About a model for the control of biological body by magnetic body

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Abstract

The recent findings about very surprisingly simple systems exhibiting life-like properties lead to a more detailed view about possible mechanism used by magnetic body (MB) to both control biological body (BB) and receive information from it. The cyclotron frequencies for biologically important ions could determine the time scales of basic bio-processes involving various kinds of molecular motors. In communications from BB to MB the difference Δf_c of cyclotron frequencies of ions associated with cell membrane at different sides of cell membrane and would determine the time scales of these communications. For large enough values of n membrane potential would add a small contribution $\Delta f = ZeV/h_{eff}$ to Δf_c and code nerve pulse patterns and therefore sensory information to the Josephson radiation. So called cofactors are good candidates for the coordinators of processes catalyzed by enzymes. Both metal ions and organic molecules act as cofactors and a simple hypothesis to be tested is that the cyclotron frequencies of proton and metallic ions in endogenous magnetic field $B_{end} = 0.2$ Gauss define bio-rhythms related to various molecular motors. Oxidative metabolism involves besides protons Fe^{2+} ions and the corresponding cyclotron frequencies are also interesting. The ions important for the functioning of cell membrane in turn define cyclotron frequencies possibly relevant for the communications from BB to MB.

Contents

1 Introduction

The recent work in TGD [L1] in attempts to understand various surprising findings [I2] [D1] about very simple self-organizing systems assuming that they are actually macroscopic quantum systems at the level of magnetic body (MB) leads to a rather concrete model for how MB carrying dark

matter identified as $h_{eff}/h = n$ phases controls the part of system consisting of ordinary matter - biological body (BB) in biological context. The key element is magnetic body (MB) involving flux tube network able to make $h_{eff} = n \times h$ changing phase transition changing its connectivity (the extreme corresponds to phase transition between crystal-like and plasma-like states).

The control is assumed to involve Alfwen waves with the frequencies of cyclotron transitions for the dark matter. Alfwen waves induce resonant forced oscillations of the particles at the nodes of the network. MB adapts to the dynamics of BB by using quantum criticality: if the length L and transversal area S of flux tube are scaled up by n, the ratio L/S is unaffected and the energetics of the system (cyclotron energies and the magnetic energies of the flux tubes) remains un-affected but frequencies scale by n. By a suitable choice of n system and L/S ratio MB can gain control over BB.

In the sequel this picture is tested in biological context. If MB controls basic biological processes at BB then cyclotron frequencies for biologically important ions determine the time scales of basic bio-processes involving various kinds of molecular motors. In communications from BB to MB the difference Δf_c of cyclotron frequencies of ions associated with cell membrane at different sides of cell membrane and would determine the time scales of these communications [K1, **?**, K2]. For large enough values of n membrane potential would add a small contribution $\Delta f = ZeV/h_{eff}$ to Δf_c and code nerve pulse patterns and therefore sensory information to the Josephson radiation.

1.1 The basic hypothesis

The basic hypothesis which led to the idea about hierarchy of dark matter labelled by n and having purely number theoretic interpretation in adelic physics [L2] is that the magnetic field at flux tubes has a spectrum of values. The ideas ab out the spectrum for the values of magnetic field has generalized gradually.

1. The first working hypothesis inspired by the work of Blackman [J1] was that the most important value is what I have called endogenous magnetic field $B_{end} = 2B_E/5$, where $B_E = 0.5$ Gauss is is the nominal value of the Earth's magnetic field.

2. This assumption turned however to be too restrictive. The spectrum of visible bio-photons identified as resulting in a phase transition transforming dark photons to ordinary photons with the same energy would correspond to that of magnetic fields corresponding to single octave.

3. The hypothesis that bio-photons with energy range in visible and UV assignable to molecular transition energies result from dark photons by energy conserving transition, predicts that actually several octaves are involved.

4. One can assign the spectrum of magnetic fields strengths also to the audible frequencies making in the case of humans 10 octaves. One could see the emergence of higher octaves as outcome of evolution extending gradually the repertoire of control actions performed by MB.

