany them and serve as their signature? Could the appearance of 4 protons in $ADP + P_i \rightarrow ATP$ process involves a reconnection of the flux tube with hydrogen bond and transfer of 4-proton dark nucleus through the mitochondrial membrane?
3. A natural question is whether also dark nuclei give rise to magnetic flux tubes giving rise to macroscopic quantum coherence. DNA double strand has very high electronic charge of two units per nucleotide assignable to the negatively charged phosphate groups. This creates problems with the stability.
 - (a) Could this charge be stabilized by dark protons forming long dark nuclear strings? This would give unit positive charge per single nucleotide which is more favorable concerning stability. Could one have one dark proton per single nucleotide with a 1-1-correspondence between the state of the nucleotide and DNA so that genetic code would be realized? Nucleotides and their conjugates in DNA double strand are connected by hydrogen bonds. Could the long dark proton strings possibly accompanying DNA and its conjugate relate with these hydrogen bonds?
 - (b) Could the dark protons have spins parallel to the DNA strand and generate the magnetic flux tubes around which the DNA strands are formed? Are also other mRNA and amino-acids formed around magnetic flux tubes generated by dark proton string?

4. The condition that the Compton length of dark proton is of order the length of DNA associated with single nucleotide (about 1 nm) would fix the value of \hbar associated with the dark protons to be about 10^6 . For this value of the Planck constant electronic Compton length would be around 1 micrometer which is the size scale of cell nucleus. Is this a mere co-incidence? In fact, the condition that dark electrons and protons appear with Planck constants giving rise to approximately same Compton lengths gives rise to a hierarchy of Planck constants in powers of integer near to the mass ratio $m_p/m_e \sim 2^{11}$ postulated in the original version of dark matter hierarchy but given up latter.

4.1.5 Empirical evidence for quantum coherence

Since 2007 empirical evidence for the importance of macroscopic quantum phases and quantum entanglement in photosynthesis has been accumulating and provides support for electronic bio-super-conductivity suggested already two decades ago.

1. The group led by Graham Fleming [I43] provided evidence for quantum coherence in light-harvesting proteins of green sulphur bacteria. The experiments were however carried out at 77 K so that one could not exclude the possibility that the effect is due to the low temperature.
2. The group led Graham Fleming 2010 has found evidence for quantum entanglement (see <http://tinyurl.com/2g7somb>) [I34] at room temperature and in much longer length scales than expected. This is against the prediction of the standard quantum theory that quantum entanglement is extremely fragile and destroyed by thermal fluctuations. The new physics explanation would be naturally as entanglement of large \hbar structures for which the length scale of entanglement would be scaled up and the energies associated with the bonds would be still above the thermal threshold. Photons with the energies of visible light and having wave lengths even in EEG range [K13, K27] are indeed basic building brick of TGD based view about living matter.
3. 2010 the group led by Elisabetta Collini (see <http://tinyurl.com/yftuca8>) [I33] found similar evidence in light-harvesting protein found in cryptophyte algae at physiological temperatures. The second finding was that the rate at which the oscillations of a coherent superposition of two electron excitations with different energies lasted about 400 fs whereas the expectation was 100 fs. The naive guess would be that the value of Planck constant was by a factor 4 larger than its standard value.
4. Greg Scholes (see <http://tinyurl.com/ygjt71k>) [I14] irradiated in his experiment the antenna proteins of marine algae at room temperature by two laser pulses lasting for about 10^{-12} seconds to induce single electron excitations with slightly different energies. This created effectively two oscillating dipoles whose electric fields were superposed. Immediately after laser beam was sent through the antenna protein system. The study of the changes in the laser beam due to the interference with the electric field generated by the electronic excitations demonstrated that the energy patterns of distant molecules fluctuated in a manner revealing correlation between them. The phenomenon observed was quantum beat (see <http://tinyurl.com/yd643tck>) [B1], a quantum version of the low frequency oscillation observed when two tuning forks with slightly different frequencies are hit simultaneously. Quantum beat demonstrated that the two electronic excitations generated by the laser pulses were non-local and superposed with each other.

These experiments provide the strongest support hitherto that the harvesting the photons in photosynthesis are macroscopically quantum coherent structures in electronic degrees of freedom. The measurements demonstrate the linear superposition for electronic excitations with different energies. Not only single molecule would be excited but a superposition of electronic excitations localized at different molecules would be generated. This would help to explain the extremely low losses of photon energy in the process. The energy would be routed from antenna proteins to nearby reaction-center proteins. Instead of choosing one classical path the electrons are transported simultaneously along all paths and every-time the shortest path will be chosen eventually.

A superposition of electronic excitations at different locations for the condensate by single photon would be in question. Visible photon wave length sets the scale in question to be at least of the order of micron (the size scale of cell nucleus). For a non-standard value of Planck constant the scale would be longer. The following picture applying quite generally rather than only in the case of antenna proteins suggests itself.

1. By their small mass electrons obey very fast dynamics and adapt to the conformational dynamics of molecules. Single electron cannot affect the conformational dynamics but acting quantum coherently together electron pairs can control the protein dynamics by collective phase transitions.
2. Magnetic flux tubes would accompany spin 1 electron pairs replacing valence electron pairs and would give rise to macroscopic quantum coherence and correlations at the level of molecules. This is more or less the original proposal made for almost two decades ago [K7, K8]. The new elements are the hierarchy of Planck constants and the identification of Cooper pair like states as valence electron pairs with spin 1. The dipole magnetic fields generated by spin 1 electron pairs make possible the web of magnetic flux tubes along which supra currents can run.
3. This could be also the mechanism of high T_c super-conductivity. Magnetic flux tubes are key players also in TGD inspired model for high T_c super-conductivity [K7] explaining the observed two critical temperatures in terms of percolation process: a phase transition in which relatively short flux tubes emerge below the first critical temperature but cannot give rise to a macroscopic super-conductivity. At lower critical temperature these flux tubes reconnect to form longer flux tubes and in this manner make possible macroscopic super-conductivity [K7]. Reconnection would be the fundamental mechanism also in high T_c super-conductivity. It should be possible to test the predicted spin 1 property of electron pairs and in the case of high T_c super-conductivity the spin 1 character has been established.
4. The interpretation in terms of a Bose-Einstein condensate of non-localized electron pairs would be a natural first guess. In this case all electron pairs would be in same state and quantum entanglement need not be present. A better guess is indeed entanglement between electron pairs at the ends of flux tubes. Whether this kind of entanglement plays a role also in high T_c super-conductivity is an interesting question.

4.2 Questions About Metabolism

Adenosine-tri-phosphate (ATP) is usually seen as a universal energy currency molecule of cell (for excellent popular article see [I3]). ATP is critical for all forms of life. ATP is involved with transport work (e.g. the transport of molecules along micro-tubuli) and mechanical work (muscle contraction and movement of flagellae and chromosomes). The major role of ATP is usually believed to be related to chemical work. ATP serves also as a switch: by bonding to a protein and receiving or giving phosphate to a protein ATP molecule can induce a conformational change of protein leading to its activation or inactivation.

The basic processes involved are charging and discharging of the ADP molecule by phosphorylation and its reverse process (according to standard view: TGD view is somewhat different). Many aspects of the ATP functioning are far from being completely understood and there are real mysteries, if not paradoxes, involved. One of them is how the process inducing ATP mediated energy transfer is accompanied by momentum transfer giving rise to a coherent locomotion. This suggests strongly quantum coherence of the process.

The TGD inspired vision allows to see the basic purpose of metabolism as a re-distribution of quantum information realized as negentropic entanglement between sender and receiver and this allows to see also ATP from a new viewpoint. Macroscopic quantum coherence is indeed the basic aspect of the process in this picture. In this framework energy metabolism might be seen as a pre-requisite for the re-distribution of bridges of negentropic entanglement.

4.2.1 ADP → ATP as a reconnection process?

The interpretation of $ADP + P_i \rightarrow ATP$ as a reconnection process is the genuinely new element in TGD view about metabolism. The reason is that this process is essentially non-local modifying the connectedness structure of the web formed by the magnetic flux tubes. As opposed to this, metabolism is purely local process in the standard view.

1. ADP → ATP could be regarded as a reconnection machine creating reconnections between various systems and in this manner re-organizing the connectedness structure of the magnetic flux tube web. Flux tubes from systems A and B going through ADP and P_i short-cut to water molecules a and b would reconnect with the mediation of ATP molecule creating connection between A and B.

O= would be in a special role since flux tubes connect at least these. Why? A possible explanation comes from the observation that the flux tube pair associated with O= gives rise to a representation of genetic codons by the total spins of two electron pairs associated with the flux tubes. Also the directions of magnetic fields associated with the flux tubes provide this kind of representation.

2. Suppose that hydrogen bonds are accompanied by flux tubes. Note that this flux tubes need not be short. Magnetic flux tubes can reconnect with the flux tubes associated with hydrogen bonds. In the initial situation: ADP is connected to system A by a flux tube and P_i to system B by a flux tube and in ATP state ATP fuses the two connections to single one.

There are two O=: s assignable to the ends of the flux tube. The flux tubes from A and B can short cut to water molecules and one obtains A-OH and B-OH connections and splitting of A-B connection. Formation of ATP is a reversal of this process. OH from water molecule a and H from water molecule b “eaten” and part of connection created between systems A and B. What remains is water molecule getting OH from and H from a.

3. What it means for the flux tube end to the water molecules? Is the negentropic entanglement (NE) present? This is possible since OH carries a dark electron pair located near OH. One could speak about macroscopic quantum phase formed by dark water molecules. If O= flux tube pairs are correlates for directed attention, one could say that water molecule is target of attention [K15].
4. Is an oxidation process involving two water molecules and producing 4 protons and electrons accompanied by the above described process involving flux tubes?
5. The communication of sensory data from the cell membrane to the magnetic body is a key element of TGD based model of living matter and EEG and its variants are involved with these communications [K13] ? This communication would naturally involve NE . Can one have a NE between the ends of the flux tubes with length scales which is astrophysical? Do the flux tubes return back to some other organism or organism itself? Or could electron pairs at the ends of flux tubes located in distant magnetosphere outside Earth be important? I have indeed proposed that the magnetic body of entire Earth is relevant for consciousness and life and there is intriguing indications that this might be the case [K21].

4.2.2 Generalized form of second law and metabolism

The non-determinism of state function reduction gives automatically rise to the ensemble entropy so that NMP implies second law of the entanglement is ordinary entropic entanglement. What happens in the case of NE : does the notion of ensemble fail now?

NE makes possible a generation of genuine negentropy locally. This is not possible in standard physics where the optimal situation means vanishing negentropy and entropy when entanglement is reduced in state function reduction process. TGD based form of second law predicts that second law holds true for zero energy states only above the time scale characterizing the CD geometry defined by temporal distance between the tips of the CD.

How the second law generalizes? Could it be that negentropic entanglement breaks the second law? In any case, second law in time scales larger than the scale of CD would be natural since one must introduce ensemble to describe the situation but does it follow when also NE is allowed?

The pessimistic generalization of second law states that the generation of NE is always accompanied by a process generating a compensating entropic entanglement. There is no rigorous justification for this proposal and it might be wrong. On the other hand, if this generalization holds true, one should be able to identify the process generating the compensating entropy in metabolism.

Consider first what happens in the generation of ATP trying to think in terms of transfer of NE - its re-distribution - rather than in terms of metabolic energy.

