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UNIVERSAL RULES OF GENOMIC STOCHASTICS AND THE DOCTRINE OF ENERGY-INFORMATION EVOLUTION BASED ON BIO-ANTENNA ARRAYS

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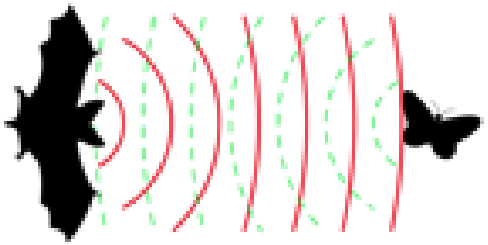
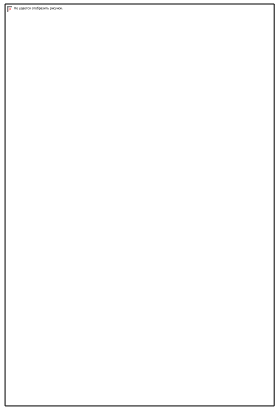


Dualism "probability-vs-determinism" in genetics

Genetics as a science began with Mendel's discovery of the stochastic rules of inheritance of traits in experiments on the crossing of organisms. Many processes in living bodies are of a stochastic nature. The well-known expressions "gene noise" or "cell noise" reflect the fact that even genetically identical cells within the same tissue exhibit different levels of protein expression, different sizes and structures due to the stochastic nature of interactions of individual molecules in cells.



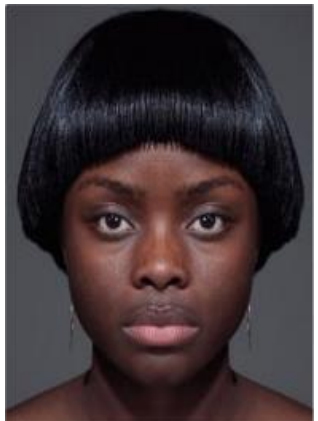
Gr. Mendel (1822-1884)

No wonder P. Jordan, who was one of the founders of quantum informatics and the author of the first article on quantum biology, stated: ***"life's missing laws are the rules of chance and probability of the quantum world"*** (see the history of "quantum biology", 2018, https://royalsocietypublishing.org/doi/full/10.1098/rspa.2018.0674)

Pascual Jordan

The stochastic nature of genetic processes in the "small" does not interfere with the inheritance of the traits determined in the "big". For example, fingerprints are different for all people, although fingers in general have a typical shape and composition (3 phalanges, etc.).

According to Mendel's law of independent inheritance of traits, information from the level of DNA molecules dictates the macrostructure of living bodies through many independent channels, despite strong noises. Thus, hair, eye and skin colors are inherited independently of each other. Accordingly, **each organism is a machine of multichannel noise-immunity encoding**.



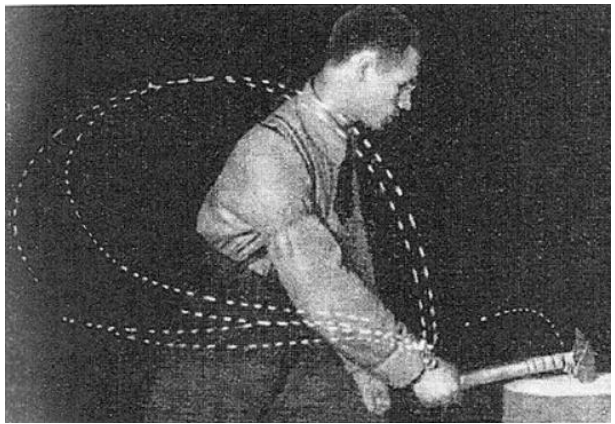
This talk presents the author's attempts to break through to an understanding of how and on what algebraic and physical foundations this biological “noise-immune multi-channel machine” is arranged.

The talk contains four main parts:

- 1) Biological dualism "probability-vs-determinism" and Gestalt biology;
- 2) Matrix-tensor representations of molecular-genetic ensembles and universal rules of stochastic (probability) organization of genomic DNAs;
- 3) Digital antenna arrays (smart antenna) and their tensor-matrix theory, which has algebraic analogies with matrix-tensor genetics;
- 4) The doctrine of evolution based on bio-antenna arrays.

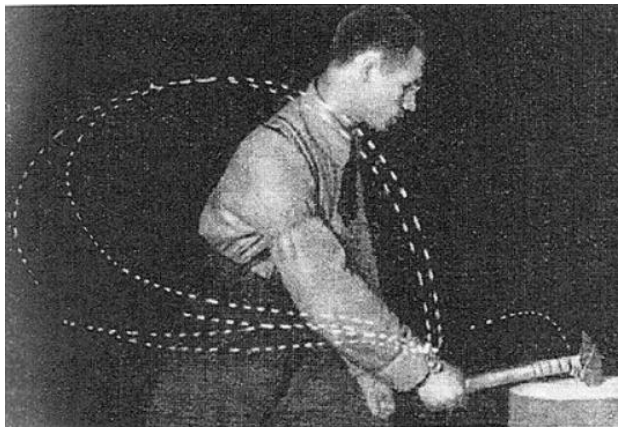
Dualism "probability-vs-determinism" and Gestalt biology

One of the examples of the connection between stochastic and deterministic features in biology is given by the phenomenon of biomechanics of movements by the classic of biomechanics N.A. Bernstein: the general target task of movement is performed exactly regardless of the inaccuracies of its constituent motor subtasks. For example, when repeating an exact hit with a hammer on a nail, each time a person uses different trajectories, speeds and accelerations of body parts with a change in both the flexion angles in the joints and the activity of many muscles of each joint with many motor neurons of each muscle.



