Horizontal Gene Transfer by Remote Replication?

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Abstract

This article was inspired by the discovery that a horizontal gene transfer (HGT) between eukaryotes is possible. The belief has been that HGT is possible only from prokaryotes to prokaryotes or eukaryotes. The basic obstacles are that the host DNA is within the cell nucleus and that DNA is tightly bound to chromosomes. The transfer should also occur to germ cells in order to have a lasting effect.

The case considered is HGT of antifreezing gene (AFG) from herring to smelt, which could have occurred during simultaneous spawning of herring and smelt in the same area. The AFT of herring associated with a transposon could have somehow attached to the sperm cell of the smelt and carried by it to the egg of the smelt. Vector carrying AFT to the sperm cell of smelt is needed and there are only guesses about what it might be.

That HGT however occurs, justifies a heretical question. Could it be only the genetic information, which is transferred and used to construct DNA in the host as a kind of remote replication analogous to quantum transportation? The findings of Gariaev and Montagnier indeed suggest remote replication and TGD provides a new physics model for it.

Contents

1 Introduction

This article was inspired by a Quantamagazine article "DNA Jumps Between Animal Species. No One Knows How Often" (`https://cutt.ly/7UKasRp`), which described the findings of Laurie Graham and Pete Davies published in the article "Horizontal Gene Transfer in Vertebrates: A Fishy Tale" in Trends in Genetics [I1] (`https://cutt.ly/SUKamqP`).

1. Marine life around the Arctic and Antarctica has evolved many defense mechanisms against the lethal cold. One common adaptation is the ability to make anti-freezing proteins (AFPs) that prevent ice crystals from growing in blood, tissues and cells. This solution has emerged repeatedly and independently, not just in fish but in plants, fungi and bacteria. AFPs make possible survival at water temperature, which is by 1 degree C colder than the *unprotected* freezing point of fish blood and this offers an evolutionary advantage.

   Remark: TGD based general mechanisms possibly associated with heat and cold shock, involving zero energy ontology (ZEO) [L13] [K5] in an essential manner, have been considered in the model for the effects of various shock proteins in [L28]. The key idea is that the macroscopic counterparts of ordinary state function reduction changing the direction of time change the arrow of time at the level of the magnetic body of the system so that, from the point of view of observer with the standard arrow of time, the system seems to extract energy from the environment instead of dissipating it.

2. Herrings and smelts are two groups of fish, which have learned to make AFP. The story began when Graham discovered that smelt had a protein gene very similar to one of the AFG genes of herring. The gene's introns, stretches of non-coding DNA involved also with TEs, which in general mutate rather fast, are more than 95 % identical. That both have exactly the same gene coding for AFP proteins, is surprising since their ancestors diverged more than 250 million years ago and the AFP gene is absent from all species relating to them. Somehow the AFP gene must have found its way to the genome of smelt.

3. Cross breeding of herring and smelt is not possible so that direct horizontal gene transfer (HGT) should have occurred. HGT is known to be possible between prokaryotes (mono-cellulars) and also between prokaryotes and eukaryotes (multi-cellulars). Herring and smelt are not rare exceptions: recent studies demonstrate that HGT occurs also in other fish, reptiles, birds and mammals.

4. However, the belief has been that HGT is not possible for eukaryotes (multicellulars) and there are several good arguments in favor of this belief. In the case of bacteria, it is enough for the gene to get through the cell membrane since there is no nucleus and HGT occurs quite generally. The DNA of eukaryotic cells is however isolated inside the nuclei and most of the time the DNA is tightly bound in chromosomes. Gene should also find its way to germ cells in order to have a lasting effect. The transferred gene of the donor should also integrate to the genome of the host.

5. In 2019, the full genome of herring was published. It turned out that the genome contains several AFP genes with associated transposable elements (TEs). The herring genome contains several copies of these TEs but they are absent from other fish with a single exception: the genome of smelt contains only a single AFP gene and this gene with similar transposable elements occurs also in the genome of herring. Therefore there is little doubt that the HGT has taken place.

Somehow HGT must be possible.