5. One can argue that the field strengths at MB are probably not higher than say .2 Tesla, which corresponds to $10^4 \times B_{end}$ and to 13 octaves as an upper bound for the range of magnetic fields. This gives a strong upper bound for the cyclotron frequencies. In case of proton the upper bound is $f_c(p) < 3$ MHz. For bats the range of audible frequencies extends to MHz. In the case of Fe this would correspond to $f_c(Fe^{2+}) < .1$ MHz. This gives a strong limitation on processes controllable by cyclotron radiation.

For signals from cell membrane the limits are not so strong. Suppose that generalized Josephson frequencies are responsible for the communications. Ordinary Josephson frequency equals to ZeV/h_{eff}, where $V \sim .05$ Volts is membrane potential. For small h_{eff} ordinary Josephson frequency dominates over the difference of cyclotron frequencies this allows rather high frequencies below 5×10^{12} Hz. One might argue that at this limit BB sends metabolic energy to MB. For large values of h_{eff} ordinary Josephson frequency gives only rise to a small modulation coding for nerve pulse patterns. At this limit BB would send only information to MB.

In the following the simplest hypothesis $B = B_{end}$ is taken as a starting point and applied to various situations. One can make several questions. One can consider the situation from the point of view of control of BB by MB and communications from BB to MB.

1. Control of BB by MB.

   The most important activities are control of phosphorylation of ADP to ATP using ATPase enzyme, replication and transcription of DNA, and translation. Various molecular motors such as ATPase, DNA and RNA polymerases, helicases, and various propellers (flagellas, kinesin, dynein) represent examples of bio-control.

   What could one say about the role of the control based on cyclotron radiation at the level of bio-catalysis? For instance, could one understand the time scales of DNA transcription and mRNA translation. Note that they should be nearly the same in an optimal situation so that also the corresponding cyclotron frequencies should be essentially same. Could one understand the role of cofactors - say Mg^{2+} - necessary for the action of enzymes using cyclotron radiation hypothesis?

2. Communications from BB to MB.

   If generalized Josephson radiation from the cell membrane to MB is responsible for these communications then the cyclotron frequencies for the ions assignable with nerve pulse transmission should be of key importance.

2 Identification of biologically important ions

The ions involved with control and communications between MB and BB should correspond to biologically important ions. The working hypothesis will be that $B_{end} = .2$ Gauss defines an especially important strength of the magnetic field associated with the flux tubes and that also ions or their Cooper pairs can reside at the flux tubes as cyclotron BE condensates with so large value of $h_{eff}/h = n$ that cyclotron energies are above thermal threshold. A stronger assumption is that the condition $h_{eff} = h_{gr}$ [K4, K3] [L1] implying that cyclotron frequencies do not depend on the mass of charge particle holds true and that bio-photons correspond to dark photons transformed to ordinary photons.

2.1 Metallic and organic cofactors

Cofactors (see `http://tinyurl.com/d6jnd49`) are necessary for the functioning of enzymes possibly realizing the bio-control by MB. They can be divided into metal ions and organic co-factors. The working hypothesis is that the cyclotron frequencies associated with co-factors coordinate the functioning of enzyme and determine the ratew of the processes involved.

It is assumed that for given oxidation state assignable to a compound also free ion with ionization state equal to the oxidation state can appear. Table 1 gives the cyclotron frequencies of metallic cofactors for their oxidation states.

For instance, the ions Mg^{2+}, Mn^{+}, Cu^{+}, appear as metallic cofactors. For$B = B_{end}$ they have cyclotron frequencies 25.0 Hz, 10.9 Hz, and 4.8 Hz ($f_c(Fe^{2+}) = 2f_c(Mn^{+})$). Note that Ca^{++} is often regarded as signalling ion rather than co-factor but that it has also important role in catalysis. A natural guess is that the cyclotron frequencies define typical rates for bio-catalytic reactions for which enzyme has metal ion as a co-factor.

There also organic cofactors having typically mass number less than 1000. This implies that cyclotron frequency is above $f_{min}0.3 \times Z$ Hz for $B = B_{end}$ if the organic cofactor has charge Z. The first guess is that also their cyclotron frequencies are important and play the same role as those of metallic cofactors. These cyclotron frequencies are considerably lower than metallic cyclotron frequencies unless the cofactor has constant charge density. DNA is a good example of molecule with constant negative charge density: the cyclotron frequencies are rather near to 1 Hz independent of the DNA sequence.