This example shows that the intelligence of an organism works with the **probabilistic** characteristics of local movements of the body's links, giving out a **deterministic** general result of movement - hitting the target.

The described phenomenon of biomechanics of movements belongs to the broad topic of **Gestalt-biology**, in which stable holistic patterns are formed regardless of the variability of their constituent parts.



For example, Gestalt psychology studies the innate properties of the brain to form holistic images that are relatively independent of their particular components. Thus, a musical melody is recognized by us, even when it is played on different instruments and in different frequency ranges.

This is an inherited fundamental property of the psyche: to seek in a disparate whole.

In biology, there are many other genetically inherited gestalt phenomena - morphogenetic, homeostatic, sensory, etc. - in which a stable holistic pattern is realized in conditions of a wide variability of its constituent components.

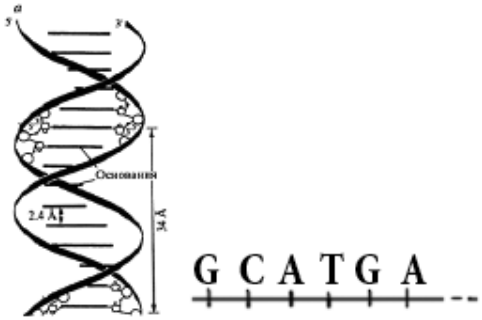
For example, the molecular composition of a living body is constantly changing while maintaining the shape of the body. Its proteins are involved in continuous cycles "life-death" of stochastic assembly and disassembly into amino acids. For example, the half-life of the hormone insulin is 6-9 minutes, etc. In other words, genetically inherited parts of our body are constantly dying and reborn. According to the physiologist A.G. Gurvich, "***the main problem of biology is maintaining the shape with constant renewal of the substrate***".

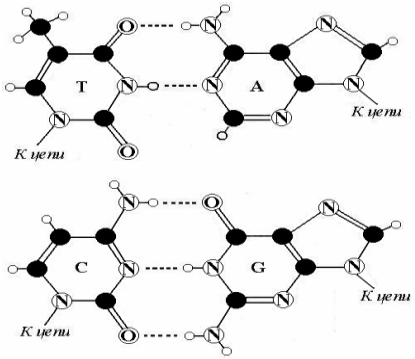
All physiological systems are genetically inherited through their genetic coding. Therefore, one should look for the origins of these inherited gestalt phenomena of physiology in the genetic system of DNA informatics.

In the course of such searches, the speaker discovered that already in the information system of DNA molecules of the genomes of higher and lower organisms, universal gestalt phenomena of their stochastic organization are embedded. Let us explain this.

Part 2.

Matrix-tensor representations of molecular-genetic ensembles and universal rules of stochastic (probability) organization of genomic DNAs.





Genetic information on DNA molecules is written in a sequence of four nucleotides (molecular letters): adenine A, guanine G, cytosine C and thymine T. DNA also contains alphabets of 16 duplets, 64 triplets, 256 tetraplets, etc. All these interrelated alphabets are represented in matrix form as members of a single tensor family of matrices $[C, A; T, G]^{(n)}$:

	1	0
1	C	A
0	T	G

	11	10	01	00
11	CC	CA	AC	AA
10	CT	CG	AT	AG
01	TC	TA	GC	GA
00	TT	TG	GT	GG

	111	110	101	100	011	010	001	000
111	CCC	CCA	CAC	CAA	ACC	ACA	AAC	AAA
110	CCT	CCG	CAT	CAG	ACT	ACG	AAT	AAG
101	CTC	CTA	CGC	CGA	ATC	ATA	AGC	AGA
100	CTT	CTG	CGT	CGG	ATT	ATG	AGT	AGG
011	TCC	TCA	TAC	TAA	GCC	GCA	GAC	GAA
010	TCT	TCG	TAT	TAG	GCT	GCG	GAT	GAG
001	TTC	TTA	TGC	TGA	GTC	GTA	GGC	GGA
000	TTT	TTG	TGT	TGG	GTT	GTG	GGT	GGG

The columns and rows of these matrices of DNA alphabets are binary numbered based on molecular binary indicators of nucleotides: the columns are numbered with binary indicators "pyrimidine or purine" (**C=T=1, A=G=0**), and rows - with binary indicators "amino or keto" (**C=A=1, T=G=0**).