1. Generation of ATP creates connection and NE between distant molecules and uses one molecule of water as a hydration process. One cannot say that the negentropy of water molecule is transferred to the high energy phosphate bond. Rather the entanglement in the final state is between two molecules A and B connected by flux tubes going through the ATP. Before the generation of ATP there were two flux tubes connecting A and B to water molecules. Metabolic energy would be basically used to realize re-distribution of NE ? The reverse process can be regarded as dehydration and one molecule of H_2O is used.
2. In phosphorylation the splitting $ATP \rightarrow ADP + P_i$ producing intermediate P_i would not occur but ADP is produced. P_i and high energy negentropic bond would be transferred to the phosphorylated molecule. It could be enzyme which is activated in this manner so that the redistribution of NE would be essential for the bio-catalysis. The phosphate P_i would be attached to the second end of a flux tube. Reconnection process inducing the transfer of entanglement would take place so that negentropic A-B entanglement would transform to A-C entanglement.
3. $ATP \rightarrow ADP + P_i$ liberates energy.
 - (a) Is the NE lost and transformed to entropic entanglement as the connection splits or is the NE only transformed to a different form?
 - (b) In the splitting short-cut of flux tube connections to water molecules happens as their reconnect with hydrogen bond. This would split the connection A-B to A-water and water-A connection. Does it make sense to speak about NE between water molecule and molecules at the end of the connection?
 - (c) The valence electron pair associated with O-H valence bond would entangle negentropically with that of molecule A/B. This process reduces the connectedness of the web formed by magnetic flux tubes: does this mean generation of entropy?

Consider next how the second law in the pessimistic form could be realized in metabolism suggested by the fact that living matter seems to be very effective polluter of environment.

1. In cellular respiration CO_2 and H_2O are regarded as “wastes”. Could this mean that the electron pairs possibly having large \hbar and spin 1 lose their flux tube connection to the organism? And could the lack of flux tube connection induce a transformation to ordinary spin 0 valence electron pair at least in the case of CO_2 ?
2. In photo-synthesis O_2 molecules are regarded as the “wastes”. They have only one valence electron pair and several unpaired electrons. Same hold true for O_2^- super-oxide molecules. Both are free radicals and highly reactive causing oxidative stress (see <http://tinyurl.com/33sevk>) [I28] inducing damage to DNA. This in turn correlates with degenerative diseases, cancer, and senescence. Could this be interpreted as an entropic effect? Is the damage to DNA caused by the transformation of high \hbar electrons to ordinary ones and their pairing with ordinary electrons so that super-conducting phase suffers damage inducing a further damage at molecular level as the magnetic body loses NE and its controlling abilities weaken? Could it be possible to “heal” the damaged super-conducting phase?

If the second law in the pessimistic form is behind the effect it could be cured only by guiding the unavoidable entropy production to take place outside body.

4.2.3 TGD inspired questions about photosynthesis

The basic assumption is that living matter is high T_c super-conductor [K7].

1. Spin 1 electron pairs with negentropic entanglement generate magnetic flux tube structures and long range coherence. These spin 1 pairs give rise to high T_c superconductivity by creating the magnetic flux tubes as the routes along which they propagate. If they have energy higher than spin 0 pairs they decay to these and magnetic flux tube structures disappear and therefore also super-conductivity.
2. Electrons and electron pairs control the conformations by their very fast adaptive dynamics. Macroscopic quantum coherence would induce macroscopic quantum coherence of this dynamics. The challenge is to preserve the macroscopic coherence for which a geometric correlate is defined by long magnetic flux tubes.
3. There is considerable evidence for quantum coherent electron transport (see <http://tinyurl.com/yaqdyupe>) [I43]? The electronic excitations are not local but superpositions of excitation located even in separate chromophores. This would suggest electronic excitations affecting the Cooper pairs of entire Bose-Einstein condensate. The decay of a Cooper pair defined by a spin 1 pair of valence electrons looks like a natural mechanism. A defect in super-conductor would be created. “Correlated protein environments” and “correlation between protein induced fluctuations in the transition energy of two neighboring chromophores” are the terms used. Magnetic flux tubes accompanying electron pairs with parallel spins along flux tubes would give rise to these environments and correlated fluctuations.
4. If one believes that a single electron process is in question, dark electron pair could be destroyed in the absorption of dark photon. This is consistent with non-locality of the electronic excitations since non-locality requires that dark electron pair absorbs the photon.

This rough picture raises further questions about the details of the photosynthesis.

1. Suppose that the photons from Sun are ordinary ones so that the presence of the dark magnetic body at some level of hierarchy induces the phase transition of solar photons to large \hbar photons. In the geometric picture this phase transition would correspond to a leakage of photon to a magnetic flux tube at the dark sector of the imbedding space. Does the leakage at the level of antenna proteins or already earlier? Or at the magnetic flux tube associated with the chlorophyll’s electron kicked to a higher energy state? Does this kicking split valence electron pair.
2. At what step the dark excited electrons combine to form spin 1 pairs again? Does this take place in the formation of ATP and ADPH and in the generation of sugar molecule? The maximization of the number of valence bonds is an empirical fact and suggests that all valence electron pairs of bio-active molecules are dark spin 1 pairs.
3. Could denaturation (see <http://tinyurl.com/yw2vuo>) [I12] of bio-polymers transform dark valence electron pairs to spin 0 pairs with standard value of Planck constant. Could something like this happen also for the possible dark protons assigned to the basic building bricks of the bio-polymer in denaturation process?

Could this proposal be tested experimentally?

- (a) The parallel spins of pairs give rise to net spin compensated by opposite orbital angular momentum. Is this kind of angular momentum present in living DNA and protein molecules and does it disappear in denaturation?
- (b) Are also water molecules of cellular water dark? If this is not the case, the oxidation process splitting water molecules to O_2 , 4 protons, and 4 electrons should induce a phase transition producing dark electrons and protons. Could large \hbar characterize the valence electron pairs of the “living” portion of water and could the presence of this dark fraction relate directly to water memory and effective $H_{1.5}O$ formula in atto-second time scale?

- (c) How water memory for which evidence is accumulating [K19] relates to electronic and protonic negentropic entanglement?

There are also questions not directly related to the electron pairs.

1. In photosystem II the 4 electrons are provided by the oxidation of water catalyzed by P680 molecule. What happens in this process? Do the 4 protons produced in the splitting of water form dark nucleus analogous to ${}^4\text{He}$ but having charge 4, which the decays to 4 dark protons received by NADP^- . What would transform the protons to dark protons. How this phase transition is catalyzed by P680 molecule? Does it provide the presence of imbedding space sector with large \hbar to which protons leak and possibly also fuse to form a dark nucleus? Or is the sector present and P680 only provide the energy needed to jump over the potential wall for the ordinary protons.
2. At which step the transfer between different space-time sheets creating or liberating zero point kinetic energy takes place for electrons and protons? Oxidative process or $\text{ADP} + P_i \rightarrow \text{ATP}$ giving out one water molecule. The P-O-P bond should contain the surplus energy and electron pair should reside be at a smaller space-time sheet at this bond. The dropping of the pair to a larger space-time sheet could destroy the bond which is stabilized by the negative Coulomb energy due to the interaction of the pair with ionized atoms at the ends of the bond.

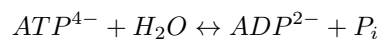
4.3 Hydrolysis Of ATP In TGD Universe

The generation of phosphate polymers and polymers in general occurs by dehydration which quite generally seems to involve dropping of a proton to larger space-time sheet and liberation of metabolic energy quantum. In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated. In the following early version of the model assigning metabolic energy quantum to the dropping of protons is considered. In [K25] a model of metabolism associating the metabolic energy quantum to the change of cyclotron energy is discussed.

It is interesting to find how one could understand these processes in TGD framework. Since the notion of wormhole magnetic flux tube playing a central role in the model of DNA as topological quantum computer and in the model of bio-catalysis, it is natural to look whether the basic steps of these processes could be understood in this conceptual framework.

1. $\text{ATP} \rightarrow \text{ADP}$ process

AMP, ADP, ATP are phosphorylated RNA nucleosides [I3] and the hydrolysis of ATP to ADP [I4] plays a key role in the metabolism. Obviously also the molecules XMP, X=U, C, G are important biologically. Each PO_3 in ATP corresponds to one unit of negative charge except for the last one which carries two units of negative charge. According to the standard chemistry $\text{ATP} \leftrightarrow \text{ADP}$ corresponds to the hydrolysis



where P_i denotes orthophosphate HPO_4^{-2} . In ADP the last phosphate group is $\text{HO} - \text{PO}_2^{-2}$ rather than $\text{O} = \text{PO}_2^{-2}$ as in case of ATP.

The actual process is however much more complex than this.

1. The process involves several steps such that energy is liberated in two steps in which the change of Gibbs free energy is $\Delta G = .42$ eV and $\Delta G = .31$ eV making altogether .73 eV, which should closely relate to the liberated metabolic energy.

2. Three protons are accelerated in electric field during the generation of ATP. The interpretation would be in terms of driving of electrons from larger space-time sheet to $k = 137$ atomic space-time sheet. If the larger space-time sheet corresponds to $k = 139$, the increment of the zero point kinetic energy of proton is $(1 - 1/4) \times E_0(137) = .375$ eV for $E_0(137) = .5$ eV of metabolic energy quantum. Three protons would give net zero point kinetic energy increment of 1.125 eV which is higher than $\Delta G_{tot} = .73$ eV. The explanation of the discrepancy should relate to Coulombic binding energy of protons with ATP and F_1 . This interpretation conforms with the observation that the liberated energy is higher for the third proton. It must be emphasized that one can imagine several alternative explanations.

Consider now a more detailed model for the process. The binding of ATP to the catalytic site involves several steps.

Step 1: The binding $ATP + F_1 \rightarrow ATP \cdot F_1$ to the catalyst site is a complex process involving the break-up of the hydrogen bonds between cellular water and ATP molecule and cell water and catalyst site and generation of hydrogen bonds between catalyst site and ATP molecule. In TGD framework this means that protons can be kicked to and dropped back from atomic space-time sheets. Only the net number of protons dropped however matters.

This process involves liberation of Gibbs free energy about $\Delta G_{ATP} = .42$ eV. It was earlier believed that this energy is liberated instantaneously but the findings about the behavior of the F_1 motor coupled to dissipative load, lead Oster and Wang to suggest that the process is more complex and starts from a loose binding and ending up to a strong binding [I47].

Step 2 Hydrolysis: $F_1 \cdot ATP \rightarrow F_1 \cdot ADP \cdot P_i$. The change of free energy is small during this step: $\Delta G \sim 0$.

Step 3: Ortophosphate is released from the catalyst site: $F_1 \cdot ADP \cdot P_i \rightarrow F_1 \cdot ADP + P_i$. Free energy $\Delta G \sim .31$ eV is liberated at this step.

Step 4: ADP is released from the catalyst site: $F_1 \cdot ADP + P_i \rightarrow F_1 + ADP + P_i$. $\Delta G \sim 0$ holds true also for this process.

This picture suggests that the notion of the high energy phosphate bond is not quite correct as suggested also by some empirical findings [D4, D1], [I45]. The metabolic energy would be stored as the zero point kinetic energy of protons rather than in phosphate bonds. Perhaps the fundamental function of phosphates would be to make DNA and RNA polymers charged in turn making possible the formation of wormhole magnetic flux tubes and braiding making possible a wide repertoire of catalytic actions.

2. Model of $ATP \rightarrow ADP$ based on wormhole magnetic flux tubes

Consider first the basic philosophy behind model.

1. In the model of DNA as topological quantum computer *XMPs*, $X = A, T, C, G$ can be connected to oxygen atoms by wormhole magnetic flux tubes having quark and antiquark at opposite throats of wormhole contact and charge conjugated quark-anti-quark pairs at the ends of the flux tubes. Dark u quark and its charge conjugate code for A, T and d quark and its conjugate for G, C so that the conjugation for nucleotides corresponds to charge conjugation for quarks and $A - G$ and $T - C$ symmetries of the third nucleotide of the codon to isospin symmetry.
2. Basic bio-catalytic processes are identified as a reconnection of the wormhole magnetic flux tubes and change of the length of the flux tube induced by the change of the value of Planck constant associated with it. It would not be too surprising if this kind of mechanism were involved also in $ATP \rightarrow ADP + P_i$. The reason for the special role of *ATP* among *XTP* might be that the positive charge $q(u) = 2/3$ of u -quark maximizes the attractive interaction between u quark and phosphate.
3. Flux tubes connect to oxygen atoms in the proposed model of bio-catalysis and protein folding [K2]. The model relies on ideas inspired by the model of DNA as topological quantum computer [K15]. In this model hydrogen bonds are assumed to correspond or to be accompanied by (wormhole) magnetic flux tubes. Also flux tubes connecting acceptor atoms or molecules of hydrogen bonds are assumed to be connected long flux tubes and represent genuinely new physics. Examples of acceptors are $O =$ atoms in phosphates and

amino-acids and aromatic rings in DNA and also in some amino-acids. The model for protein folding has tight connections with existing chemistry and leads to a very simple and successful criterion for the formation of hydrogen bond between $N - H$ and $O =$ in the constant part of amino-acid and to a successful proposal for the folding code.