2.2 Biologically important ions assignable to the communications from BB to MB

There are also other important biological ions involved with the communications from BB to MB. Besides Ca^{2+} ion also Na^{+}, Cl^{-}, K^{+} are important ions in the dynamics of nerve pulse transmission. In TGD inspired for nerve pulse and EEG the generalize Josephson frequencies for

Table 1: Metallic cofactors possibly important for the control of BB by MB. A denotes atomic weight for the most stable isotope. Cyclotron frequencies are calculated for $B_{end} = .2$ Gauss.

$Metal$	A	$Oxidation\ states$	f_c/Hz
Mg	24	2	25.0
Ca	40	2	15.0
Cr	52	3	17.3
Mn	55	2	10.9
Fe	56	$(2,3)$	$(10.7, 16.0)$
Co	59	$(1,3)$	$(5.1, 15.3)$
Cu	64	1	4.7
Zn	65	2	9.2
V	51	$2, ..., 5$	$(9.2, ..., 29.4)$
Mo	96	$-2, 1, ..., 6$	$(3.1, ..., 15.7)$
Cd	112	$(1,2)$	$(2.7, 5.4)$
I	127	$(1,2,..)$	$(2.4, ...)$

Table 2: Ions possibly important for communications from BB to MB. A denotes atomic weight for the most stable isotope. The smallest cyclotron is calculated for $B_{end} = .2$ Gauss.

Ion	A	$Oxidation\ states$	f_c/Hz
Li^+	(6,7)	1	$(50.0, 42.8)$
Na^+	23	1	13.0
Cl^-	55	-1	8.6
K^+	39	1	7.7
Ca^{++}	40	(1)	15.0

these ions are involved with the communications from brain to MB. Li^+ ion is also known to be important and too low concentration of Li^+ is known to correlate with depression and infection like state of brain.

All these frequencies are in EEG range. Li_6^+ cyclotron frequency is 50 Hz and is known to correspond to a frequency having effects on living matter. Li_7^+ cyclotron frequency is 37.5 Hz and is rather near the thalamocortical resonance frequency with nominal value of 40 Hz.

There are bio-molecules involved with signalling inside bio-system rather than from BB to MB. First messengers consist of hormones and neurotransmitters. Second messengers couple to first messengers to overcome the cell membrane barrier (see `http://tinyurl.com/yajhj9zb`. An interesting question is how they relate to the communications from MB to BB: could cyclotron radiation control these communications?

I have proposed that messengers do note represent real communications but only represent the ends of the communication lines so that their transfer would generate flux tube connections between the sender and receiver. The real signal would proceed as dark photons and/or super currents along the flux tube connections. If so then MB would control communication by first and second messengers by building the communication lines unless they already exist as flux tubes.

Second messengers include also neutral gases such as NO, CO and H_2S. Hydrophobic molecules such as diacylglycerol, and phosphatidylinositols and hydrophilic molecules such as cAMP, cGMP, IP3 appear as second messengers. For instance, could control of MB be involved to the transformation of first messenger signal to second messenger signal. Note that also Ca^{2+} is second messenger.

3 About the role of cyclotron frequencies in the bio-control by MB

Bio-catalysis is a basic tool of bio-control and should be controlled by MB. Enzymes should involve a part making possible the control by MB, and so called cofactors (see http://tinyurl.com/d6jnd49) are excellent candidates for this part since without them enzyme does not perform its function.

In the following the cyclotron frequency hypothesis is tested for some biologically important processes assuming $B = B_{end}$. There is a web page (see http://tinyurl.com/y7aes93x) about various scales involved with the key biological processes.

I proceed from fast to slow time scales starting from ATP synthesis and proceeding via DNA related processes involving Mg^{2+} as cofactor to oxidative metabolism involving Fe^{2+}.

3.1 Molecular motors

Molecular machines (see http://tinyurl.com/h3dqauo) are divided into two categories: molecular switches, which perform control actions and molecular motors. One might regard molecular switches as higher level motors. Here is a brief summary of molecular motors.

Molecular motors (see http://tinyurl.com/y879vdel) come in several types.