1. 94 % HGTs occur between fishes and only 3 per percent between birds and mammals. Therefore the water environment must be part of the explanation.

2. What comes first in mind is spawning. In a situation in which one has sperms and eggs in water, germ cells which are effectively monocellulars apart from the presence of cell nuclei. Most of the cells degrade and could produce fragments of DNA, say TE+AFP gene.

If the spawning of two species occurs at the same time at the same location, HGT might have taken place from the sperm or egg cells of herring or of their degradation products to the sperm cells of smelt. These would have naturally found their way to the eggs of smelt. The amount of spawn in the sea water is so high that it changes the color of water white: this would increase the probability of HGT.

3. Maybe the AFP gene of herring has somehow attached to the DNA of the smelt sperm cells during spawning. Sperm mediated gene transfer is indeed a standard technique of genetic engineering. The challenge is to understand how the AFP genes were transported from herring cells to the smelt sperm cells. AFP gene is not able to make the travel between cells alone. In standard biology, some vector should have transported the gene between the two cells and one can make only guesses about the mechanism.

1.1 The notions of transposon and horizontal gene transfer

The notions of transposon or transposable element (TE) and horizontal gene transfer (HGT) will be needed in the sequel.

1.1.1 Transposons

Transposable elements or simply transposons (TEs) (`https://cutt.ly/HUZIItW`) were discovered by Barbara McClintock. TEs are jumping genes, which involve introns were once regarded as "junk". The basic operation is cut and paste operation.

TEs are now known to have several important functions: they make the genome dynamic and affect its identity and size, induce mutations or their reversals, and can also lead to a duplication of pieces of the genome. TEs are also involved with the control of gene expression and epigenesis (amusingly, they are still regarded as selfish genes!).

TEs are abundant in eukaryotic cells. TEs make approximately 64 % of the maize genome, 44 % of the human genome, and almost half of the mouse genome.

TEs serve as a kind of text editing tool. The TE (`https://cutt.ly/HUZIItW`) consists of inverted repeats (TEs in my terminology) at its beginning and end, and the structural genes between them.

There are at least two kinds of TEs: class I and class II. In the human genome 98 per cent of TEs class I and the rest are of type II.

1. Class I TEs or retrotransposons are first transcribed to RNA, and reverse transcriptase often encoded by the TE itself catalyzes the reverse transcription of RNA to DNA, which is then pasted to DNA sequence. The text processing analog is copy and paste.

   Retrotransposons are classified into 3 types:

   - Retrotransposons with long terminal repeats (LTRs), which encode reverse transcriptase producing DNA from the RNA transcribed from TE, which is then glued to a DNA. Retrotransposons are similar to retroviruses.
   - Retroposons, long interspersed nuclear elements (LINEs). Also they encode reverse transcriptase but lack LTRs and are transcribed by DNA polymerase II to RNA.
   - Short interspersed nuclear elements (SINEs) do not encode reverse transcriptase and are transcribed by DNA polymerase II.

   Also retroviruses can be regarded as TEs. They can transfer genes between eukaryotic target and host cell. The integrated gene in the host cell is called produces and this transfer can be seen as an eukaryotic analog of the transfer of bacterial TEs.

2. Class II TEs or DNA transposons encode for protein transposase, which they require for excision and insertion. No intermediate RNA is produced. The text processing analog is cut and paste.

   The figure `https://en.wikipedia.org/wiki/File:DNA_Transposon.png` of the Wikipedia article illustrates the situation. The structure of TE is : TSD+TIR+gene+TIR+TSD. Two

inverted tandem repeats (TIR) flank the transposase gene. Two tandem site duplications (TSD) are present on both sides of the insert.

Transposase makes a staggered cut at the target site with sticky ends and the complex TIR+gene+TIR is transferred to the new site. Gene itself is not duplicated as in the copy and paste process for retrotransposons. TSDs are left at the target site. DNA polymerase fills in the gaps at the target site leading gradually to long repeating sequences. The insertion sites can be identified by short direct repeats followed by inverted TIRs.