	1	0
1	C	A
0	T	G

	11	10	01	00
11	CC	CA	AC	AA
10	CT	CG	AT	AG
01	TC	TA	GC	GA
00	TT	TG	GT	GG

	111	110	101	100	011	010	001	000
111	CCC	CCA	CAC	CAA	ACC	ACA	AAC	AAA
110	CCT	CCG	CAT	CAG	ACT	ACG	AAT	AAG
101	CTC	CTA	CGC	CGA	ATC	ATA	AGC	AGA
100	CTT	CTG	CGT	CGG	ATT	ATG	AGT	AGG
011	TCC	TCA	TAC	TAA	GCC	GCA	GAC	GAA
010	TCT	TCG	TAT	TAG	GCT	GCG	GAT	GAG
001	TTC	TTA	TGC	TGA	GTC	GTA	GGC	GGA
000	TTT	TTG	TGT	TGG	GTT	GTG	GGT	GGG

	0	1
0	C	A
1	T	G

;

	00	01	10	11
00	CC	CA	AC	AA
01	CT	CG	AT	AG
10	TC	TA	GC	GA
11	TT	TG	GT	GG

	000	001	010	011	100	101	110	111
000	CCC	CCA	CAC	CAA	ACC	ACA	AAC	AAA
001	CCT	CCG	CAT	CAG	ACT	ACG	AAT	AAG
010	CTC	CTA	CGC	CGA	ATC	ATA	AGC	AGA
011	CTT	CTG	CGT	CGG	ATT	ATG	AGT	AGG
100	TCC	TCA	TAC	TAA	GCC	GCA	GAC	GAA
101	TCT	TCG	TAT	TAG	GCT	GCG	GAT	GAG
110	TTC	TTA	TGC	TGA	GTC	GTA	GGC	GGA
111	TTT	TTG	TGT	TGG	GTT	GTG	GGT	GGG

These 3 tables form a single tensor family of matrices: the second and third tensor (Kronecker) powers of the (2*2)-matrices [C, A; T, G] automatically give this (4*4)-matrix of 16-doublet alphabet and this (8*8)-matrix of 64-triplet alphabet.

The tensor product of matrices plays an important role in quantum informatics and quantum mechanics: the state space of a multicomponent quantum system is the tensor product of the state spaces of its components.

	000	001	010	011	100	101	110	111
000	CCC	CCA	CAC	CAA	ACC	ACA	AAC	AAA
001	CCT	CCG	CAT	CAG	ACT	ACG	AAT	AAG
010	CTC	CTA	CGC	CGA	ATC	ATA	AGC	AGA
011	CTT	CTG	CGT	CGG	ATT	ATG	AGT	AGG
100	TCC	TCA	TAC	TAA	GCC	GCA	GAC	GAA
101	TCT	TCG	TAT	TAG	GCT	GCG	GAT	GAG
110	TTC	TTA	TGC	TGA	GTC	GTA	GGC	GGA
111	TTT	TTG	TGT	TGG	GTT	GTG	GGT	GGG

How are the 20 amino acids encoded by them and the stop signals of protein synthesis located in this matrix of 64 triplets? The number of options for the arrangement of amino acids with their some kind of repetitions to fill the entire (8 * 8) matrix is huge: >> 10^{100} (for comparison, in physics, the lifetime of the Universe is estimated at 10^{17} seconds).

Will this arrangement of amino acids be chaotic or will it suddenly turn out to be naturally symmetrical?

It turns out that from the ocean of possibilities, **nature has chosen an algebraically regular version** of the repetition and arrangement of amino acids and stop signals in this matrix of 64 triplets (the case of the genetic code of vertebrate mitochondria is shown):

	000	001	010	011	100	101	110	111
000	CCC	CCA	CAC	CAA	ACC	ACA	AAC	AAA
001	CCT	CCG	CAT	CAG	ACT	ACG	AAT	AAG
010	CTC	CTA	CGC	CGA	ATC	ATA	AGC	AGA
011	CTT	CTG	CGT	CGG	ATT	ATG	AGT	AGG
100	TCC	TCA	TAC	TAA	GCC	GCA	GAC	GAA
101	TCT	TCG	TAT	TAG	GCT	GCG	GAT	GAG
110	TTC	TTA	TGC	TGA	GTC	GTA	GGC	GGA
111	TTT	TTG	TGT	TGG	GTT	GTG	GGT	GGG

CCC Pro	CCA Pro	CAC His	CAA Gln	ACC Thr	ACA Thr	AAC Asn	AAA Lys
CCT Pro	CCG Pro	CAT His	CAG Gln	ACT Thr	ACG Thr	AAT Asn	AAG Lys
CTC Leu	CTA Leu	CGC Arg	CGA Arg	ATC Ile	ATA Met	AGC Ser	AGA Stop
CTT Leu	CTG Leu	CGT Arg	CGG Arg	ATT Ile	ATG Met	AGT Ser	AGG Stop
TCC Ser	TCA Ser	TAC Tyr	TAA Stop	GCC Ala	GCA Ala	GAC Asp	GAA Glu
TCT Ser	TCG Ser	TAT Tyr	TAG Stop	GCT Ala	GCG Ala	GAT Asp	GAG Glu
TTC Phe	TTA Leu	TGC Cys	TGA Trp	GTC Val	GTA Val	GGC Gly	GGA Gly
TTT Phe	TTG Leu	TGT Cys	TGG Trp	GTT Val	GTG Val	GGT Gly	GGG Gly