4. DNA as TQC model gives further constraints. The structure of the phospholipids suggest that in the case DNA nucleotides long flux tubes connect the aromatic ring of the nucleotide to the $O =$ atom at the hydrophilic end of the lipid acting as a standard plug which in turn can be connected to another acceptor and eventually terminates to a donor of hydrogen bond. The detailed charge structure of the aromatic ring(s) should determine the quark-nucleotide correspondence. The connection line to the lipid could involve several intermediate $O =$ plugs and the first plug in the series would be the $O =$ atom of the monophosphate of the nucleotide. Not surprisingly, phosphorylation would be absolutely essential for the operation of DNA as topological quantum computer. $O = -O =$ flux tubes could also act as switches inducing a shortcut of the flux tube connection by reconnecting with a hydrogen bond connecting two water molecules. This is an essential step in the model for how DNA acts as topological quantum computer.

A possible model (perhaps the simplest one found hitherto) for the reaction $ATP \rightarrow ADP + P_i$ is based on the assumption that it splits a flux tube connection defining strand of a braid defining topological quantum computation. A change of the hardware of topological quantum computer would be therefore in question.

1. Suppose that ATP defines a standard plug in flux tube connections. This would mean that aromatic ring and the oxygen atoms $O =_1$, $O =_2$, and $O =_3$ of the phosphates are connected by magnetic flux tubes to a string and $O =_3$ in turn is connected to some (hydrogen bond) acceptor elsewhere, say $O =$ or aromatic ring. These flux tubes represent genuinely new physics in accordance with the fact that “high energy phosphate bonds” are not really understood in the standard chemistry.
2. The reconnection of $(O =_2) - (O =_3)$ flux tube with the hydrogen bond connecting two water molecules leads to the splitting of the flux tube so that the incoming and outgoing the flux tubes are shortcut by $(O =_2) - -H - (OH)$ resp. $(O =_3) - -H - (OH)$ hydrogen bonds (connection to ground is the analog in circuit theory). This corresponds in the usual terminology the liberation of the third phosphate: $ATP \rightarrow ADP + P_i$. P_i however remains at the end of flux tube to be attached later to another ADP.
3. The process involves also hydration. $(OH)^-$ ion joins to the third P to give P_i^{-3} and H^+ to $O - P$ in second P to give $H^+ - O$ in ADP^{-1} . The exchange of electron would lead to the final state $ADP^{-2} + P_i^{-2}$.

A possible model for the dropping of protons would be following.

1. It is absolutely essential to realize that F_1 is an open system and that naive thermodynamic considerations can lead to misunderstandings. In particular, the notion of high energy phosphate bond does not make sense. The source of metabolic energy is chemical energy used to drive protons to the atomic space-time sheets of F_1 . The function of the large negative charge of ATP is to increase the rate for the binding of ATP^{-4} to F_1 . In the classical picture the binding to F_1 is followed by the dropping of two protons to larger space-time sheet. The value of the metabolic quantum could be reduced from .5 eV to about .21 eV by the Coulombic interaction energy of proton with PO_4^- . The Coulombic binding energy of the remaining protons at F_1 with $ADP + P_i$ is smaller and the dropped proton liberates larger energy about .31 eV. In quantum picture the division of the process to this kind of sequence might not be a good approximation.
2. One function of the $ATP \rightarrow ADP$ would be to induce the dropping of the third proton from F_1 space-time sheet. Metabolic energy should make possible information processing. Second function might indeed relate to the topological quantum computation like process since the decay would correspond to a splitting of a braid strand coming to the aromatic ring of A and

proceeding along string defined by the ring and three $O =$ s of phosphates and continuing further. This would make possible TQC as a braiding for both halves of the split flux tubes. After the reconnection the total braid structure would be different.

3. The reason for why P_i leaves the catalyst site and proton is dropped (step 2) should be the in-stabilization of the bound state of positively charged proton with $ADP^{-2} + P_i^{-2}$ which does not have so strong Coulomb interaction energy with proton as ATP^{-4} . As a consequence, proton can drop to the larger space-time sheet.
4. What remains open are the details of the transformation of the chemical energy to zero point kinetic energy of protons. Remote metabolism suggests that protons send negative energy phase conjugate photons to the direction of geometric past inducing a transition of an energy carrying molecule to a lower energy state. This would mean the failure of the standard description in terms of reaction kinetics. The catabolism of nutrients is the eventual provider of the metabolic energy and the coenzyme nicotinamid adenic dinucleotide NAD^+ [I23] receives electron and the energy liberated in the catabolic reaction. In the proposed framework it is not an surprising that NAD^+ is analogous to RNA dinucleotide (perhaps as remnant from RNA era when dinucleotides defined the 2-codon code) and consists of two phosphates and adenine and nicotinamide nucleosides. The oxidation reaction $NADH \rightarrow NAD^+$ in turn liberates this energy. Protons could gain their energy by sending negative energy photons to $NADH$. Negative energy photons would propagate along “topological light rays” parallel to the flux tubes connecting the system in a precisely targeted manner to $NADH$ aromatic rings. Alfvén waves propagating along magnetic field lines would be the standard electrodynamics counterpart for these topological light rays.

Many details of the process remain open but it would seem that the key ideas of TGD based quantum vision about living matter are fused together in rather detailed manner in this picture.

4.4 Could High Energy Phosphate Bond Be Negentropic Bond With Negative Binding Energy?

Most people assign the word “love” to the word “life” as their first association. There is a notable exception to this: scientists including biologists. Un-educated layman might however wonder whether one can understand life without identifying any physical counterpart for this notion (, which could be replaced with that of compassion, sex, or ability to act synergetically or just X if some of these notions sounds less un-scientific). Certainly the word “love” stimulates a deep feeling of disgust in a reductionistically conditioned scientist. But isn’t the duty of scientist to win this kind of feelings and try to see whether this identification might be possible after all? The prize could be high: the understanding of what distinguishes between living and dead matter could change the entire culture. Who knows, maybe it could be possible to identify some poorly understood fundamental biological process allowing a quantitative model using a guess for what this physical correlate could be. The basic step of metabolism is at the core of life and indeed poorly understood, and I shall argue that the identification of the negentropic entanglement as the counterpart for the notion of love could allow to model quantitatively what happens in this process.

4.4.1 Basic ideas

Before continuing general motivating comments about implications of negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig.** ?? in the appendix of this book) are in order.

1. Ordinary bound states are stable because they have positive binding energy. One can visualize this kind of binding as a jail: the second particle resides near the bottom of a potential well. Organized marriage is a social analogy for this situation. Negentropic entanglement makes possible bound states for which binding energy can have and perhaps even has always a wrong sign. The state is not prevented from decaying to free particles in state function reduction by energy conservation: Negentropy Maximization Principle (NMP) [K22] takes care that

they remain correlated. The social analogy would be a voluntary marriage based on love. Partners are completely free to leave but want to stay together. One implication could be explanation for the stability of highly charged basic molecules of life such as DNA and ATP.

2. The presence of the negentropic entanglement implies the directedness of the biological processes since the outcome of the state function reduction would be far from random since the behavior of negentropic bonds could be almost deterministic. In the case of time-like entanglement this would select only particular initial final state pairs so that determinism would emerge also in this sense and could lead to almost deterministic irreversible cellular automaton behavior characteristic for the living matter very different from the reversible determinism of classical physics and very difficult to understand in quantum context.
3. The determinism would of course be only partial and would allow volition not spoiled by randomness of quantum jump. This would provide a general explanation for the ability of the living matter to overcome the second law basically implied by quantum randomness predicted by the standard quantum theory. This would happen in time scales shorter than the time scale of the appropriate causal diamond (CD) only but one would have hierarchy of CD meaning that in arbitrary long time scales there are levels of hierarchy at which second law is broken. The hierarchy of Planck constants would be also crucial since it would allow zooming up to arbitrarily long time scale. Non-equilibrium thermodynamics and cellular automaton models could be seen as phenomenological descriptions for the actual breaking of second law in the intersection of real and p-adic worlds.
4. High energy negentropic bonds need not be present only in phosphates. O=s are present in all important biomolecules. Phosphates are present in DNA. Each peptide bond in amino-acid polymer contains O=. Also sugars contain it. Maybe O= indeed acts as a universal plug defining then ends of negentropic flux tube bonds between biomolecules. For instance, protein folding for which a possible model is discussed in [K2] from different view point could be more or less deterministic cellular automaton like process if the bonds are negentropic. Negentropic entanglement would also guarantee the stability of the folding pattern. Certainly the assumption that the process is random -as standard quantum theory would suggest- leads to Levinthal paradox stating that the rate of the process is quite too slow. The simplest possibility is that the flux tube bonds are between O=s of subsequent amino-acids before folding and the folding process involves formation of reconnections possibly drawing by a reduction of Planck constant certain amino-acids near to each other. O=s could also act as plugs connecting protein to other biomolecules. One must however notice that many neurotransmitters, hallucinogens, and alcohol having strong effects on consciousness have O-H groups instead of O=s. This inspires the question what happens to the flux tube in $O=\leftrightarrow O-H$ process.

4.4.2 General formulation of the model

Consider now the model. High energy phosphate bond (see <http://tinyurl.com/yar7zv7j>) [I17] assigned with the two outer-most phosphates of ATP (see <http://tinyurl.com/clnu4>) [I3] is fundamental for the basic processes in living matter. The $ATP \rightarrow ADP + P_i$ liberates metabolic energy loaded to ATP in the cellular respiration process (see <http://tinyurl.com/yyvrpb>) [I7] or its equivalent and occurs again and again and defines a kind of Karma's cycle in living matter. The phosphate bond is assumed to have a high energy content liberated as ATP is hydrated to ADP (see <http://tinyurl.com/5w7cud>) [I2] and phosphate ion (see <http://tinyurl.com/2xbv3y>) $P_i = PO_4^{3-}$ [I29]. The notion of high energy phosphate bond has been however challenged as being meaningless [D4, D1], [I45].

1. One can of course consider a high energy bond for which the interaction potential looks like a well at the top of mountain and spin glass degeneracy of quantum TGD would certainly allow to consider this kind of notion. I do not know whether models realizing this idea concretely have been really constructed.
2. My earlier proposal for $ATP \rightarrow ADP + P_i$ process is inspired by the notion of many-sheeted space-time and p-adic length scale hypothesis making sense in the intersection of real and

p-adic worlds and involves the dropping of protons (or electrons) to larger space-time sheets and driven back in oxidative metabolism. The energy liberated in this process corresponds to the zero point kinetic energy of protons (or electrons), which is smaller at the larger space-time sheet. The maximum value of zero point kinetic energy is predicted to be $E_0 \simeq .5$ eV for $k = 137$ in the case of proton and for $k = 148$ in the case of electron (for electron the energy would be by a factor $2^{-11}m_p/m_e \simeq .94$ smaller).