3. TEs can also replicate.

TEs can be also classified as autonomous and non-autonomous. Autonomous TEs can move by themselves whereas non-autonomous TEs require other TEs to move.

1.1.2 Horizontal gene transfer

Horizontal gene transfer (HGT) (`https://cutt.ly/zUKTED5`) occurs mostly in prokaryotes but also in some eukaryotes. HGT tends to occur in extreme environments.

Diatoms and algae have received genes from bacteria. For eukaryotes HGT to germ cells is required, which makes the process difficult to realize. Donor and host tend to be closely associated organisms. HGT from bacteria to chordates occurred shortly after this lineage arose.

There are several mechanisms of bacterial HGT.

1. Transformation involves three steps: introduction, uptake and expression.
2. Transduction: DNA is transferred by virus
3. Bacterial conjugation. DNA is transformed in cell-to-cell contact.
4. Gene transfer agents are viruslike elements coded by the host.

Transposable elements (TE) are often involved with HGT. One speaks of the transfer of horizontal TE (HTT). TE transfer occurs also for eukaryotes. This suggests that TEs, which distinguish between prokaryotes and eukaryotes, involve a new transfer mechanism. The mechanism of TE transportation requiring a vector carrying the TE, has not been identified and this allows us to wonder whether only information could be transferred?

1.2 General constraints on the model

Consider first general constraints on the model.

1. For eukaryotes, cell and nuclear membranes make HGT difficult if not impossible. The transfer should also occur to germ cells.
2. Water must be essential since in other species than fish the process is much rarer.
3. Sperm cells are analogous to monocellulars, and the HGT occurs for monocellulars. Note however that sperm cells and eggs have a nucleus and chromosomes, which are obstacles for HGT.
4. That HGT would occur during spawning looks a highly plausible hypothesis. This increases the probability of HGT, whatever the mechanism is. Sperm mediated transfer would allow to overcome the basic obstacles and the basic properties of TEs involved would make possible the integration to the host genome.
5. Most of the cells and their DNA degrades during the spawning and the resulting DNA fragments would also contain AFG+TE, which could be transferred to the smelt sperm cells.

How the TE involving the AFG from the sperm of herring could be transported to the sperm of smelt? This is not known.

According to Wikipedia:

Though the actual mechanism for the transportation of TEs from donor cells to host cells is unknown, it is established that naked DNA and RNA can circulate in bodily fluids. Many proposed vectors include arthropods, viruses, freshwater snails, endosymbiotic bacteria and intracellular parasitic bacteria. In some cases, even TEs facilitate the transport for other TEs.

This justifies a heretic question. Could it be only the genetic information, which is transferred and used to construct DNA in the host as a kind of remote replication analogous to quantum transportation?

2 Some key ideas of TGD inspired quantum biology

In this section basic notions of TGD inspired quantum biology relevant to the recent article are discussed. The ideas discussed the notion of magnetic body (MB) as a controller of ordinary matter; the hierarchy of effective Planck constants assigned to the hierarchy of extensions of rationals defining a hierarchy of phases of ordinary matter behaving like dark matter; Galois confinement as a universal mechanism for the formation of bound states; dark realizations of genetic code; communications and control in TGD inspired quantum biology. Zero energy ontology (ZEO) [L13] [K5] plays a central role in TGD inspired quantum biology but is not discussed in the sequel.

2.1 MB carrying dark matter as controller of ordinary biomatter

MB contains dark matter identified, as phases of ordinary matter characterized by EQ with a dimension $n = h_{eff}/h_0$ serving as a measure of the algebraic complexity of a given space-time region [L17, L18], and interpreted as a universal IQ. The scales of quantum coherence increase with h_{eff}. The layers of MB characterized by the value of n naturally form a master-slave hierarchy in which ordinary matter with the smallest Planck constant is at the bottom, and controlled by higher levels. The energies of systems increase with h_{eff} and since h_{eff} tends to be spontaneously reduced, an energy feed is needed to preserve the distribution of h_{eff}: the interpretation is as an analog of a metabolic energy feed.