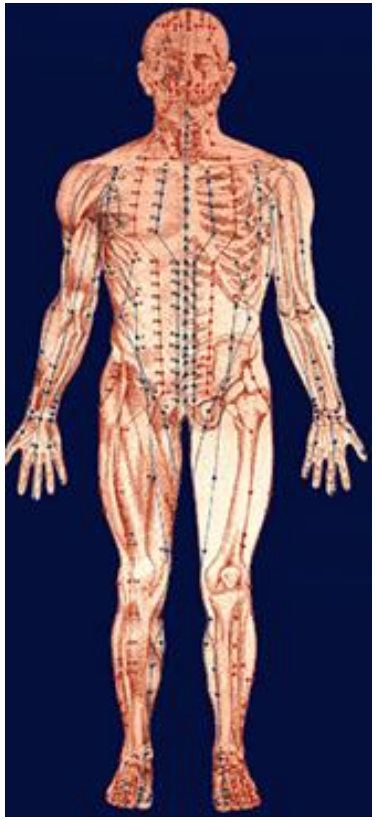
The matrix of encoded amino acids and stop signals shown on the right **consists of pairs of adjacent rows of identical amino acids and stop codons** (in colors). This tensor-matrix regularity is one of the evidence of a deep connection between genetic coding and the formalisms of quantum informatics.

It is interesting that the matrix of 64 triplets in its binary oppositional structure is similar to the famous table of **64 Yin-Yang hexagrams of the ancient Chinese "Book of Changes" (I-Ching)**:

	111	110	101	100	011	010	001	000
111	CCC	CCA	CAC	CAA	ACC	ACA	AAC	AAA
110	CCT	CCG	CAT	CAG	ACT	ACG	AAT	AAG
101	CTC	CTA	CGC	CGA	ATC	ATA	AGC	AGA
100	CTT	CTG	CGT	CGG	ATT	ATG	AGT	AGG
011	TCC	TCA	TAC	TAA	GCC	GCA	GAC	GAA
010	TCT	TCG	TAT	TAG	GCT	GCG	GAT	GAG
001	TTC	TTA	TGC	TGA	GTC	GTA	GGC	GGA
000	TTT	TTG	TGT	TGG	GTT	GTG	GGT	GGG

	111 CHYAN	110 TUI	101 LI	100 CHEN	011 HSUN	010 KAN	001 KEN	000 KUN
111 CHYAN	111111	111110	111101	111100	111011	111010	111001	111000
110 TUI	110111	110110	110101	110100	110011	110010	110001	110000
101 LI	101111	101110	101101	101100	101011	101010	101001	101000
100 CHEN	100111	100110	100101	100100	100011	100010	100001	100000
011 HSUN	011111	011110	011101	011100	011011	011010	011001	011000
010 KAN	010111	010110	010101	010100	010011	010010	010001	010000
001 KEN	001111	001110	001101	001100	001011	001010	001001	001000
000 KUN	000111	000110	000101	000100	000011	000010	000001	000000

I-Ching was written several thousand years ago and has had a powerful influence on oriental medicine and culture. In connection with it, acupuncture and Tibetan pulse diagnostics were developed. Carl Jung believed that its trigrams and hexagrams fix a universal set of archetypes (innate mental structures).



	111 CHYAN	110 TUI	101 LI	100 CHEN	011 HSUN	010 KAN	001 KEN	000 KUN
111 CHYAN	111111	111110	111101	111100	111011	111010	111001	111000
110 TUI	110111	110110	110101	110100	110011	110010	110001	110000
101 LI	101111	101110	101101	101100	101011	101010	101001	101000
100 CHEN	100111	100110	100101	100100	100011	100010	100001	100000
011 HSUN	011111	011110	011101	011100	011011	011010	011001	011000
010 KAN	010111	010110	010101	010100	010011	010010	010001	010000
001 KEN	001111	001110	001101	001100	001011	001010	001001	001000
000 KUN	000111	000110	000101	000100	000011	000010	000001	000000

The ancient Chinese claimed that this table of 64 hexagrams is a universal natural archetype. They did not know anything about the genetic code, but it with its 64 genetic triplets and binary properties turns out to be surprisingly similar to this table and schemes of the I-Ching.

In our study, this matrix of 64 triplets is used in resultive analyzes of stochastic organization of genomic DNAs.