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

3. With an inspiration coming from DNA as topological quantum computer model [K15] I have also proposed that the magnetic flux tubes connecting bio-molecules to each other define a kind of Indra’s net plays a key role in the biological information processing. For instance, topological quantum computations could be realized in terms of braids formed by flux tubes [K15, K2]. O=: s associated with phosphates would serve as universal plugs to which flux tubes could be connected connecting intronic nucleotides and lipid layers of nuclear or cell membrane. In particular, the innermost O= of *ATP* could be connected by a flux tube to any biomolecule needing metabolic energy- say some catalyst or the F_1 machine central for energy metabolism. The reduction of Planck constant would bring *ATP* and biomolecule near each other and lead to a formation of a weakly bound state making catalytic processes possible. The outer O=: s of the *ATP* molecule could be connected by a flux tube to each other, which could be rather long loop. This flux tube could provide the new physics realization of the high energy phosphate bond.
4. *ATP* (P_i) has 4 (3) units of negative charge and at least ordinary layman might wonder why this does not induce instability. Similar problem is encountered in the case of DNA, which contains two units of negative charge per nucleotide. This particular problem is regarded as completely real. The idea about life as something in the intersection of real and p-adic worlds [K29] raises the question whether these high energy states could be made possible by the presence of negentropic bonds- most naturally associated with the flux tubes with large \hbar . This love marriage would stabilize *ATP*, *ADP*, and DNA and other charged biomolecules. The presence of phosphates would be a clear-cut signature of this stabilization mechanism. Also proteins involve phosphates playing a key role in the bio-control: typically phosphorylation activates or de-activates the protein and is also involved with the generation of signal pathways. Why this happens would be easy to understand in Indra’s net model.
5. In $ATP \rightarrow ADP + P_i$ transformation the energy carried by the negentropic bonds would be liberated but leave the flux tube bonds negentropic. Cell respiration would take care of the loading of the batteries with negentropic metabolic energy. This would involve also the kicking of protons back to the smaller space-time sheets. Also the molecular lovers *ADP* and P_i would find each other again as the Planck constant for the flux tube connecting them would be reduced during the cellular respiration transform *ADP* and P_i back to *ATP*.

4.4.3 Quantitative estimates

Consider now a more detailed model for $ATP \rightarrow ADP + P_i$. The binding of *ATP* to the catalytic site involves several steps. I have described them in the previous section and in the following add to this template the interpretation suggested by the proposed picture.

1. **Step 1** : The binding $ATP + F_1 \rightarrow ATP \cdot F_1$ to the catalyst site is a complex process involving the break-up of the hydrogen bonds between cellular water and *ATP* molecule and cell water and catalyst site and generation of hydrogen bonds between catalyst site and *ATP*

molecule. In TGD framework this means that protons can be kicked to and dropped back from atomic space-time sheets. Only the net number of protons dropped however matters.

This process involves a liberation of Gibbs free energy per single attachment, which is about $\Delta g_{ATP} = .42$ eV. It was earlier believed that this energy is liberated instantaneously but the findings about the behavior of the F_1 motor coupled to dissipative load, lead Oster and Wang to suggest that the process is more complex and starts from a loose binding and ending up to a strong binding [I47].

Comment: One can question the assumption that strong binding is generated. Instead of binding proton or electron would be dropped to a larger space-time sheet and liberate zero point kinetic energy.

- (a) The simplest interpretation in the proposed picture is that the negentropic flux tube connecting ATP and F_1 molecule and behaving as high energy phosphate bond associated with the innermost O= is contracted via the reduction of Planck constant. Then proton is dropped from $k = 137$ space-time sheet to a much larger space-time sheet and liberates metabolic energy quantum $E(137) \simeq .5$ eV. Another possibility is that electron at $k = 148$ space-time sheet is dropped. This process would replace the instantaneous generation of binding energy and in zero energy ontology the time scale for this process would correspond to the time scale of appropriate causal diamond (CD).
- (b) Instead of single particle energy macroscopic Gibbs energy $G = E + PV - TS$ is the useful notion now since macroscopic quantities of matter are studied and pressures and temperature are typically constant in the situations considered ($dG = -SdT + VdP$). G is minimized for constant T and P prevailing in the situation considered.
- (c) In the attachment of ATP to catalyst S is reduced and a good guess is that volume is not affected so that PV term does not change. From this one can deduce that the liberated energy per catalyst particle -call it $\Delta e = e_i - e_f = \Delta g - T\Delta s$ (i and f refer to initial and final states) satisfies $\Delta e > \Delta g = .42$ eV.
- (d) One must estimate the value of Δe . The attachment reduces the kinetic energy of relative motion of catalyst and ATP to zero. If it makes sense to speak about thermal equilibrium for ATP an catalyst in translational degrees of freedom the reduction of kinetic energy is $\Delta e_K = 3T/2$, which is of order .045 eV at room temperature. Whether this energy remains in the catalyst- ATP system or is it liberated in the process is not clear. The energy liberated in the dropping of the proton or electron gives a contribution $\Delta e = E_0 = .5$ eV. This gives the condition

$$\Delta g_1 = E_0 + 3T/2 - T\Delta s = .42 \text{ eV} . \quad (4.1)$$

If the liberated kinetic energy remains in the system, the first guess is $\Delta e = E_0 = .5$ eV, where E_0 is the nominal value of zero point kinetic energy. This would give for $T\Delta s$ the estimate $T\Delta s = .08$ eV about 3 times thermal energy corresponding to three translational degrees of freedom. This looks rather reasonable order of magnitude estimate.

- (e) NMP suggests-maybe even requires- that the bond remains negentropic. The binding energy associated with ATP - catalyst binding could be small- of the order of thermal energy about .045 eV.

2. **Step 2** Hydrolysis: $F_1 \cdot ATP \rightarrow F_1 \cdot ADP \cdot P_i$. The change of free energy is small during this step: $\Delta G \sim 0$.

Comment: The simplest option explaining the fact that the change of energy is small is that hydrolysis leaves the flux tube between outer O=: s of ATP intact and removes only the P-O-P bond. This flux loop could have rather large \hbar .

3. **Step 3** : Ortophosphate is released from the catalyst site: $F_1 \cdot ADP \cdot P_i \rightarrow F_1 \cdot ADP + P_i$. Free energy $\Delta G \sim .31$ eV is liberated at this step.

Comment: The simplest option is that the negentropic flux tube liberates its energy but remains negentropic. The increase of Planck constant might be involved.

- (a) The value of Δe is now smaller than ΔG , which suggests that the metabolic energy quantum in the case of proton corresponds to $\Delta e = E(139) \simeq .25$ eV. The average change of kinetic energy can be assumed to be equal to thermal energy in final state and is same as above. This gives the condition

$$\Delta g_2 = E_0/2 - 3T/2 + T\Delta s = .32 \text{ eV} .$$

- (b) By adding this equation with the similar equation for Step 1 (see Eq. 4.1) one obtains the condition

$$\Delta g_1 + \Delta g_2 = 3E_0/2 = .74 \text{ eV} .$$

This gives $E_0 = .49$ eV so that the model seems to be internally consistent.

4. **Step 4** : ADP is released from the catalyst site: $F_1 \cdot ADP + P_i \rightarrow F_1 + ADP + P_i$. $\Delta G \sim 0$ holds true also for this process.

Comment: \hbar increases back to the original value for the innermost flux tube which could it still have small positive energy and be negentropic.

The model would predict that ADP and P_i and remain highly correlated (connected by flux tubes) as do also AXP and F_1 . These predictions should be testable by marking ADP and P_i of ATP with the same “color” (say radioactively) and finding whether the colors of ADP and P_i remain the same during the subsequent cycles or whether they mix immediately. These love affairs at molecular level could be modified only by reconnections of flux tubes as also in human relationships. For instance, two ADPs could exchange their P_i s or F_1 s. Negentropic entanglement could guarantee the highly organized and directed nature of basic bio-catalytic processes.

4.5 Directed Attention And Metabolism

There must be a connection between metabolism and generation and/or re-arrangement of flux tubes responsible for negentropic entanglement: quantum criticality and hierarchy of Planck constants would also be involved. In the following I try to formulate this gut feeling more precisely.

1. We assign information to self-organization patterns. Energy feed is necessary to build non-trivial self-organization patterns as far from thermal equilibrium states and in this case negentropy is thought of as the deviation of entropy from its maximum value in thermodynamical equilibrium. When a new pattern is generated, the system is driven to criticality (quantum criticality in TGD) so that a new self-organization patterns are generated.
2. The recent, view about NMP means generating entanglement for which one has large number of eigenstates of density matrix of subsystem entangled with second one. The eigenvalues of the density matrix are exactly identical implying that the entanglement probabilities are equal to $p = 1/N$, N integer. This is a very strong condition and requires some kind of criticality. This means also maximal entanglement. For primes dividing N one obtains negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig.** ?? in the appendix of this book).
3. Intuitively it is clear that a large representative power requires a large number of degenerate states with essentially same physical properties. A natural possibility suggested by the interpretation of hierarchy of effective values of Planck constant and by the failure of the strict determinism of Kähler action is that these degenerate states correspond to particle states localized at different sheets of N -furcation of Kähler action meaning N -branching of preferred extremal. Two systems of this kind can entangle negentropically. Therefore ability to have negentropic entanglement with N -fold degeneracy and $\hbar_{eff} = N\hbar$ would accompany each other: this would give the long-sought precise connection between hierarchy of Planck constants and negentropic entanglement.

Could $\text{ATP} \rightarrow \text{ADP}$ feed to the system only energy making its space-time sheet critical against the generation of N -furcation? This option does not look attractive. The effects of what ATP gives should be something independent of the receiving system. If it is only energy, this is not the case. Could the ability to generate negentropic entanglement in standard manner be the real gift of ATP. Or could $\text{ATP} \rightarrow \text{ADP}$ be responsible for generating directed attention realised in terms of flux tube connections?

1. Generation of directed attention coupling two molecules to single quantum coherent system seems to be the basic operation in living matter. Reconnection of the Indra's web defined by flux tubes as $AC + BD \rightarrow AD + BC$ is the basic process generating attention; now between A and D and B and C . This is actually the fundamental braiding operation and crucial also in topological quantum computation. Could $\text{ATP} \rightarrow \text{ADP}$ generate attention between some system connected to the phosphate of ATP and the system receiving the phosphate?
2. One can build a toy model for what is needed to build a wormhole flux tube connection between systems A and B and thus generate $N = 2$ negentropic entanglement between them. Consider wormhole flux tubes identified as $N = 2$ -furcations giving rise to negentropic entanglement. Make following assumptions. ATP can be regarded as ADP connected to P by small loop-like flux tube L_1 . P is connected to system A by a flux tube. The receiving system B has flux loop L_2 beginning and ending from it. With these assumptions the reconnection process for L_1 and L_2 creates a flux tube connection between A and B and ADP becomes connected with B . The reconnection of ADP-B with phosphate having self-loop creates ATP-B. At the next step B can be connected to system, say, C in the similar manner. The process would continue in this manner building an attention sequence A-B-C-...
3. One can also consider multi-furcations of wormhole flux tubes to get higher even values of N . Two systems connected by flux tubes can negentropically entangle with N sheets of N -furcation being analogous to the different spin states of two entangled spins.
4. Can phosphate bond have varying value of N and \hbar_{eff} by previous argument so that one could speak about evolutionary level of ATP? $N = 2$ and $p = 2$ -adicity would be of course, the simplest possibility. By feeding several phosphate bonds one would obtain 2^N -furcations and Boolean algebra like structures.

This is not the only interpretation of negentropic entanglement that I have considered. In the model for Becker's DC currents (see <http://tinyurl.com/ybnjk9bq>) [L4] I have considered an alternative possibility: in this case metabolic energy feed would excite a negentropically entangled state of cyclotron Bose-Einstein condensate at magnetic flux tube.

5 Many-Sheeted Model For Photosynthesis

Photosynthesis is a fundamental metabolic function and a many-sheeted model allows to concretize the general ideas about quantum metabolism. What happens in photosynthesis at the level of energy balance seems to be relatively well-understood [I38, I32] but the detailed molecular mechanisms remain obscure. Several strange features, such as the appearance of electron pairs, suggest that super-conductivity and atomic and molecular Bose-Einstein condensates are involved. p-Adic length scale hypothesis gives very strong quantitative guidelines in the attempt to understand photosynthesis in many-sheeted space-time, and one ends up to a general view about how Bose-Einstein condensates store metabolic energy as zero point kinetic energy and how this energy is utilized by remote metabolism by generating negative energy MEs. What is so remarkable is that the resulting extremely simple model of photosynthesis is successful both at qualitative and quantitative level.