1. Rotary molecular motors include F_0F_1 ATP synthase (briefly ATPase) family of proteins (see http://tinyurl.com/h23hjkn) converting the electrochemical energy in presence of a proton gradient over the cell membrane to the chemical energy of ATP (or vice versa).

   The rotary motion of the shaft of F_0F_1 rotor makes the addition of phosphates. The rotating shaft is analogous to an assembly line containing ADPs to which phosphates are added as it rotates. The flow of protons through cell membrane pumped back through membrane using the metabolic energy from nutrients provides energy for the rotary motion and ATP. One can wonder whether this energy is provided as dark Josephson photons.

   The maximal rotation frequency is 300 Hz which corresponds to the proton cyclotron frequency for $B = B_{end}$. This suggests that dark protons at either side of membrane structure could coordinate ATP synthesis. ATP serves as universal metabolic energy currency so that this mechanism would appear everywhere in bio-logy.

   The rotary motor controlling flagellum can turn as fast as 300 Hz (see http://tinyurl.com/yaoowf9l and http://tinyurl.com/ybotnsg4), which suggests that proton cyclotron frequency in B_{end} determines the upper limit for the rate.

2. Polymerization motors are rather complex motors. Actin polymerization uses ATP. Microtubule polymizerization GTP uses GTP. Dynamine (see http://tinyurl.com/ycp5t52p is a GTPase responsible for the separation of clathrin buds from the plasma membrane.

   Actin (see http://tinyurl.com/y9npk83f) polymerization involves competing factors (see http://tinyurl.com/y7hqmm72). The rate has upper bound .3 $\mu m/s$. Actin monomer is called G-actin, and actin (micro-)filament formed from actin monomers is called F-actin. Actin monomer has mass of 41,795 proton masses and charge of -7 units (for B_{end} this would correspond to cyclotron frequency .05 Hz).

   Actin monomers are accompanied by both ATP molecule and Mg^{2+} suggesting that both cyclotron frequencies are involved with the coordination of polymerization. From the length taken by single actin monomer about 2.75 nm one can conclude that the average rate is in the range 5.5 actin monomers per second to be compared with the $f_c(Mg^{2+}) = 25$ Hz. The assumption that cyclotron frequency coordinates the process does not seem plausible.

3. Cytoskeletal motors (myosins for muscle contraction, kinesin for moving cargo along microtubules, and dynein producing axonemal beating of flagellum and moving cargo along microtubules). These rely on ATP so ATPase (dark proton cyclotron frequency) is expected to dictate the rate. These motors bind filamentous actin and are also rather complex.

3.2 Nuclei acid motors

There is a large variety of nucleic acid motors. Consider first motors, which do not utilize ATP.

1. DNA polymerase (see `http://tinyurl.com/y9k9k8zj`) turns single-stranded DNA to double-stranded DNA. These motors use deoxynucleoside triphosphate XTP, C= A, T, C, G. XTP transforms to XMP by dropping diphosphate and XMP is attached to the growing DNA strand. Note that ATP gives only P to the acceptor molecule.

   One can distinguish between two rates.

   (a) The average DNA polymerase requires about one second to locate and bind to a primer/template junction. Once it is bound, a non-processive DNA polymerase adds nucleotides at a rate of one nucleotide per second. Interestingly, the cyclotron frequency of DNA sequence in B_{end} is near 1 Hz irrespective of the length.

   (b) Processive DNA polymerases works much faster since single catalytic event adds large number of nucleotides to the polymer. The rate of processive polymerization at 37 °C is 749 nucleotides per second and corresponds to about 250 codons per second. This suggests that the rate of processive polymerization is determined by ATPase driven at proton cyclotron frequency of 300 Hz.

2. RNA polymerase (see `http://tinyurl.com/y982vb46`) catalyzes the transcription of DNA to RNA (see `http://tinyurl.com/ydaosrhg`). The basic mechanism might be though to be similar to that of DNA polymerase but the structure of these molecules is different. RNA polymerization is also 20 times slower that than DNA polymerization in E. Coli suggesting that cyclotron frequency of Mg^{++} ions, which are indeed involved, determines the rate.

   The averate rate for DNA transcription and RNA translation has upper limit of 24 codons per second and could naturally correspond to the cyclotron frequency 25 Hz of Mg^{2+} for $B = B_{end}$ appearing as cofactor in the catalyst.