Study of the stochastic organization of genomic DNAs

For example, let's turn to the DNA of the first human chromosome, which contains a sequence of about 250 million nucleotides. Calculating in this DNA the percentages of each member of the DNA **alphabet of 4 nucleotides** (%C,%A,%T, %G), we obtain a table of their probabilities:

%C	%A		0.2085	0.2910
%T	%G	=	0.2918	0.2087

Then we represent the same DNA as a text of two-letter words (such as CA-TT-GA-) based on the **alphabet of 16 duplets** and, calculating the percentage of each of the types of duplets, we get a table of percentages of 16 types of duplets:

%CC	%CA	%AC	%AA		0.05409	0.07274	0.05033	0.09504
%CT	%CG	%AT	%AG	=	0.07134	0.01031	0.07429	0.07137
%TC	%TA	%GC	%GA		0.06008	0.06312	0.04402	0.06008
%TT	%TG	%GT	%GG		0.09568	0.07286	0.05046	0.05419

Similarly, presenting the same DNA as a text of three-letter words, and then as a text of four-letter words, etc., we obtain the corresponding tables of percentages of kinds of n-plets in these texts, written respectively using the alphabets of 64 triplets, 256 tetraplets, etc. For example, for a text of three-letter "words" we have a percentage of 64 triplets:

%CCC	%CCA	%CAC	%CAA	%ACC	%ACA	%AAC	%AAA
%CCT	%CCG	%CAT	%CAG	%ACT	%ACG	%AAT	%AAG
%CTC	%CTA	%CGC	%CGA	%ATC	%ATA	%AGC	%AGA
%CTT	%CTG	%CGT	%CGG	%ATT	%ATG	%AGT	%AGG
%TCC	%TCA	%TAC	%TAA	%GCC	%GCA	%GAC	%GAA
%TCT	%TCG	%TAT	%TAG	%GCT	%GCG	%GAT	%GAG
%TTC	%TTA	%TGC	%TGA	%GTC	%GTA	%GGC	%GGA
%TTT	%TTG	%TGT	%TGG	%GTT	%GTG	%GGT	%GGG

=

0.01385	0.01878	0.01524	0.01861	0.01183	0.01977	0.01447	0.03693
0.01853	0.00291	0.01789	0.02104	0.01622	0.00254	0.02375	0.01988
0.01758	0.01275	0.00251	0.00227	0.01317	0.01942	0.01441	0.02237
0.02009	0.02088	0.00259	0.00291	0.02388	0.01781	0.01614	0.01848
0.01588	0.01964	0.01103	0.01986	0.01255	0.01456	0.00962	0.01960
0.02226	0.00233	0.01939	0.01284	0.01437	0.00253	0.01327	0.01756
0.01972	0.01981	0.01457	0.01947	0.00956	0.01115	0.01256	0.01600
0.03725	0.01884	0.01988	0.01895	0.01445	0.01534	0.01185	0.01382

Thus, according to this method, the nucleotide sequences in each single-stranded genomic DNA turn out to be a whole bunch of parallel texts, each of which is written in its own alphabet of n-plets, and the DNA as a whole appears as a multilingual object. This method proved to be effective and has led to the discovery of universal rules and symmetries of the stochastic organization of genomes.

Taking this into account, figuratively speaking, any genomic DNA speaks many languages, is a polyglot!

At first glance, the resulting sets of percentages of n-plets in these n-plets DNA texts are quite chaotic. Moreover, the percentage of types of n-plets in these texts depends on the order of the letters. For example, in the duplet-textual representation of the DNA under consideration, the percentage of CG and GC duplets of the same letter composition differs several times: %CG = 0.0103, a %GC = 0.0440.

%CC	%CA	%AC	%AA
%CT	%CG	%AT	%AG
%TC	%TA	%GC	%GA
%TT	%TG	%GT	%GG

=

0.05409	0.07274	0.05033	0.09504
0.07134	0.01031	0.07429	0.07137
0.06008	0.06312	0.04402	0.06008
0.09568	0.07286	0.05046	0.05419

But in this seeming chaos, there are many universal rules for n-plet groupings that are valid for all studied genomes. For example, special n-plet groupings in matrices of probabilities for different n-texts of the DNA are numerically interrelated.

Knowing the percentage of a nucleotide in genomic DNA, it is possible to predict with high accuracy the sums of the percentages of 4 duplets, 16 triplets, 64 tetraplets with this nucleotide at fixed positions in the duplet-, triplet- and tetraplet-representations of the genomic DNA sequence.

For example, percent C is practically equal to: the sum of the percentages of 4 duplets starting with C; the sum of the percentages of 16 triplets beginning with C; the sum of 64 tetraplets beginning with C, and so on (see the table, where N denotes any of nucleotides C, A, T, G):