5.1 A Rough Overall View About Photosynthesis

The photosynthesis in eukaryotes occurs in chloroplasts, which are the counterparts of mitochondria in animal cells and contain photosynthetic pigment-protein complexes [I38, I32]. Prokaryotes do

not possess chloroplasts and it is believed that chloroplasts are ancient prokaryotes captured by eukaryotic cells. In both cases the crucial structures are membranes.

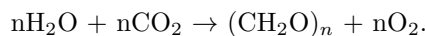
There is an antenna system harvesting photon energy. Antennae are photosensitive pigments sensitive to visible light (400-700 nm). In some bacteria pigments are also sensitive to infrared light in the wave length range 700-1000 nm. The energy is transmitted in electromagnetic form to the so called reaction center. Antenna pigments as well as reaction center pigments are bound to proteins. After the light is transmitted to chlorophylls it excites electron pairs in turn transferred between pigments.

Oxygen producing plants have two photo-systems, photo-system I present also in plants not producing [J6] [I38, I32]. These photo-systems have several tasks to perform.

1. To store the energy of photons permanently to various energy carrying molecules, in particular glucose. Photo-system I takes care of this. Besides hydrogen carbon dioxide serves as the basic raw material of these molecules. The covalent double bonds between carbon and oxygen are reduced in the process. The photons excite in the reaction center of photo-system I electron pairs transferred to NADP^+ to give NADPH which transfers electrons and metabolic energy to where they are needed. Photo-system II draws electron pairs from water and feeds them to the photo-system I to compensate the electrons lost in the generation of NADPH. As water molecules lose two electrons, oxidation happens which means the generation of O_2 molecules. The production of oxygen utilized also by plants themselves is a further basic function of plants.
2. To store photonic energy temporally by transforming ADP molecules to ATP molecules to be used for various purposes. In the photo-system I the electrons can also circulate energizing *one* ADP molecule to ATP per electron pair whereas photo-system II energizes *two* ADP molecules per electron pair to ATP molecule.

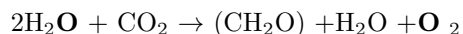
The overall reaction balance equations for photosynthesis deserve a consideration.

1. The overall reaction equation reads as

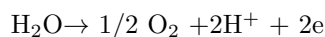


$n = 6$ corresponds to hexoses, in particular glucose, which are the basic products of molecular synthesis and carriers of the metabolic energy.

2. A more precise form of the reaction equation is

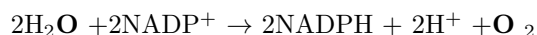


O means that free oxygen derives from water rather than from carbon monoxide which enters to the reaction much later than the oxidation of water. The oxidation of water



indeed happens in photo-system II and provides the electron pair to compensate the electron pair lost by the photo-system I.

3. Hill's equation



tells what happens in photo-system I before CO_2 enters the game. The equation tells that the oxidation of two water molecules providing two electrons and two hydrogen atoms for two NADP^+ ions happens first (for basic facts about NADP molecules see [I24]). NADPH carries then the electrons and hydrogen atoms to the process leading to the formation of say glucose.

5.2 A General Model For Energy Storage And Energy Utilization By Remote Metabolism

It is good to formulate first a general model for energy storage and utilization based on remote metabolism.

1. Metabolic energy can be stored as zero point kinetic energy to various space-time sheets. The storing particles form Bose-Einstein condensates so that the energy storage is analogous to a population inversion in laser. Bose-Einstein condensates of electronic Cooper pairs, H atoms, H₂ atoms and protonic Cooper pairs, O and O₂ atoms, ... are possible. The dropping of a particle to a larger space-time sheet liberates a standardized energy quantum. Since Bose-Einstein condensate is in question, this process can occur coherently which allows high metabolic power. Electronic Cooper pairs kicked to $k = k_{ex} < 151$ space-time sheet from $k = 151$ cell membrane space-time sheets are involved with photosynthesis.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

2. Remote metabolism provides an elegant manner to utilize the stored energy. The user must only send negative energy ME at energy sufficiently near to the energy currency. This implies a highly economical use of the metabolic energy. For instance, when an enzyme needs energy, it generates negative energy ME activating ADP to ATP by kicking proton to the atomic $k = 137$ space-time sheet. In this case .5 eV plus possibly an additional energy .34 eV to kick phosphate ion to $k = 131$ space-time sheet is needed. As already found, the model for the ATP → ADP transformation favors a situation in which space-time sheets involved are linear structures with thickness $L(137)$ and $L(139)$ predicting that the kicking of single proton gives rise to energy .25 eV.

“Seesaw” mechanism minimizes the waste of metabolic energy since the same energy can be used repeatedly [K27]. In the simplest situation two users send repeatedly negative energy MEs for each other and dissipative losses are minimized.

Energy and momentum conservation deserve separate comments.

1. Momentum conservation requires that the kicked particles interact with the Bose-Einstein condensate so that it can receive the momentum of ME. The resulting energy transfer to the condensate is very small, a fraction p/M about the energy of ME.
2. It is of paramount importance to realize that the particles of the Bose Einstein condensate cannot be free. This assumption would lead to contradictions since atomic binding energies are more than order of magnitude larger than metabolic energy quantum. This means that Cooper pairs must possess a binding energy not too far from that possessed the spin-paired valence electrons of water molecule.

Hence the pairs of valence electrons form Bose-Einstein condensates at larger space-time sheets $k = k_{gr}$ are analogous to the de-localized valence electrons in metal. In the excitation of electrons $k_{gr}(i) \rightarrow k_{ex}(i)$, $i = I, II$ the binding energy of electron pair (electron) is not changed appreciably. Also electronic Cooper pairs have their binding energy with Opp system since the nuclear charge is still there, and are de-localized like electrons in metal. Hence there are two separate de-localizations involved and naturally allowed by the many-sheeted space-time. The system is nearest to water if oxygen appears in atomic form.

5.3 The General Model For Photosynthesis

The model for the energy storage and utilization by remote metabolism in living matter is stupendously simple and equally simple is the many-sheeted model for photosynthesis resulting as a by-product.

5.3.1 A more detailed model for photosynthesis

The existing ideas about remote metabolism and p-adic length scale hypothesis provide useful hints concerning what happens in the process.

1. The appearance of electrons as pairs is a hint about the presence of electronic super-conductivity.
2. The basic constraint is that single electronic Cooper pair gives rise to single ATP in the case of photo-system I and 2 ATPs for photo-system II. Accepting the proposed model predicting that dropping $k = 137 \rightarrow 139$ of single proton liberates .25 eV and 3 protons drops in single ATP \rightarrow ADP transition, one has that in photo-system I the increment of zero point energy for electronic Cooper pair should correspond to .75 eV at least and in photo-system II to 1.5 eV at least.
3. If the dropping of electron Cooper pairs is the mechanism liberating the zero point kinetic energy in both cases, this gives $k_{gr}(I) = k_{gr}(II) + 1$. Assuming $k_{ex}(i) = k_{gr}(i) - 2$ and the absence of energy losses the conditions $\Delta E_0(e, I) = 3\Delta E_0(p) = .75$ eV and $\Delta E_0(e, II) = 6\Delta E_0(p) = 1.5$ eV give

$$(k_{ex}, k_{gr})(I) = (147, 149) \quad , \quad (k_{ex}, k_{gr})(II) = (146, 148) \quad .$$

For larger values of $k_{gr}(I)$ the metabolic quanta approach to the limits 1 eV and 2 eV.

4. The objection against this model is that single Cooper pair cannot generate to ATP molecules in single stroke. This encourages to consider the option $(k_{ex}, k_{gr})(II) = (148, 151)$ assuming that electron Cooper pairs decay at $k = 148$ space-time sheet and then drop to $k = 151$ space-time sheet. Because one has $\Delta E_0(e, 148) = \Delta E_0(2e, 147)$ and the electrons drop separately, the energy yield is twice that for a Cooper pair. The decay of the Cooper pair would be induced by the absorption of photon naturally since photon energy would be about two times higher than in the case of photo-system I.
5. The most natural p-adic space-time sheets carrying permanent Cooper pair condensates would be $k_{gr}(I) = 151$ giving $\Delta E_{2e} .86$ eV consistent with the upper bound .84 eV liberated as single ATP molecule is used. Same result is obtain in photosystem II. That ground state space-time sheets correspond to different p-adic primes would guarantee that photo-systems I and II are separate even when they have (apparent) spatial overlap.

The model for the effective axonal super-conductivity [K8] supports the view that the BE-condensate residing at $k = 151$ cell membrane space-time sheet is a fundamental electronic Cooper pair BE condensate since the p-adic prime characterizing the fundamental condensate is that for which thermal kicking of Cooper pairs to space-time sheets with smaller p-adic prime are not possible.

5.3.2 A model for the functioning of photo-systems

The previous considerations lead to the following model for the functioning of the photo-systems.

1. The function of the antenna system is to collect energy and store it to chlorophyll molecules by kicking electronic Cooper pairs from $k = k_{gr}(i)$ space-time sheet to $k = k_{ex}(i) < 1$, $i = I, II$ space-time sheets. Antenna pigments could generate MEs transferring the photonic energy to the reaction center as Bose-Einstein condensed photons.
2. Photo-systems II and I act in series. Photo-system II creates oxygen and generates 2 ATP molecules per electron pair whereas photo-system I is responsible for electron transfer and generates NADPH molecules. In the absence of photo-system II it generates only single ATP molecule per electron pair.
3. For both photo-systems chlorophyll acts as a population inverted many-sheeted laser receiving radiation, which inverts the electronic Cooper pair population. Energy storage reduces to the kicking of electrons to $k = k_{ex}(i)$, $i = I, II$, space-time sheet so that they get energy of 1 eV per electron.

4. The primary energy quanta absorbed from the solar radiation differ from the 2 eV and 1 eV energy currencies defined by Cooper pairs and electrons, and one can wonder how the transformation to standardized quanta occurs. Chlorophyll transition is certainly responsible for the absorption of quantum and the whole spectrum of visible light is involved. The question is how the absorbed energy of the chlorophyll is transformed to 2 eV or 1 eV quanta in the population inversion for electronic Cooper pairs. One could guess that the excited chlorophyll system generates ME bridges with energy 2 eV allowing the Cooper pairs to flow from $k = k_{gr}(i)$ to $k = k_{ex}(i)$ space-time sheet, $i = I, II$. In consistency with the seesaw mechanism, this emission would most naturally result from the dropping of electronic Cooper pairs from $k = k_{ex}(i)$ to $k = k_{gr}(i)$ space-time sheets induced by the absorption of photonic energy by chlorophyll.

5.3.3 What happens in the oxidation of the water molecules?

The oxidation of water is perhaps the most mysterious aspect of photosynthesis. The equation $H_2O \rightarrow 1/2 O_2 + 2p + 2e$ serves only book-keeping purposes and serious consideration of what might happen generates doubts about whether standard chemistry allows to understand what is involved. Since it is O_2 molecules which are produced, at least two water molecules are needed for the equation to make sense.

This observation suggests that collective effects are of importance, and one is almost unavoidably led to ask whether Bose-Einstein condensates of H, protonic and electronic Cooper pairs, H_2 , O, and O_2 at larger space-time sheets might be involved. If the Bose-Einstein condensates of O_2 and electronic Cooper pairs are involved, situation simplifies dramatically. The model for sol-gel phase transition already led to the tentative idea that Bose-Einstein condensates of hydrogen atoms could be present in the cellular water. Only a small fraction of O_2 , H_2 , H, 2p and 2e would reside at larger space-time sheets. O-, O_2 - and protonic Bose-Einstein condensates might perhaps make water some kind of liquid crystal structure for which electronic Cooper pairs are de-localized like electrons in metal and thus experience the Coulomb force. Also H atoms forming local bound states with O atoms could be de-localized just like valence electrons in the metal lattice.