MB acts as a "boss" controlling ordinary matter and induces self-organization [L12].

2.1.1 Anatomy of MB

MB has, as its body parts, magnetic flux quanta: flux tubes and flux sheets. There are two kinds of flux quanta. Flux can be vanishing, which corresponds to a Maxwellian regime. Flux can also be non-vanishing and quantized corresponding to a monopole flux. In the monopole case, the magnetic field requires no current for its creation. This option is not possible in the Maxwellian world. By fractality of the TGD Universe, these flux tubes play a key role at all scales [L11].

Also the Earth's magnetic field with nominal value of $B_E = .5$ Gauss has two parts.

1. The monopole flux part corresponds to the "endogenous" magnetic field $B_{end} = .2$ Gauss and explains the strange effects of ELF EM radiation on the physiology and behavior of vertebrates [J1].

   The presence of this part explains the stability of the Earth's magnetic field. This field should have decayed long ago in a Maxwellian world since it is generated by currents which disappear.The contribution of the molten iron in the Earth's core to B_E decays but the changes of the orientation of B_{end} regenerate it [L5]. Also, magnetic fields that penetrate super-conductors as quantized fluxes and even those of permanent magnets (as opposed to electromagnets) may have a monopole part consisting of flux quanta.

2. The interaction of MB with the gravitational field of Earth is discussed in [L27]. Intriguingly, the metabolic energy currency with the nominal value of .5 eV is rather close to the energy for the escape velocity of a proton. Could the transfer of ions from the surface of the Earth to MB be a standard process?

2.1.2 Communications to and control by MB

Communication from the biological body (BB) to MB and its control by MB would rely on dark photons, which can transform to ordinary photons with a large h_{eff} and vice versa. Molecular transitions would represent one form of control.

1. Cell membranes could act as generalized Josephson junctions generating dark Josephson radiation with energies given by the sum $E_J + \Delta E_c$ of ordinary Josephson energy E_J and the difference ΔE_c of cyclotron energies for flux tubes at the two sides of the membrane. The variation of the membrane potential modulates the Josephson frequency and codes the sensory information at the cell membrane to a dark photon signal sent to MB.

2. The large effects of radiation at ELF frequencies observed by Blackman and others [J1] could be understood in terms of the cyclotron transitions in $B_{end} = .2$ Gauss if "h" in $E = hf$ is replaced with h_{eff}. h_{eff} should be rather large and possibly assignable to the gravitational flux tubes with $\hbar_{eff} = \hbar_{gr} = GMm/v_0$. For the simplest model, M represents the Earth's mass coupling to the small mass m, and v_0 is a parameter with dimensions of velocity expected to have discrete spectrum. The energies $E = h_{eff}f$ of dark photons should be in the biophoton energy range (visible and UV) characterizing molecular transitions [K2, K3].

3. For the value $v_0/c \simeq 2^{-11}$, suggested by the Nottale's model for planetary orbits [E1], the predicted cyclotron energy scale is 3 orders of magnitude higher than the energy scale of visible photons. Several solutions of this problem were considered [L26]. The most plausible solution [L26, L20] is $\beta_0 = v_0/c = 1/2$ for living matter so that gravitational Compton length $\Lambda_{gr} = GM/\beta_0$ equals to Schwartschild radius at the surface of Earth. and brings nothing new to the original Nottale hypothesis.

By its higher level of "IQ", MB would naturally be the master controlling BB by cyclotron radiation - possibly via a genome accompanied by dark genome at flux tubes parallel to the DNA strands.

1. Cyclotron Bose-Einstein condensates (BECs) of bosonic ions, Cooper pairs of fermionic ions, and Cooper pairs of protons and electrons would appear as dark matter in living systems and the $h_{eff} = h_{gr}$ hypothesis predicts a universal cyclotron energy spectrum in the range of bio-photon energies.

2. Dark photons may transform to bio-photons [L3, L2] with energies covering the visible and UV energies associated with the transitions of bio-molecules. This control of biomolecules implies that remote mental interactions are routine in living matter. EEG signals would represent a particular instance of these communications: without the presence of MB it is difficult to understand why the brain would use such large amounts of energy to send signals to outer space.