%C ≈ **0.2085**	%G ≈ **0.2087**	%A ≈ **0.2910**	%T ≈ **0.2918**
Σ%CN ≈ **0.2085**	Σ%GN ≈ **0.2088**	Σ%AN ≈ **0.2910**	Σ%TN ≈ **0.2917**
Σ%NC ≈ **0.2085**	Σ%NG ≈ **0.2087**	Σ%NA ≈ **0.2910**	Σ%NT ≈ **0.2918**
Σ%CNN ≈ **0.2084**	Σ%GNN ≈ **0.2088**	Σ%ANN ≈ **0.2910**	Σ%TNN ≈ **0.2917**
Σ%NCN ≈ **0.2085**	Σ%NGN ≈ **0.2088**	Σ%NAN ≈ **0.2910**	Σ%NTN ≈ **0.2917**
Σ%NNC ≈ **0.2085**	Σ%NNG ≈ **0.2087**	Σ%NNA ≈ **0.2910**	Σ%NNT ≈ **0.2918**
Σ%CNNN ≈ **0.2085**	Σ%GNNN ≈ **0.2088**	Σ%ANNN ≈ **0.2910**	Σ%TNNN ≈ **0.2917**
Σ%NCNN ≈ **0.2085**	Σ%NGNN ≈ **0.2087**	Σ%NANN ≈ **0.2910**	Σ%NTNN ≈ **0.2918**
Σ%NNCN ≈ **0.2085**	Σ%NNGN ≈ **0.2088**	Σ%NNAN ≈ **0.2910**	Σ%NNTN ≈ **0.2918**
Σ%NNNC ≈ **0.2085**	Σ%NNNG ≈ **0.2087**	Σ%NNNA ≈ **0.2910**	Σ%NNNT ≈ **0.2918**

%C ≈ **0.2085**	%G ≈ **0.2087**	%A ≈ **0.2910**	%T ≈ **0.2918**
Σ%CN ≈ **0.2085**	Σ%GN ≈ **0.2088**	Σ%AN ≈ **0.2910**	Σ%TN ≈ **0.2917**
Σ%NC ≈ **0.2085**	Σ%NG ≈ **0.2087**	Σ%NA ≈ **0.2910**	Σ%NT ≈ **0.2918**
Σ%CNN ≈ **0.2084**	Σ%GNN ≈ **0.2088**	Σ%ANN ≈ **0.2910**	Σ%TNN ≈ **0.2917**
Σ%NCN ≈ **0.2085**	Σ%NGN ≈ **0.2088**	Σ%NAN ≈ **0.2910**	Σ%NTN ≈ **0.2917**
Σ%NNC ≈ **0.2085**	Σ%NNG ≈ **0.2087**	Σ%NNA ≈ **0.2910**	Σ%NNT ≈ **0.2918**
Σ%CNNN ≈ **0.2085**	Σ%GNNN ≈ **0.2088**	Σ%ANNN ≈ **0.2910**	Σ%TNNN ≈ **0.2917**
Σ%NCNN ≈ **0.2085**	Σ%NGNN ≈ **0.2087**	Σ%NANN ≈ **0.2910**	Σ%NTNN ≈ **0.2918**
Σ%NNCN ≈ **0.2085**	Σ%NNGN ≈ **0.2088**	Σ%NNAN ≈ **0.2910**	Σ%NNTN ≈ **0.2918**
Σ%NNNC ≈ **0.2085**	Σ%NNNG ≈ **0.2087**	Σ%NNNA ≈ **0.2910**	Σ%NNNT ≈ **0.2918**

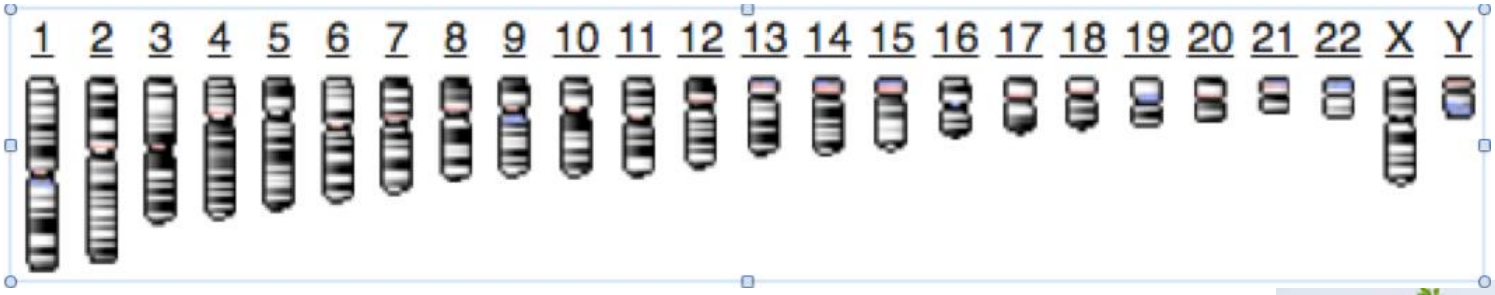
This constancy of sums of probabilities of n-plets under conditions of different values and numbers of summands is one of the types of **Gestalt rules of probabilities in genomic DNAs**.

Other types of Gestalt rules for probabilities in genomic DNAs can be found in the speaker's publications on his website http://petoukhov.com/ .

GENOMES OF EUKARYOTS AND PROKARYOTS

Similar Gestalt rules of stochastic organization of genomic DNAs holds for all already analyzed DNA sequences:

- 1) all 24 human chromosomes; 2) all chromosomes of Drosophila, mouse, worm, many plants; 3) 19 genomes of bacteria and archaea; 4) many extremophiles living in extreme conditions, for example, radiation with a level 1000 times higher than fatal for humans.