3. DNA helicases (see `http://tinyurl.com/y8h3jsq2`) separate double strands of nucleic acids prior to transcription or replication. DNA replication, transcription, translation, recombination, DNA repair, and ribosome bio-genesis utilize DNA helicase. DNA strand is known to rotate during the transcription.

   If the rotation is in a direction opposite to the twisting of DNA strand, the DNA strand could open if helicase simply fixes the position part of DNA codon at which the transcription begins. Since the strands are twisted in opposite directions, this mechanism requires that the transcription takes in opposite directions for the complementary strands: this is indeed known to be the case. The average rate of opening is about 20 codons per second and opening of the strand. The rate of opening could thus be determined by the RNA polymerase having Mg^{++} as cofactor.

   Using quantum classical correspondence (QCI) the classical angular momentum assignable to the rotation of DNA can be estimated to be

   $$\frac{L}{\hbar} \sim 2\pi N\langle A\rangle \frac{d^2 \times f}{L_p} \sim 172 \times N \quad .$$

   Here N is the number of rotating nucleotides,$\langle A\rangle \sim 300$ is the average weight of DNA nucleotide, $d \sim 1$ nm is the radius of the helix, $L_p = m_p/\hbar$ is proton Compton length, and $f \sim 20$ Hz is the estimate for the rotation frequency.

   (a) If $h_{eff}/h = n$ serves as a unit of quantized angular momentum (thish need not be the case for ordinary DNA as opposed to the dark analog of DNA for which the states 3 dark protons define a realization of DNA codons) an upper bound $n < n_{max} \sim 172 \times N$ emerges from the condition $L/\hbar_{eff} = 1$. The interpretation of dark DNA as dark nuclei gives the estimate $h_{eff}/h = d/L_p \sim 2^{20} \simeq 10^6$ the radius of nucleus. This would require $N \sim 10^4$.

(b) Another manner to satisfy the stronger quantization condition is to assume that the semiclassical quantization condition is satisfied for the system consisting of *both* ordinary and dark DNA. The simplest manner to satisfy the condition is that the angular momenta of ordinary and dark DNA are opposite and in this case be smaller than $\hbar_{eff}$. This condition would be rather natural since there would be no need to bring angular momentum to the system from outside by applying torque. Energy is however needed to break up the hydrogen bonds between strands.

There are also nucleic acid motors utilizing ATP and deserve to be listed.

1. Topoisomerase reduces supercoiling of DNA in the cell.
2. RSC and SWI/SNF complexes remodel chromatin in eukaryotic cells.
3. SMC proteins are responsible for chromosome condensation in eukaryotic cells.
4. Viral DNA packing motors inject viral genomic DNA into capsids.

Also ribosome (see `http://tinyurl.com/yacy6m3h` and `http://tinyurl.com/ybfqa423`) is a molecular motor. For some reason the list of Wikipedia article (see `http://tinyurl.com/y879vdel`) does not include it. The rate of translation is in good approximation the same as the rate of transcription as it indeed must be to make the process effective and Mg^{2+} cyclotron frequency might determine the rate.

For all motors involving ATP cyclotron frequency of proton is involved but and poses only upper limit for the rate.

3.3 The possible role of Mg^{2+} in RNA translation

Transcription and translation both occur on the time scale of 1 minute for a protein of typical length (see `http://tinyurl.com/ycm5uur9`). However, longer transcripts and bigger proteins take proportionally longer to make: this probably due to the additional operations involved. The largest protein in the human body is titin. It would take approximately an hour to translate its $\sim$ 30,000 amino acids, which makes 8 amino-acids per second. If DNA codons are transcribed with the same average rate than amino-acids are translated (synchrony), transcription rate is 24 nucleotides per second. This happens to be rather near to $f_c(Mg^{2+}) = 25Hz$ to letter.

The estimates for the translation rate however vary. Probably this is due to the definition used and the organism in question. For E. Choli the average translation rate is reported to be roughly 20 aa per second (see `http://tinyurl.com/ycm5uur9`). For synchrony this would correspond to 60 nt/s in DNA transcription. The actual transcription rate is 40-80 nt/s for nucleotide and gives 60 nt/s on the average.