3. In ZEO, the field body (FB) and MB correspond to 4-D rather than 3-D field patterns and quantum states correspond to quantum counterparts of behaviors and biological functions. Conscious holograms could be generated as a result of interference of a dark photon reference beam from MB and a dark photon beam carrying the sensory information. This hologram would be read by MB using the conjugate of the reference beam.

   In ZEO time reversals of these processes also take place. This makes it possible to understand memory as a result of communications with memory mental images.

2.2 Galois confinement

Galois confinement is a universal number theoretical mechanism for the formation of all bound states [L25, L24]. Galois confinement emerged originally in TGD inspired quantum biology but has become a central theme of also the TGD view about condensed matter. Galois confinement provides a purely number-theoretic mechanism for the formation of hierarchies of bound states.

1. Galois confinement involves $M^8 - H$ duality and requires $h_{eff} > nh_0 > h$. M^8 has an interpretation as an analog of momentum space and the points of $X^4 \subset M^8$ assignable to polynomial P with rational coefficients have interpretation as 4-momentum. Monic polynomials P are physically especially interesting [L19]. P defines an algebraic extension of rationals with dimension $n = h_{eff}/h_0$. The physical interpretation is as a hierarchy of phases of ordinary matter with an increasing value of effective Planck constant behaving like dark matter.

2. The roots r_n of P correspond to 3-D mass shells $m^2 = r_n$ in fixed $M^4 \subset M^8$ and X^4 itself contains these mass shells and is determined as a deformation of M^4 which corresponds to an element of local group $SU(3) \subset G_2$, where G_2 is automorphism group of M_c^8 having interpretation as complexified octonions. The condition that $U(2) \subset SU(3)$ leaves the point $g(x)$ invariant implies that one has local CP_2 element defining the $M^8 - H$ duality.$SU(3)$ corresponds to color group physically.

3. Quark states as solutions of algebraic octonionic Dirac equation (all equations are algebraic at M^8 side of $M^8 - H$ duality while everything is differential geometric at H side) correspond to points of M^8 assume to correspond to algebraic integers in the extensions of rationals defined by P so that the points carrying quark define what I have called cognitive representation playing a key role in adelic physics [L7, L8]. For instance, p-adic variants of the cognitive representations make sense.

4. Periodic boundary conditions allow only many-quark states assignable to mass shells for which the total M^4 momentum is an ordinary integer (in suitable units defined by the size scale of CD considered) are possible [L25, L24]. This is the simplest realization of Galois singlet property/confinement. The integer valued total momenta emerge also in the twistorial construction of scattering amplitudes [L19]. This is the simplest realization of Galois singlet property/confinement.

5. This gives rise to an infinite hierarchy of bound states. One can also consider composite polynomials and if they vanish at origin, the roots of composite polynomials contain also the roots of the functional factors of the composite. This is analogous to conservation of genes. All kinds of states: nucleons, nuclei, photons, etc... , can form Galois bound states. It is enough that one deforms the states so that they are not Galois singlets with the original Galois group or to increase the extension so that they are not Galois singlets in the larger extension. From these kinds of states one can form Galois singlets.

2.3 Dark realizations of genetic code

The model of bio-harmony [K4] [L10, L15, L21, L22] is essential for the TGD based understanding of what might be called emotional intelligence (whose reality is accepted) and its relations with ordinary intelligence. The surprising outcomes are the connection with genetic code and the key role of bioharmony in quantum information processing in living matter.

1. The notion of bioharmony relies on icosahedral and tetrahedral geometries. The representation of the 12-note scale as a sequence of quints, reduced by an octave equivalence (notes differing by octave are experienced as equivalent) to the basic octave, defines the harmony for a given Hamiltonian cycle: the 20 allowed 3-chords of the icosahedral harmony correspond to the 20 triangular faces. The symmetries of the harmony are defined by some subgroup (Z_6,Z_4, or Z_2) of the icosahedral group.