The universal Gestalt rules and symmetries identified by the speaker in the stochastic organization of genomic DNA of higher and lower organisms indicate the existence of nontrivial algebraic invariants of a **globally** genomic nature, which remain unchanged over million years of biological evolution, during which millions of species of organisms die off and new ones appear (although **locally** genomic sequences are modified by mutations, natural selection mechanisms, etc.). This seems to be connected with the question of the origin of life, since these patterns are presented also in archaea and bacteria.

The discovered universal Gestalt rules of the block-stochastic organization of genomic DNA indicate the existence of quantum-mechanical long-range links in the nucleotide DNA sequences.

They are used to create new approaches to artificial intelligence and a new view of organisms as algebraic entities associated with the formalisms of quantum informatics.

Part 3.

System algebraic analogies of matrix-tensor genetics with the tensor-matrix theory of digital antenna arrays (Smart antennas).

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The speaker revealed that the described matrices of probabilities of n-plets from n-texts of any considered genomic DNA are interrelated on the base of algebraic equations, using block matrices and the Hadamard product of matrices, which is a well-known operation symbolized by **O**

For example, in genomic DNAs, the (2*2)-matrix of monoplet probabilities is interrelated with the (4*4)-matrix of duplet probabilities by the equation with additional (2*2)-matrices B_C, B_A, B_T, B_C:

$$\begin{bmatrix} \%C & \%A \\ \%T & \%C \end{bmatrix} \circ \begin{bmatrix} B_C & B_A \\ B_T & B_G \end{bmatrix} = \begin{bmatrix} \%CC & \%CA & \%AC & \%AA \\ \%CT & \%CG & \%AT & \%AG \\ \%TC & \%TA & \%GC & \%GA \\ \%TT & \%TG & \%GT & \%GG \end{bmatrix}$$

where additional matrices are:

$$B_C = \begin{bmatrix} \%CC:\%C & \%CA:\%C \\ \%CT:\%C & \%CG:\%C \end{bmatrix}, \quad B_A = \begin{bmatrix} \%AC:\%A & \%AA:\%A \\ \%AT:\%A & \%AG:\%G \end{bmatrix}$$

$$B_T = \begin{bmatrix} \%TC:\%T & \%TA:\%T \\ \%TT:\%T & \%TG:\%T \end{bmatrix}, \quad B_G = \begin{bmatrix} \%GC:\%G & \%GA:\%G \\ \%GT:\%G & \%GG:\%G \end{bmatrix}$$

Similarly the interrelation between the (4*4)-matrix of duplet probabilities and the (8*8)-matrix of triplet probabilities are expressed by the equation using the Hadamard product:

$$\begin{bmatrix} \%CC & \%CA & \%AC & \%AA \\ \%CT & \%CG & \%AC & \%AG \\ \%TC & \%TA & \%GC & \%GA \\ \%TT & \%TG & \%GT & \%GG \end{bmatrix} \circ \begin{bmatrix} B_{CC} & B_{CA} & B_{AC} & B_{AA} \\ B_{CT} & B_{CG} & B_{AT} & B_{AG} \\ B_{TC} & B_{TA} & B_{GC} & B_{GA} \\ B_{TT} & B_{TG} & B_{GT} & B_{GG} \end{bmatrix} =$$

%CCC	%CCA	%CAC	%CAA	%ACC	%ACA	%AAC	%AAA
%CCT	%CCG	%CAT	%CAG	%ACT	%ACG	%AAT	%AAG
%CTC	%CTA	%CGC	%CGA	%ATC	%ATA	%AGC	%AGA
%CTT	%CTG	%CGT	%CGG	%ATT	%ATG	%AGT	%AGG
%TCC	%TCA	%TAC	%TAA	%GCC	%GCA	%GAC	%GAA
%TCT	%TCG	%TAT	%TAG	%GCT	%GCG	%GAT	%GAG
%TTC	%TTA	%TGC	%TGA	%GTC	%GTA	%GGC	%GGA
%TTT	%TTG	%TGT	%TGG	%GTT	%GTG	%GGT	%GGG

See preprint - https://www.preprints.org/manuscript/202203.0100/v1 (doi: 10.20944/preprints202203.0100.v1).

Analogies with tensor-matrix theory of digital antenna arrays.

The analogy method is one of the basic methods in sciences, as known at least from the time of B.Bolzano. M.Planck wrote: «*We thus find that it is a characteristic of every new idea occurring in science that it combines in a certain original manner two distinct series of facts*».