In this framework oxygen production in photosynthesis could be seen as automatic side product due to the leakage of the O_2 molecules from the system. The sucking of electronic Cooper pairs from the Bose-Einstein condensate associated with water perturbs the critical system and O_2 molecules can be evaporated unless they are utilized by the system itself. The evaporation of O_2 molecules would correspond to the dropping of O_2 molecules to some larger space-time sheet giving at the same time a recoil momentum for the electronic Cooper pair so that it can enter to the reaction center to compensate the excited Cooper pair. The energy in question would be about .0039 eV.

5.4 Applying The General Model Of Energy Storage And Utilization To Ionic Pumps

The general model allows also to understand the value of the cell membrane resting potential.

1. The $k = 139$ Bose-Einstein condensate of hydrogen atoms would be responsible for .125 eV energy quantum crucial for sol-gel phase transitions controlled by micro-wave MEs. Also electronic Cooper pairs at $k = 147 = 3 \times 49$ space-time sheet liberate same energy when dropping to larger space-time sheets.
2. H_2 and/or Cooper pairs of protons correspond to energy of .0625 eV (recall that there is small numerical uncertainty involved). Also electrons dropping from $k = 149$ lipid layer space-time sheet liberate this energy. Since the resting potential is .065 eV, this energy is very near to the energy needed/gained by singly charged particle when it traverses cell membrane. The zero point kinetic energy .125 eV of H atoms in turn correspond to the energy needed to carry doubly charged ion such as Mg^{2+} or Ca^{++} through the cell membrane. This leads to the hypothesis that the TGD counterparts of ionic pumps are based on remote metabolism, that is sending of negative energy MEs inducing the dropping of H, H_2 and possibly 2p from $k = 169$ space-time sheet or dropping of electronic Cooper pair from $k = 149$ and electron from $k = 151$ space-time sheet.

5.5 Quantum Coherence And Photosynthesis

During years the experimentation to test the presence of quantum effects in living matter has begun. And the positive evidence is accumulating. In Discover magazine there is an article titled *Is Quantum Mechanics Controlling Your Thoughts?* [I46] telling among other things about the latest direct evidence of quantum effects provided by experiments related to photosynthesis.

The article summarizes in popular terms the contents of the paper *Evidence for wavelike energy transfer through quantum coherence in photosynthetic systems* by Fleming and collaborators [I39] reporting evidence for quantum coherence in photosynthesis. The absorption of photon induces electron current from the point of capture- chlorosome- to the reaction centers. The semiclassical theory predicts the dissipation of the electronic energy to be about 20 per cent whereas the observed dissipation is only about 5 per cent. This suggests quantum coherence. The following abstract of the original article summarizes the essentials.

Photosynthetic complexes are exquisitely tuned to capture solar light efficiently, and then transmit the excitation energy to reaction centres, where long term energy storage is initiated. The energy transfer mechanism is often described by semiclassical models that invoke “hopping” of excited-state populations along discrete energy levels. Two-dimensional Fourier transform electronic spectroscopy has mapped these energy levels and their coupling in the FennaMatthewsOlson (FMO) bacteriochlorophyll complex, which is found in green sulphur bacteria and acts as an energy “wire” connecting a large peripheral light-harvesting antenna, the chlorosome, to the reaction centre. The spectroscopic data clearly document the dependence of the dominant energy transport pathways on the spatial properties of the excited-state wave functions of the whole bacteriochlorophyll complex. But the intricate dynamics of quantum coherence, which has no classical analogue, was largely neglected in the analyses even though electronic energy transfer involving oscillatory populations of donors and acceptors was first discussed more than 70 years ago¹¹, and electronic quantum beats arising from quantum coherence in photosynthetic complexes have been predicted and indirectly observed. Here we extend previous two-dimensional electronic spectroscopy investigations of the FMO bacteriochlorophyll complex, and obtain direct evidence for remarkably long-lived electronic quantum coherence playing an important part in energy transfer processes within this system. The quantum coherence manifests itself in characteristic, directly observable quantum beating signals among the excitons within the Chlorobium tepidum FMO complex at 77 K. This wavelike characteristic of the energy transfer within the photosynthetic complex can explain its extreme efficiency, in that it allows the complexes to sample vast areas of phase space to find the most efficient path.

The popular article translates the article to the following piece of text.

To unearth the bacteria’s inner workings, the researchers zapped the connective proteins with multiple ultra-fast laser pulses. Over a span of femto seconds, they followed the light energy through the scaffolding to the cellular reaction centers where energy conversion takes place. Then came the revelation: Instead of haphazardly moving from one connective channel to the next, as might be seen in classical physics, energy traveled in several directions at the same time. The researchers theorized that only when the energy had reached the end of the series of connections could an efficient pathway retroactively be found. At that point, the quantum process collapsed, and the electron’s energy followed that single, most effective path.

My own interpretation would be following.

1. *Remarkably long lived electronic quantum coherence* is claimed to be present. Authors propose that quantum computation like process -quantum random walk [I10] - could be in question. If I have understood correctly, the proposed process can halt only by a state function reduction localizing the electron at the reaction center. Completely standard Schrödinger evolution in the network would be otherwise in question. The good news is that the average time to find from the entrance to exit in this kind of process is exponentially shorter than in the classical random walk. One can say that exit plus all other points are always reached after some minimum time and it is enough to perform the state function reduction localizing the electron to the exit.
2. Somewhat confusingly, the popularizers claim that the authors argue (I do not have access to the original article) that the quantum random walk selects the shortest path from the chlorosome to the reaction center is in question. Quantum collapse is a non-deterministic

process and if it selects the path in this particular case it can select any path with some probability, not always the shortest one. The selection of the shortest path is not necessarily needed since the quantum random walk with fixed entrance and exit is by its inherent nature exponentially faster than its classical counterpart. The proposed interpretation makes sense only if the state function reduction takes place immediately after the electron's state function at the exit becomes non-vanishing. Does it? I cannot say.

If one accepts this view, the sole problem is to understand how macroscopic quantum coherence is possible in the length scales considered. There are good arguments supporting the view that this is not the case for the ordinary quantum mechanics. In TGD framework the hierarchy of Planck constants [K16] suggests that both macroscopic quantum coherence and very low dissipation rate are due to the large value of \hbar for electrons. For instance, for $\hbar = 5 \times \hbar_0$ the naive estimate is that dissipation rate should reduce by a factor 1/5 and coherence times and lengths should increase by a factor 5. I have proposed much larger values of \hbar in the model of living system.

5.6 Pollack's mechanism and photosynthesis

An obvious idea is that Pollack's mechanism is the predecessor of photosynthesis [K20] [L8]. The question is therefore whether photosynthesis could involve the formation of exclusion zones (EZs) by the analog of whether photosynthesis could involve the formation of exclusion zones (EZs) by the analog of Pollack's mechanism [I37, I49, I48] (see <http://tinyurl.com/oyhstc2> leading to charge separation taking place also in photosynthesis. Pollack's mechanism creates in presence of radiation and water bounded by a gel at the boundary of water and gel an EZ, which is a layer negatively charged water with effective stoichiometry $H_{1.5}O$ consisting of layers with hexagonal structure. The TGD inspired proposal is that hydrogen bonded pairs of H_2O molecules are formed and that each of them loses one proton as dark proton at magnetic flux tubes outside EZ. The notion of many-sheeted space-time and topological field quantization are essential elements of the proposal. Same phenomenon could be caused also by irradiation by sun light.

The light dependent step $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ of photosynthesis pumps protons through thylakoid membranes (for an illustration see <http://tinyurl.com/ycccu6uf>). The electrons excited by photons of sunlight are transferred along electron transport chain and lose energy used to pump protons through the thylakoid membrane and being thus transferred from stroma to grana against electric gradient. ADP transforms to ATP as these protons return to back through ATP synthase. This step is repeated again and again.

Could dark protons created by the analog of Pollack's mechanism be involved with photosynthesis? In what step the protons are transformed to dark protons by this mechanism?

1. The model of cell membrane leads to a proposal that pumps and channels quite generally are dark magnetic flux tubes and protons (and also other ions) are transferred through them as dark protons (dark ions). This would imply almost dissipationless transfer.
2. The protons are pumped as dark protons through the thylakoid membrane along dark magnetic flux tubes serving as pumps using the energy provided by electrons flowing down in the electron chain. The dark protons return from grana through ATP synthase as dark protons as ATP is generated and transform with some rate back to ordinary protons in stroma. Otherwise the fraction of dark protons would steadily increase.
3. This leaves two options under consideration. Already the step $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ step $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ creates dark protons by a generalization of Pollack's mechanism or this step creates ordinary protons transformed by Pollack's mechanism to dark protons as they are transferred to dark magnetic flux tubes serving as pumps. The first option looks more plausible.

What is interesting is the electron transport chain is involved also with the cellular respiration. There are various light therapies using red or IR light, and they seem to provide basically metabolic energy. Cells would act like plant cells and the analog of photosynthesis could be in question. This would explain the claims that the members of some religious cults can practically live utilizing only sunlight. I have actually proposed that analog of photosynthesis storing the energy by $ADP + P_i \rightarrow$

ATP type process using standard machinery could be actually involved and transfer the energy of IR light to metabolic energy further distributed by ATP.

The metabolic machinery for cellular respiration contains so called oxidative phosphorylation (OP) as a basic step: OP adds to ADP a phosphate giving metabolic currency ATP. ATP in turn distributes the metabolic energy further. OP uses electron transport chain to transfer metabolic energy from NADH by $NADH \rightarrow NAD^+H^+ + 2e^-$. The electrons go through the electron transport chain as in photosynthesis and transfer protons outside the mitochondrial membrane very much like through thylakoid membrane in photosynthesis. The protons return through ATP-synthase and induce $ADP + P_i \rightarrow ATP$.

The metabolic energy must come from somewhere and OP indeed follows Krebs cycle in which the energy is extracted from nutrients and given to the NADP molecule. The photon energy could be fed directly to OP electron transport chain just as photon energy is transferred to this chain in photosynthesis. The presence of electron transport chain is necessary and one must feed the electrons and protons to this chain somehow.

1. Could the analog of photosynthetic reaction $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ with visible photons replaced with IR photons produce dark protons? Whether this is energetically possible and whether the electrons have high enough energies to drive the dark protons through the membrane is far from clear. One can of course imagine, that the number of pumped protons per electron is lower than usually.
2. A mechanism that I have called quantum credit card or remote metabolism [K20] looks more plausible. The splitting $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ could occur - not by absorption of positive energy photon but by emission of negative dark IR photon with the energy of visible photon. Cell would actively suck metabolic energy from IR light source. The emitted dark negative energy IR photon would decay to ordinary IR photons in reverse time direction, which would look like fusion in standard time direction and is thermodynamically non-favoured. ZEO predicting kind of syntropic processes to occur in living matter would be an essential prerequisite.

At deeper level metabolic energy might correspond to negentropic entanglement and thus information. Information could be the basic metabolic currency.

5.7 Gut cells without mitochondria can survive: proof for the notion of remote metabolism?

Gut cells without mitochondria can survive (see <http://tinyurl.com/hqq79th>)! There are many other strange findings. Visible and IR light energize human skin cells transferring energy for the cells- the analog of photosynthesis. Some spiritual groups and also traditionally the people called saints are reported to survive by using only sunlight as their source of metabolic energy. NASA has studied sleigh dogs able to run for days without eating and showing no signs of getting tired.

Could photosynthesis work also in animal mitochondrial cells? The basic mechanism could be essentially the same: electron transfer chain providing energy to pump protons through cell membrane against potential gradient. This is the key step of both photosynthesis and cellular respiration. After that protons flow spontaneously back through ATP synthase and liberate energy to build ATP from ADP. This is like power plant. In plants solar photons provide the energy for electrons. In the animal cells dark photons with large $h_{eff} = n \times h$ (transforming now and then to biophotons) could do it. In the case of IR lmetabolism electrons could send to the energy source dark negative energy IR photons, which decay to ordinary IR photons. This would be an active variant of metabolism and time reversal of the usual mechanism: I have called it quantum credit card mechanism or remote metabolism [L8](see <http://tinyurl.com/gu3nbnp>).