Note that the range for the rate corresponds to octave. If cyclotron radiation coordinates the process, the variation could be due to variation of magnetic field strength by octave. For DNA codon the rate would be in range $[13.35 - 26.7]$ codons per second. This could correspond to Mg^{2+} cyclotron frequency in B_{end} assignable to co-enzyme Mg^{2+} (see `http://tinyurl.com/d6jnd49`).

3.4 Translational motion and propeller mechanism

Molecular propellers (see `http://tinyurl.com/y7ftgzuk`) can be rotated by molecular motors that can be driven by chemical, biological, optical and electrical means or various ratchet-like mechanisms. Biological propellers are therefore only a special case. In the case of biological propellers interaction with the medium and dissipation are involved and transform rotational motion to linear motion. Medium or substrate structure such as medium or microtubule receives the recoil angular momentum.

Biology involves a large number of highly sophisticated molecular motors, such as myosin, kinesin, and ATP synthase based on propeller mechanism. For example, rotary molecular motors attached to protein-based tails called flagella can propel bacteria (see `http://tinyurl.com/y83939x7`). In this case the rotation frequency has 300 Hz, which suggests that ATPase and dark protons in magnetic field B_{end} with it determines the rate.

Second example is kinesin moving linearly along microtubule (see http://tinyurl.com/o4glesu). Also kinesin can be regarded as ATPase. The linear motion supports several functions such as mitosis, meiosis and transport of molecules along axon. The linear motion takes place in discrete steps of length 8 nm (cell membrane thickness is about 10 nm).

One can raise several questions related to the possible role of MB. How the energy and angular momentum are transmitted to the propeller? Could dark cyclotron BE condensates analogous to magnets be formed? For cyclotron BE condensates spin would be replaced with orbital angular momentum for the dark ions rotating at flux wall: this could give rise to large angular momentum. Could the generation of cyclotron BE condensate and angular momentum at magnetic flux wall give rise to opposite angular momenta at the propeller as a recoil effect: could this quantum phase transition happen by the exchange of polarized cyclotron photons. Does ATP provide the metabolic energy needed to build the cyclotron BE condensate in turn giving part of its energy for the propeller.

4 Oxidative metabolism, red cells, the fundamental bio-rhythm, and iron

Understanding the possible role of cyclotron radiation in the coordination and control of cellular respiration (see http://tinyurl.com/pkfup3g) is a further natural challenge.

1. The basic guidelines are the interpretation of "high energy" bonds as containing dark electrons $h_{eff}/h = n$ larger than for normal atoms. Also dark protons must be present when the molecule containing dark electrons is neutral. Metabolism could be basically transfer of dark protons and electrons from the nutrients possibly reducing gradually the value of n and gradually sharing the liberated energy. The energy would go to the pumping of protons through the cell membrane and be eventually transferred to high energy phosphate bond in ADP $\rightarrow$ ATP process in ATPase as protons flow back through the membrane.

2. In oxidative metabolism O_2 is used as oxidizing agent. O_2 molecules are transferred from respiratory organs to the rest of the body using hemoglobin (see http://tinyurl.com/ya5kyv6u) as a carrer. Oxygens atoms are bound to the heme part of the hemoglobin containing Fe^{2+} ion. O_2 binds to Fe^{2+} and oxidizes it so that one temporarily obtains Fe^{3+} ion and O_2^- (superoxide) ions.

   Concerning cyclotron frequencies, what puts bells ringing is that both $f_c(Fe^2) = 10.7$ Hz, $f_c(O_2^-) = 9.7$ Hz are in alpha band and near to the fundamental biorhythm with frequency 10 Hz: could the fundamental bio-rhythm be seen as a direct signature of the role of MB in metabolism? $f_c(Fe^{3+}) = 16.0$ Hz is in beta band. $f_c(Fe^{3+}O_2^-) = 6.8$ Hz makes sense at least formally and is in theta band. One can of course ask whether it is possible to regard Fe^{3+} ion and O_2^- ions as independent, possibly dark, cyclotron states. If the electrons involved are dark this might make sense.