2. Genetic codons correspond to dark photon triplets (3-chords of light) defined by the triangular faces of an icosahedron and tetrahedron. The counterparts of amino-acids are identified as orbits of 3-chords under the symmetries of a given harmony.

   Any combination of 3 icosahedral harmonies with 20 chords with symmetries Z_6, Z_4 and Z_2 and of the tetrahedral harmony with 4 chords gives a particular bioharmony with 20+20+20+4=64 chords assignable to DNA codons. DNA codons coding for a given amino acid correspond to the chords at the orbit of the symmetry group. Rather remarkably, the numbers of DNA codons coding for a given amino acid come out correctly.

3. Music expresses and creates emotions. Musical harmony codes for moods and emotions as holistic aspects of music. Bio-harmony with 64 3-chords, would assign the binary, local, aspects of information to the 6 bits of the codon and its holistic, emotional aspects to the bio-harmony. A chemical representation of the genetic code can thus correspond to several moods represented by bioharmony. In contrast with physicalism, emotions would appear already at the molecular level, and would have physical effects that are not reducible to bio-chemistry. This understanding is not possible without using the notion of MB.

   The model of bio-harmony requires that the values of B_{end} correspond to those associated with the Pythagorean scale definable by the quint cycle. These frequencies correspond to energies that a molecule must have in order to serve as a basic biomolecule. This criterion could select DNA, RNA, tRNA, and amino-acids.

In the second model of genetic code [L9, L6, L10], codons are represented as dark proton triplets assignable to flux tubes parallel to DNA strands.

1. The numbers of dark proton triplets turn out to correspond to numbers of DNA, RNA, tRNA codons, and amino acids. The numbers of DNA and RNA codons assignable to a given amino-acid in the vertebrate genetic code are correctly predicted. Genes would correspond to sequences of dark proton triplets [L14].

2. Dark proton triplet - dark codon - would be analogous to baryon and Galois confinement [L16] behaving like a single quantum unit. The N dark codons of a dark gene would, in turn, bind to Galois confined states of the Galois group of an EQ associated with the sequence of codons. An entire hierarchy of confinements is possible.

3. Galois confinement can be realized also for dark photon triplets and the sequences of N dark-photon triplets representing genes as dark $3N$-photon states. Genes could serve as addresses for communications based on dark $3N$-photon resonances.

   For communications between levels with the same value of h_{eff} there would be both energy and frequency resonance and for levels with different values of h_{eff} only the energy resonance. It is an open question whether dark $3N$-photons transform to a single ordinary photon or $3N$ ordinary photons (biophotons) in dark-ordinary communications.

4. The basic hypothesis is that both DNA, RNA, tRNA, and amino acids are paired with their dark analogs, and that energy resonance mediates the interaction between the members of pairs.

How could the icosahedra and tetrahedra be realized? Why must one glue them together? This looks aesthetically unappealing. However, surprisingly, both icosahedrons and tetrahedrons appear in, perhaps the simplest honeycomb of the hyperbolic 3-space H^3 (cosmic time = constant hyperboloid). H^3 is also central to special relativity and cosmology [L22]. Dark genetic code can be realized in terms of both dark protons and photons using this particular tessellation and would be universal. This master tessellation would induce sub-tessellations at the space-time surface, in particular representations of genetic code at magnetic flux tubes. Also 2-D and even 3-D representations of genetic code can be considered (i.e. cell membrane and microtubules) [L23].

2.4 Communication and control in living matter

The TGD inspired model for bioharmony suggests a universal communication and control mechanism based on frequency modulation of dark photon radiation and its resonant receival producing a sequence of pulses. The signal sent by the DNA sequence would be resonantly received by a similar DNA sequence as a temporal sequence of resonance peaks determined by the modulation.

An interesting hypothesis is that nerve pulse patterns are basically produced by this mechanism transforming membrane potential oscillations producing Josephson radiation sent to MB and producing pulse sequences initiating nerve pulse pattern at the level of cell membrane.