Now even mitochondria are missing! Could remote metabolism work also without mitochondria? $ADP \rightarrow ATP$ transformation should occur since ATP is the universal energy currency. Could it take place as remote metabolism by sending negative energy photons to the cells having the mitochondria. The electron transfer chain is preceded by Krebs cycle extracting the energy from nutriens: could the absorption of negative energy photons induce the decay of nutrient without transfer of energy to electron chain of the mitochondria. The hungry gut cell without mitochondria would be allowed to eat in the table of the luckier ones. Again one quantum objection against

vulgar darwinism. This would be like kicking laser from population reversed state to ground state by phase conjugate negative energy irradiation.

6 Metabolic energy and negentropy and chemical qualia as number theoretical qualia?

I had Facebook discussions with biologists James Kohl about metabolism, information, and energy. I agreed with him that the importance of metabolism and nutrition in evolution has been underestimated.

1. It is of course known that metabolism is fundamental but the reason why this should be the case is far from clear. Energy and information are closely related but identifying energy with information proposed by Kohl is of course wrong.
2. The standard thermodynamical explanation is that metabolic energy is ordered energy like work so that metabolic energy is basically information or reduction of entropy from its maximal value. The problem is however that thermodynamics provides only a fundamental definition of entropy, not of information. One can speak of entropy currents reducing local entropy but this is not enough to understand living matter. The belief that life is just a thermodynamical fluctuation is non-sense.
3. Energy feed is certainly the prerequisite of having self-organization but the notion of non-equilibrium thermodynamics is only a phenomenological description. Criticality and even quantum criticality seem to be basic aspects of life but again it seems that neither thermodynamics nor the existing quantum theory is enough.
4. My conviction is that one must have a genuine notion of information and the only genuine information is conscious information. Information is always about something, and information is also relative notion. Bit sequence is information only for a conscious entity for which it has a meaning. Shannon entropy based notion of information fails in these respects. One must identify physical correlates of cognition.

One must extend standard real number based physics describing dead matter but unable to say anything interesting about animate matter. What is required is what I call adelic physics. Number theory would become a new mathematical building brick of physics.

These discussions led to a little discovery about chemical senses having tastes and smells as qualia. The usual belief shared also by me is that they are strictly chemical senses and they indeed might be so but only partially. Taste and smell might actually be number theoretic senses telling about average value of $h_{eff}/h = n$ serving as kind of number theoretic IQ of a biomolecule. We could perceive dark matter by sensing it! Quite generally, qualities like beauty could correlate with the value of n assignable to sensory input. This interpretation relies on progress occurred in the understanding of TGD inspired theory of consciousness and adelic physics so that I will describe the background before discussing the idea.

6.1 Brief summary of TGD view about consciousness and quantum biology

In the following I describe first the basic building bricks of the most recent TGD vision about consciousness and quantum biology.

6.1.1 Zero energy ontology

Zero energy ontology (ZEO) replaces the notion of quantum state with zero energy state. It can be regarded as pair of initial and final states of quantum event. At space-time level these events correspond to 3-surfaces at opposite boundaries of causal diamond $CD \times CP_2 \equiv CD$, where causal diamond CD is the intersection of future and past directed light-cones of 4-D Minkowski space M^4 . The conserved quantum numbers of quantum states at opposite boundaries of CD have opposite values.

1. ZEO leads to a modification of quantum measurement theory leading to a theory of consciousness [L10]. Self can be seen as a generalized Zeno effect and corresponds to a sequence of state function reductions leaving everything fixed at second boundary of CD. Self dies and re-incarnates as time-reversed self as the first reduction to the opposite boundary takes place. Negentropy Maximization Principle (NMP) was originally postulated as an independent variational principle of consciousness but it seems that adelic physics implies in statistical sense automatically.
2. Remote metabolism is one of the possible implications of ZEO. System could send negative energy radiation to geometric past (this radiation would correspond to time reversed “radiation self”). If there is a system able to receive this radiation - say population inverted laser, remote metabolism as active gain of metabolic energy becomes possible. Also remote metabolism based on positive energy photons is possible but is passive. Remote metabolism could be in central role in living matter.
3. Motor actions could quite generally involve sending of negative energy radiation to past: this would explain Libet’s finding that volitional action is preceded by neural activity.
4. Also active remote perception by sending radiation to past or future reflected there as radiation with opposite arrow of time becomes possible and could make control and sensory perception possible in arbitrarily long scale: finite light-velocity would not be a problem. One cannot exclude the possibility that what is regarded as hallucinations caused by some psychoactive drugs are actually remote perceptions of this type.

6.1.2 Hierarchy of Planck constants and dark matter

TGD based model relies heavily on the identification of dark matter as a hierarchy of phases labelled by the value of effective Planck constant $h_{eff} = n \times h$.

1. The larger the value of n , the longer the Compton lengths scaling as n . Atomic size scale scales as n^2 . The binding energies of hydrogen atom scale as $1/n^2$ so that the phase transition increasing n and making quantum coherence in larger length scale possible requires energy [K40, K43]. Hydrogen atom is simplest atom and proton transfer reactions are indeed very important. They occur also between bases of DNA base pairs (see <http://tinyurl.com/jxqvkcb>).

Cyclotron energies are proportional to n and again metabolic energy is required. The phase transitions increasing n take place at quantum criticality: scale up quantum lengths correspond to long range correlations and quantum fluctuations. Living matter would be quantum critical system in which metabolic energy feed makes possible phase transitions increasing the value of n .

2. This picture leads to a model of bio-catalysis in which the temporary reduction of n for atom of catalyst or reactans liberates binding energy kicking reactants over the potential wall so that the reaction can proceed swiftly [K40]. After than the energy could be returned to the catalyst. In $ATP \rightarrow ADP$ the dark atom assignable to high energy phosphate bond would be given to the acceptor molecule. ATP would be created by using ATPsynthase using the energy or protons going through mitochondrial membrane and kicking atom to dark atom state in phosphate attache to ADP. The energy to drive protons through the membrane would basically come from nutrient molecule. The protons would be also dark.
3. There are two quite different ranges of values of n [K40, K41]. Quantum criticality corresponds to a situation in which the perturbative QFT fails. Since em gauge couplings strength is of form $\alpha = Z_1 Z_2 e^2 / 4\pi\hbar c$, perturbation theory can fail for large charge values $Z_1 Z_2$. The phase transition h to $\hbar_{em} = Z_1 Z_2 e^2 / 4\pi v_0$, where $v_0 < c$ has dimensions of velocity, makes perturbation theory possible ($\alpha_{eff} = v_0/c$). Nature is theoretician friendly as one might say. Same applies to color interaction and weak interaction and also to gravitation: gravitational coupling strength GMm can be also very large and the phase transition increasing \hbar to $\hbar_{eff} = \hbar_{gr} = GMm/v_0$. Now the values of h_{eff} are extremely large.

4. If one has $h_{eff} = h_{gr}$ at magnetic flux tubes defining the magnetic body (MB) of the system, the dark cyclotron energy does not depend on the mass of the particle and is universal. The mysterious bio-photons can be identified as ordinary photons resulting in phase transition changing $h_{gr} \rightarrow h_{eff}$ for matter visible to us. The energy spectrum would be in visible and UV and this allows to deduce estimate for the value of h_{gr} . Note that the value of h_{eff} for matter visible to us need not be its smallest value corresponding to $n = 1$. The notion of hydrino atom claimed by Randell Mills with scaled up binding energy suggest $n = 6$ [L7].
5. The overall conclusion is that the organism-environment duality must be generalized to a trinity including also MB carrying dark matter. MB uses biological body as motor instrument and sensory receptor. MB has a hierarchical structure with a wide spectrum of values of h_{eff} . The purely biological level corresponds to flux tubes and atoms $h_{eff} = h_{em}$ and the more spiritual level to $h_{eff} = h_{gr}$ giving rise to time scales of EEG [K32] and even longer time scales. Even the galactic MB could be involved as the fact that certain biorhythms are naturally expressed in terms of galactic day and year suggests. These would give rise to the analogs of EEG and time scales of human consciousness (say hour or day).

6.2 Can we smell and taste the value of h_{eff}/h ?

$h_{eff}/h = n$ brings in new degrees of freedom associated with the Galois group. If the proposed interpretation makes sense, one can ask whether evolution might have developed sensory perception of h_{eff}/h .

1. The same molecule can have large number of chemically more or less identical variants differing only by the values of n assignable to its atoms and with its MB. I learned long time ago from my chemist friend in sauna discussion that it has not been possible to produce artificially vanilla having the same taste as the natural vanilla. Maybe the explanation derives from these number theoretical degrees of freedom.

This leads to expect that biomolecules, cells and larger structures can have different distributions of n both in short and long scales. In particular, neurons could be cellular elite in this respect and even differences between individuals of the same species can be imagined and it might be that the life style could affect the distribution of n . This might have rather interesting implications concerning the taste of food. The chef could have a decisive role in determining the taste of food. Also the so called junk food could have very low value of n as a consequence of preparation process.

2. The higher the value of $h_{eff}/h = n$, the higher the complexity of extension of rationals, and the higher the value of maximal entanglement negentropy, and therefore the intelligence of the system. Dark atoms are possible and therefore dark variants of molecules. Also dark variants of nuclei are possible and the numbers for states of dark proton sequences turn out to correspond to those of DNA, RNA, tRNA, and amino-acids [L6]. Furthermore, the numbers of DNA codons coding for given amino-acid in vertebrate genetic code are predicted correctly. The proposal is that dark analogs of basic biomolecules have served as templates for visible molecular biomatter: biochemistry would be dynamics of shadows. Dark matter would be master and biomolecules the slave.
3. If this picture is correct, one can characterize biomolecules and also larger systems by the spectrum of the values of n identified as dimension of extension and also by the value spectrum for the order $ord(G)$ of Galois group characterizing the algebraic complexity of the extensions. Best nutrients would have large average value of n and large $ord(G)$, which is maximal for $n = p$, p prime- p -adic physics again! Therefore it would very advantageous to sensorily perceive the value of n . Maybe odors and tastes give idea about the value of n . The better the odor or taste, the higher the value of n !

This would also explain why excretion products smell bad. It has low value of n since metabolism has removed from excretion produces the dark component as effectively as possible and therefore they are not good as nutrients except possibly for bacteria. Same applies to non-organic matter and therefore it cannot be used as nutrients.

Also in sexual reproduction it is advantageous to find the best possible partner and high average value of n is desirable. Pheromones giving rise to social odors are central here. Pheromones could carry information about the spectrum of n . They could thus carry not only information about - say - genome but also about number theoretic IQ.

4. One can also understand the emergence of immune systems. Dark atoms - number theoretical complexity - are cognitive currency and living systems are fighting for it. The dirty trick is to eat another living system and use its dark matter for own survival. We indeed eat other animals and plants instead of being happy with sun-light as some spiritual people claim to be. Even cells are autophages "eating" those parts of cell, which are not functioning properly. Immune system would have evolved to prevent dark atom thefts. Both micro- and macro-organisms (in particular in capitalism and market economy!) would do their best to steal negentropy and dark matter. Also viruses could steal dark atoms and thus energy and information from a more advanced system.
5. It is also possible to clone maximal entanglement with density matrix proportional to unit matrix. The conjecture is that number theoretic entanglement for which the p-adic variants of density matrix reduces to unit matrix but not necessarily the one, can be also cloned. Shared joy is doubled joy. This would be alternative but rather rarely used strategy of survival.

6.3 Adelic physics and cognition

It took more than 10 years to deduce hierarchy of dark matters as hierarchy of Planck constants from what I call adelic physics.

1. The notion of p-adic physics was introduced by colleagues already around 1990. In lack of any idea about the connection to reality it however remained purely formal exercises such as the construction of p-adic variants of quantum field theories.

At that time I however realized that p-adic thermodynamics for a system with superconformal invariance and standard model symmetries predicted by TGD provides extremely elegant description of particle massivation and that the predictions are correct with one per cent accuracy if p-adic length scale hypothesis stating that primes near certain powers of two are physically favored [K39].