3. In an-aerobic respiration (see http://tinyurl.com/m955wzb) sulfate (SO_4^2, $f_c = 6.3$ Hz), nitrate (NO_3, $f_c = 6.3$ Hz), sulphur (S,$f_c = 9.4$ Hz), or fumarate ($HO_2CCH{=}CHCO_2H$) are used instead of oxygen. Interestingly, the cyclotron frequencies for sulfate and nitrate are very near to each other and for sulphur ion the cyclotron frequency is also in alpha band.

Cellular respiration converts biochemical energy from nutrients - carbohydrates, amino-acids, fats - into energy carried by ATP and then releases the waste products such as CO_2 and H_2O. The reactions include catabolic reactions breaking down the large molecules to smaller ones, releasing energy in the process as weak "high-energy" bonds are replaced by stronger bonds in the products. Cellular respiration can be seen as a combustion reaction - burning of nutrients.

The most common oxidizing agent (electron acceptor) is molecular hydrogen O_2: in this case one talks about oxidative metabolism or aerobic respiration. The energy of ATP in "high-energy" phosphate bond drives biosynthesis, locomotion or transportation of molecules across cell membranes.

Aerobic respiration is the preferred method of pyruvate (CH_3COCOO, see http://tinyurl.com/yadb3fsn) breakdown in glycolysis. Pyruvate contains two O= bonds reduced to O- type

bonds in the process producing CO_2 and water. Pyruvate enters to mitochondria and is fully oxidized by the Krebs cycle (see http://tinyurl.com/p6599hq) also known as tricarboxylic cycle or citric acid cycle.

1. Krebs cycle produces NADH (nicotin-amide-adenine-dinuclotide contaning two adenines and two phosphates, see http://tinyurl.com/mcodgjs)) carrying metabolic energy in "high energy" bonds.

   (a) Coenzyme CoA (see http://tinyurl.com/ydbvd5q4) in acetyl-CoA (see http://tinyurl.com/z6fc4zc) brings the acetyl group CH_3 (see http://tinyurl.com/y74cyyqk) and metabolic energy from the nutrient to the Krebs cycle.

   (b) The metabolic energy from the nutrients is associated with high energy thioester bond at the ened of acetyl-CoA in which C has bonds of type CH_3- and O= and S-. Sulphur belongs to coenzyme CoA involving phospho-adenosine and di-phosphate.

2. The NADH produced by Krebs cycle carrying the metabolic energy is received by the electron transport chain (see http://tinyurl.com/hxwb6ay) performing oxidative phosphorylation (see http://tinyurl.com/yacue4an) transforming ADP to ATP. NADH is oxidized to NAD^+ and is returned back to the Krebs cycle.

   Electron transport chain is needed to transfer the electrons from donors to acceptors and to extract the energy of electrons and use it to the pump of protons trough the inner membrane. Electron transport chain involves as the first step the process NADH $\rightarrow NAD^+ + H^+ + 2e^-$ producing protons and electrons. This happens inside the inner membrane of mitochondria. Electrons and protons are then transported through the inner membrane to the inter-membrane space using co-enzyme Q(10) (see http://tinyurl.com/y9tosfzc) as a carrier. Electrons are transported further with the help of cytochrome c (see http://tinyurl.com/ybkb7dbu), which is soluble to water.

   (a) Ubiquinone enzyme Q takes care of the transfer of protons and electrons through the inner membrane to the inter-membrane space. Q receives two protons and electrons and is reduced to QH_2 at the inner side of the membrane. QH_2 oxidizes back to Q at the outer side of the membrane and therefore shuttles the protons through the membrane.

   (b) In the inter-membrane space of mitochondria (having double membrane) electrons are transferred along a chain of water cytochrome c (see http://tinyurl.com/ybkb7dbu) molecules forming a kind of ladder along which electrons move down. At given step Fe receives the electron and then gives it to the next cytochrome c molecule. At the bottom of the chain electrons with lowered energy are given to oxygen molecules in oxidative phosphorylation of ADP by ATPase.

3. Free radicals having one or more unpaired valence electrons appear as side products of the process. The working hypothesis is that paired valence electrons have non-standard value of $h_{eff}/h = n$ and unpaired ones have the standard value being highly reactive. Peroxides, superoxide (O_2^+), hydroxyl radical OH, and singlet oxygen (O) are free radicals having negative biological effects. O_2 molecule is di-radical but in its ground state has parallel unpaired spins and is stable: in combustion it transforms to unstable and highly reactive spin single state with paired spins.