U-shaped flux tubes serve as the basic tools of communication. Their reconnection replaces U-shaped flux tubes with pairs of flux tubes between two objects and occurs when a resonant dark photon communication between objects is possible. This requires the same cyclotron energy

implying identical cyclotron frequencies if the values of h_{eff} are the same: this implies the value of magnetic field and by flux quantization the same thickness of flux tubes.

Galois confinement allows a generalization replacing U-shaped flux tubes with N-flux tubes along which dark N-photons can propagate and to replace dark photon resonance with M-resonance. This communication and control mechanism would be realized at the level of DNA and other biomolecules. The generalization of the notion of genetic code allowing higher dimensional realization of DNA generalizes this communication mechanism further.

2.4.1 Some applications

The proposed general model of communications and control has an impressive number of applications to living matter.

1. The model of water memory involves dark DNA [K1] [L1, L4] assignable to the ordinary DNA and also the dark variants of other biomolecules can be involved. The MBs of water clusters can vary the thickness of their U-shaped flux tubes and therefore their cyclotron frequencies. This makes possible recognition of bio-active molecules with MB involving flux tubes with cyclotron frequencies shared by living matter. When the U-shaped flux tube meets a similar flux tube of a bio-active molecule, reconnection takes place and if it leads to dark photon resonance, a long-lived flux tube pair is formed. The bioactive molecule is "caught".

2. The MB of water clusters can mimic the MBs of invader molecules and this could give justification for the claimed homeopathic effects. Resonant reconnection could be behind water memory, immune system, the claim about homeopathic healing [K1], and the biocatalysis involving the mysterious looking ability of reactants to find each other in dense molecular soup.

3. The most general option is that every polar molecule in living matter is accompanied by a dark nucleon sequence or several of them (as in the case of amino-acids) serving as its "name"". This would also associate a unique dark nucleon sequence with the MB of DNA so that DNA-dark DNA association would be automatic. The same applies to mRNA and tRNA and amino-acids.

The model for the communications also leads to a model for the emergence of language [L29, L30]. Amazingly, only a few point mutations for relatively few genes seem to have led to human languages and transformed biological evolution to cultural evolution? What happened to these genes? In the biochemistry framework it is difficult to imagine an answer to this question. Here TGD could come to the rescue.

One can assign a value of h_{eff} characterizing the evolutionary level also to genes. The genes with larger h_{eff} would serve as control genes and the increase of h_{eff} would mean an evolutionary step. Perhaps a dramatic increase of h_{eff} occurred to FOXP2 and some other genes as human language emerged.

The fundamental language would be defined by genetic code realized in terms of dark $3N$-photons and h_{eff} as a measure of algebraic complexity and a universal "IQ" would characterize the realizations of this language.

2.4.2 What is the role of introns and TEs?

Interesting questions relate to the role of introns and transposons (TEs), which involve introns besides genes.

1. Introns do not express themselves as proteins and their fraction is highest in humans so that the interpretation as junk DNA does not look realistic. TGD inspired quantum biology motivates the proposal that the dark genes could express themselves electromagnetically and that remote replication (and the remote variants of transcription and even translation) could rely on this. This leads to a general model for communications and control.

2. The simplest assumption is that all DNA related structures and also RNA proteins and tRNA, can "talk" by applying these communication mechanisms.

The difference between TEs and genes not belonging to TEs brings to mind the difference between animals and plants. TEs can move and actively control their environment. TEs are also involved with epigenesis, that is control of gene expression, and modifications of genes.

Animals and plants differ also in that animals have a nervous system. Could also TEs and ordinary genes have an analogous difference? Animals are thought to represent a level of evolution higher than plants. Could this be true also for TEs? A higher value of h_{eff} for the MBs of TEs would concretize this idea. Nervous system in TGD inspired quantum biology means communications to MB by Josephson radiation. Could one think something like this also now?

The relation of TEs to genes looks like the relation of a programmer to the program modules of a software. This suggests that the MBs of TEs represent a higher level in the h_{eff} hierarchy than the MBs of genes. The higher value of h_{eff} means also a longer scale of quantum coherence so that TEs might be involved also between communications of even different organisms of the same species.

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