This forced the question about interpretation and about how to integrate real and various p-adic physics to a larger coherent whole

2. Adelic physics is indeed a fusion of real physics for matter and various p-adic physics for cognition, p prime. Various number fields are like pages of a book having common back consisting of rational numbers common to all of them.

Allowing extensions of rational numbers (by adding roots of N :th order polynomial) one obtains reals and induced extensions of p-adic number fields. Entire hierarchy of books defined by the extensions of rationals. This defines hierarchy of adelic physics identified as evolutionary hierarchy.

3. It became clear already in the beginning that that $h_{eff}/h = n$ naturally corresponds to the number of sheets of space-time surface representable as a covering space. Galois group of extension act as its automorphisms respecting arithmetics.

Since cognitive representations correspond to intersections of real and p-adic space-time surfaces having points with coordinates in the extension of rationals as common points, Galois group has a natural action to this cognitive representation and gives rise to n -fold covering space. The identification of $h_{eff}/h = n$ as the dimension of extension dividing the order of Galois group is natural. Cognitive degrees of freedom are discrete degrees of freedom characterized by the Galois group of extensions.

$n > 0$ measures the complexity of extension and it is bound to increase in quantum jumps like the distance from the origin in random walk at half line. This implies evolution. The Universe

becomes algebraically increasingly complex. This also means that its negentropy (negentropic entanglement) increase on the long run. Universe learns and this learning changes it.

Positive negentropy is made possible - as one might guess - by cognition that is p-adic number fields: for these one can indeed generalize Shannon entropy so that it gets negative values and has interpretation as negentropy [L10]. This implies that NMP - originally postulated as a separate principle - follows from adelic physics and holds true in statistical sense. We do not live in the best possible world since this form of principle allows us to do stupid things.

4. p-Adic differential equations have a very special feature that one can have non-constant functions with zero derivative. Integration constants are piecewise constant functions and differential equations are non-deterministic. This corresponds to the non-determinism of imagination.

If one has fixed the cognitive representation defined by points with coordinates in extension of rationals one can ask if it can be continued to a preferred extremals of action. In p-adic sectors pseudo-constants make this easy: one can speak of imagination realized as p-adic space-time surface. In real sector continuation need not be possible. In this case the imagination is not realizable.

For some extensions of rationals there can be very many realizable imaginations. System is not only imaginative but also able to realize its imaginations. These extensions are winners in the fight for number theoretic survival.

Extensions of rationals are characterized by so called ramified primes. The generic rational prime decomposes to a maximal number of primes of extension (order of the polynomial determining it). For ramified primes this number is not maximal. There are good reasons to identify them as preferred p-adic primes for the extension in question. The preferred p-adic primes near to powers of two or small prime could be ramified primes for extensions, which have survived [L9].

6.4 Comments to the vision of James Kohl about top-down and bottom-up causation, immune system, nutrients, and olfaction

With these prerequisites I am ready to comment the claims of X picked rather randomly from his FB pages. I am of course not professional biologists and do not know about the detailed definitions of various notions.

6.4.1 Comments to the vision about hierarchy of causations

James Kohl: The sun's biological energy from top-down causation in microbes to the most recent model of bottom-up gene activation and cell type differentiation in vertebrates.

TGD: Solar photons provide the energy kicking atoms to dark states with larger $h_{eff}/h = n$ and large size scale proportional to n^2 . Whether solar photons are dark or transform to dark photons in the biosphere such that frequency is reduced but $E = h_{eff}f$ is not affected, is still unclear. Solar photons would in any case be effectively anti-entropic as Schrödinger conjectured. The maximal entanglement negentropy increases with h_{eff}/h since new number theoretic degrees of freedom making possible cognition emerge.

In TGD inspired quantum biology MB is a new key player. MB is the boss and the causation begins from the level of dark MB and proceeds down to the level of biomatter. One possibility is that the control signals go through genomes, where the counterpart of bottom-up cascade is initiated.

Genomes could form a hierarchy in which the MBs of separate cells would fuse to larger MBs and these in turn to even larger ones [?, K17]. One could even have genome or organ, organism, population, or even species. The coding would be as bio-rhythms defined by cyclotron frequencies, which in turn correspond to energies in the universal energy range of visible and UV bio-photons ($E = h_{gr}f$) inducing molecular transitions.

Sensory input would arrive from cell membranes to the MB. EEG and its fractal variants would mediate this input [K13, K28]. Cell membrane would be a generalized Josephson junction generating dark Josephson radiation allowing the communication of the sensory input. Frequency

modulation would be the manner to code sensory data represented as nerve pulses to Josephson radiation [K27].

6.4.2 Comments to the vision of James Kohl about immune system

I already described the view about immune system as preventing theft of dark matter.

1. **James Kohl:** For comparison, successful reproduction links energy from supercoiled DNA to protection of all organized genomes from virus-driven energy theft and pathology.

TGD: Dark atoms are cognitive currency and living systems are fighting for it. The dirty trick is to eat another living system. Immune system would have evolved to prevent dark atom thefts. Both micro- and macro-organisms (in particular in capitalism and market economy!) would do their best to steal negentropy and algebraic complexity - that is dark matter. Viruses could steal dark atoms and thus energy and information from more advanced system. Supercoiled DNA mentioned by James Kohl as system preventing viral energy theft could provide new dark atoms to compensate the stolen ones or serve as an immune system.

2. **James Kohl:** Theorists seem willing to continue to ignore all facts about UV-light induced DNA repair that were presented in the poster that linked femtosecond blasts of UV light to all biophysically constrained energy-dependent RNA-mediated changes in protein folding chemistry and to all differentiated morphological phenotypes and all differentiated behavioral phenotypes.

TGD: This suggests a new mechanism of metabolism or transfer of metabolic energy/increase of $h_{eff}/h = n$. In TGD dark photons with large value of $h_{eff}/h = n$ and low frequency but energy $E = h_{eff}f$ in visible (the original motivation for h_{eff} hypothesis) and UV range provide a mechanism of communications and also of metabolism having two variants based on positive and negative energy photons.

Positive energy photons would allow only passive reception of metabolic energy. Negative energy photons would make possible active gain of metabolic energy (remote metabolism): the system needing metabolic energy would send *negative* energy dark photons to a system able to receive them and thus provide the metabolic energy (quantum credit card).

Negative energy photons are analogs of phase conjugate light rays known to dissipate in “wrong” time direction). This is possible in ZEO, which is the basis of TGD inspired theory quantum measurement theory implying in turn theory of consciousness. Fantappie [J8] proposed long time ago that time direction in living matter can vary and introduced the notion of syntropy as time reversed entropy.

Dark photons travelling along flux tubes of a network of magnetic flux tubes would effectively replace sunlight and also the analog of photosynthesis could occur by using “artificial sunlight” rather than nutrient molecules.

3. **James Kohl:** Nothing suggests gene expression evolved to depend on any ATP-consuming factor. Gene expression is energy-dependent. It cannot evolve itself to be energy-dependent and that fact is exemplified in the context of my model of virus-driven energy theft and genomic entropy.

TGD: DNA repair mechanism involving UV light - recall that biophotons are in visible and UV - could kick atoms with reduced $h_{eff}/h = n$ back to states with large value of n - healing. Same applies to energy-dependent RNA-mediated changes in protein folding chemistry, etc...

6.4.3 TGD inspired comments about nutrients and pheromones

For a background reader can read the article “Human pheromones and food odors: epigenetic influences on the socioaffective nature of evolved behaviors” by Kohl (see <http://tinyurl.com/zammzfe>), which represents a lot of facts serving as constraints on TGD based view about odors and tastes as adelic qualia.

Pheromones are social odors: Kohl's article "Nutrient-dependent/pheromone-controlled adaptive evolution: a model" (see <http://tinyurl.com/zb7c42y>) is about this aspect. The basic message is that nutritional odors and social odors control the behavior via hormones.

The TGD proposal is that these odors give information about the distribution of $h_{eff}/h = n$ distribution of nutrient and another individual and the value of n telling about number theoretic evolutionary level, could be the main factor: the larger the value of n , the more attractive the odor. The article "Honey bees as a model for understanding mechanisms of life history transitions" gives a nice example about how epigenetics determined by the nutrition determines the cast system of beehive.

1. **James Kohl:** This atoms-to-ecosystems model of ecological adaptations links nutrient-dependent epigenetic effects on base pairs and amino acid substitutions to pheromone-controlled changes in the microRNA /messenger RNA balance and chromosomal rearrangements.

TGD: The distribution of values of $h_{eff}/h = n$ for the dark atoms (at least hydrogens) in DNA, amino-acids, and biomolecules in general tells the evolutionary level of DNA, measured also as complexity. It is affected by nutrients if metabolism creates a dark atom in phosphate with same value of $h_{eff}/h = n$ as in nutrient. Complexity of nutrient is transferred to the organism: both its morphology and behaviors (ZEO implies that behaviors correspond to 4-D morphologies for space-time surfaces!). The complexity of the organism's biochemistry correlates with that of its nutrients.

Two DNAs can be identical chemically but at very different evolutionary level. This is seen in epigenesis and different forms of gene expression and also as large fraction of introns possibly involved with quantum computational activities made possible by braiding of magnetic flux tubes connecting DNA and lipid layers and/or microtubules and axonal lipid layers [K15].

Nutrients contain dark (not necessarily only hydrogen) atoms characterized by $h_{eff}/h = n$. The higher the average value of n , the more negentropic the nutrient is. We would smell the average value of n ! The higher the value of n , the better the smell. Metabolic process picks dark atoms from the nutrient and the end product has a low negentropy: it smells bad. Not a good idea to eat it. This is why olfactory system is so important. This also explains why we do not eat non-organic matter.

Quite generally, various disorders and diseases mean reduction of the average value of n in some parts of organism inducing also the reduction of the complexity of DNA, and therefore that of gene expression, and makes the system vulnerable to mutations and attacks of micro-organisms. The generic healing mechanism would be simple: increase the value of n .

2. **James Kohl:** The *nutrient-dependent pheromone-controlled changes* are required for the thermodynamic regulation of intracellular signaling, which enables biophysically constrained nutrient-dependent protein folding; experience-dependent receptor-mediated behaviors, and organism-level thermoregulation in ever-changing ecological niches and social niches.

TGD: If the metabolic effect of nutrient depends on $h_{eff}/h = n$, also effects on protein folding are expected. The detailed mechanism could rely on remote metabolism based on dark photon - either active or passive - dark photons would have h_{eff}/h assignable to the nutrient and be involved with protein folding and DNA activities and large n would be optimal: you are what you eat!

Vegetarians believe that vegetables are better nutrients than meat: could plant molecules have higher average intelligence quotient $h_{eff}/h = n$ than meat? How much the preparation of the food can affect the value of n . Could here be the secret of master chef? Could microwave ovens reduce it?

3. **James Kohl:** Nutrient-dependent pheromone-controlled ecological, social, neurogenic and socio-cognitive niche construction are manifested in increasing organismal complexity in species from microbes to man. Species diversity is a biologically-based nutrient-dependent morphological fact and species-specific pheromones control the physiology of reproduction.

The reciprocal relationships of species-typical nutrient-dependent morphological and behavioral diversity are enabled by pheromone-controlled reproduction. Ecological variations and

biophysically constrained natural selection of nutrients cause the behaviors that enable ecological adaptations.

Species diversity is ecologically validated proof-of-concept. Ideas from population genetics, which exclude ecological factors, are integrated with an experimental evidence-based approach that establishes what is currently known. This is known: olfactory/ pheromonal input links food odors and social odors from the epigenetic landscape to the physical landscape of DNA in the organized genomes of species from microbes to man during their development.

TGD: This is what is expected. Good nutrients increase the complexity of organisms and its behavioral repertoire. Pheromones tell among other things about genotype. They could also tell about the distribution of n : about complexity, about the level of molecular intelligence. This would give connection with nutrition and complexity of of pheromones and in turn link with success in reproduction.

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