5 Model for RNA life

There is to a very interesting paper about the possible mechanism giving life-like properties to RNA system during the conjectured RNA era [I1] (see http://tinyurl.com/ydhr3qnq). The title of the article is "*The life story of hydrogen peroxide II: a periodic pH and thermochemical drive for the RNA world*". "Life-like" would mean "breathing" realized as these oscillations and would require a metabolic energy source.

I try to interpret the proposal on basis of my own model [L1] bringing in the control of chemistry by magnetic body (MB). The idea is that MB adapts to the chemical dynamics and gets a control

over it by driving forces realized in terms of dark cyclotron radiation form MB resonating with the chemical oscillations. "Breathing" would basically correspond to the periodic formation of flux tube network with high connectivity giving rise to crystal-like or gel-like state and subsequent decay to plasma-like state with low connectivity and would require metabolic energy feed.

1. The periodic drive is central in TGD based model and gives rise to the "breathing". Metabolic energy feed must be involved. In the model for life-like properties of plastic ball system it would be dark nucleosynthesis. In another experimental system acoustic wave feeds energy to the magnetic body (MB). It is said that the peroxide ($H-O-O-H$) bond between oxygens would be the source of the metabolic energy. Peroxide - usually regarded as a mere nuisance (highly Reactive Oxygen Species causing biological damage) - would serve as the "food" of the system. This is the new and radical idea. According to the article, the primary energy source would be solar or geothermal. In TGD one can consider dark nucleosynthesis preceding ordinary nucleosynthesis as the source (it might have even given rise to Fe in the core of Earth!).

2. Figure 1 in the article illustrates that peroxide H_2O_2 would produce in presence of $S_2O_3^{-2}$ or $S_2O_3^{-1}$ thermal and pH oscillations: "breathing". Peroxide is also told to produce oxidized sulfur species and oxidixe RNA nucleotides: this would liberate metabolic energy in RNA? The outcome would be the replication of RNA. Oxidation of thiosulfate ion by H_2O_2 mentioned in the abstract would naively mean that $S_2O_3^{-2}$ gives 1 or 2 electrons to H_2O_2. Table 1 listing various reactions involved in oxidation is however rather complex. It begin to accept that I will never really understand what chemists mean with oxidation! In any case, also the oxidation reaction can happen in several steps.

Consider next the situation from quantum TGD point of view.

1. Periodic oxidation would correspond to breathing generating repeatedly connected magnetic body with quantum coherence and larger h_{eff} - following the model for breathing plastic ball system as periodic formation of crystal-like and plasma-like states.

2. Cyclotron radiation from cyclotron condensates of some important ions would serve as clocks - breathing in several time scales. What are these ions? In plastic ball system protons and Argon ions. 300 Hz is the frequency for $B = B_{end} = .2$ Gauss and also the rate of ATP:s produced by ATPase: of course, it was not present at that time. Thiosulfate cyclotron frequency would be 5.4 Hz in B_{end} for charge of -2 units.

   The chemical oscillation periods emerging in the model of authors are measured in fraction of hour whereas the cyclotron periods for ions are fractions of second for ions for $B = B_{end}$. Therefore the strength of the magnetic field is much lower than that of Earth. Intergalactic magnetic fields are of order nanoTesla and this would bring scale factor of about 10^4 to cyclotron periods and they would be of same order of magnitude as the time scales coming from chemical kinetics. For proton the cyclotron period would be 33 seconds. For $S_2O_3^{-2}$ cyclotron time scale would be scaled up by the atomic weight 112 giving roughly 40 minutes. This suggests that RNA era occurred in intergalactic space if it occurred at all. If it continues in recent biology, the dark matter must reside at the flux tubes of intergalactic magnetic field. This does not make sense in Maxwell's theory but makes sense in the many-sheeted space-time of TGD Universe.

3. pH oscillation means that at least dark protons would be involved. pH could be quite generally a direct measure for the density of dark protons. The density of dark protons oscillating periodically meaning formation of cyclotron condensate and its decay could correspond to oscillating pH.

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