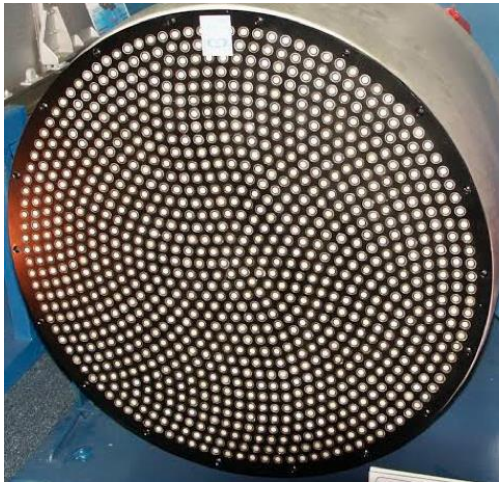
The speaker pays attention that the described algebraic connections between the probability matrices of genomic DNAs are analogical to formalisms of the well-known tensor-matrix theory of digital antenna arrays. This theory using the Hadamard product was developed by Ukrainian Prof. V.Slyusar [https://en.wikipedia.org/wiki/Vadym_Slyusar]. It gives very advantageous possibilities in the field of many-component digital antenna arrays also called Smart Antennas.

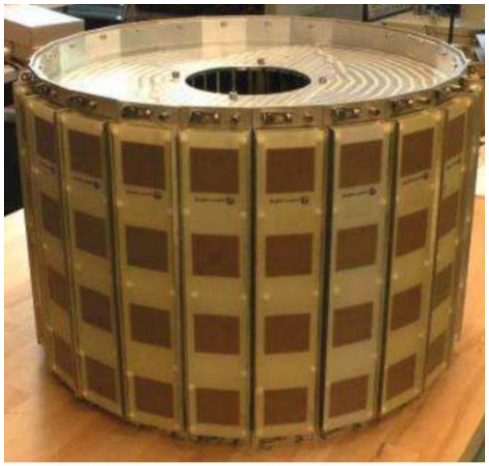
It was this analogy between the matrix-tensor formalisms in genetics and in the theory of Smart Antennas that initially led the speaker to the doctrine of energy-information evolution based on bio-antenna arrays.

The topic of Smart antennas is very new for biology and we should briefly describe them.

Antenna arrays have thousand applications: medical ultrasound scanning technology, sonar systems, radio relay stations, radio astronomic devices, avionics, and many others.

Modern science connects with antenna arrays future revolutionary changes in computers (biophotonics) and energetics (effective using solar energy) by using nanoantenna arrays.

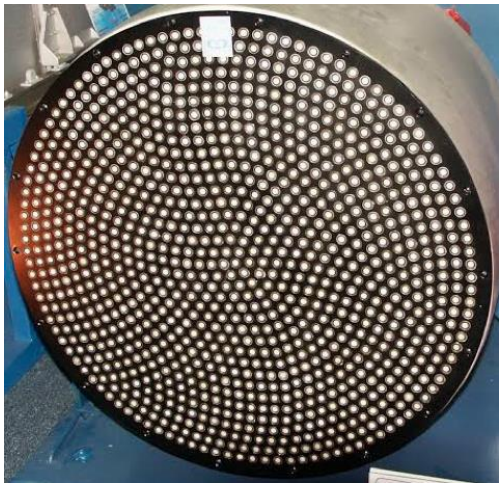


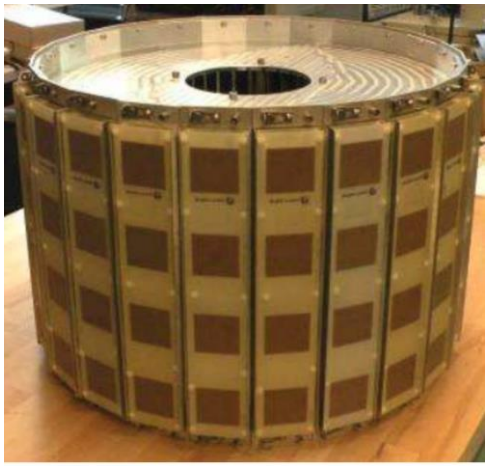


Пример ЦАР Alcatel-Lucent, 2011 год

(These images are taken from Internet in free access sites)

Antenna arrays consist of many separate antennas, each of which can emit or absorb waves of a specific frequency range. These sets of antennas in antenna arrays can be located in space in variety configurations and dimensions. The design of nanoantenna arrays can use photonic crystals and liquid crystals, which are actively used in modern technology and which exist in all bio-bodies.





Пример ЦАР Alcatel-Lucent, 2011 год

(These images are taken from Internet in free access sites)

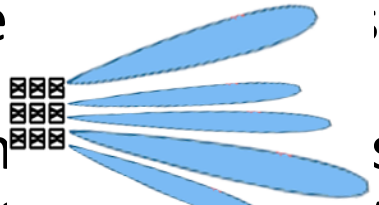
Emergent properties of antenna arrays

Antenna arrays provide such kinds of radiation patterns (or beamforming), which are unable for a single antenna element. Let's list main emergent properties of antenna arrays:

-1) In a compare with a single antenna, an array of N elements allows to increase approximately N times the directivity and the gain of the antenna, as well as allows to narrow beams;

- 2) Antenna arrays are a unique tool for providing communication noise-immunity and extracting a weak signal from a strong noise;

- 3) Phased antenna arrays capable of operating with multi-beam radiation patterns. A phased array usually means an electronically scanned and computer-controlled array of antennas, which creates a beam of radio waves that can be electronically steered to point in different directions without moving the [illegible].

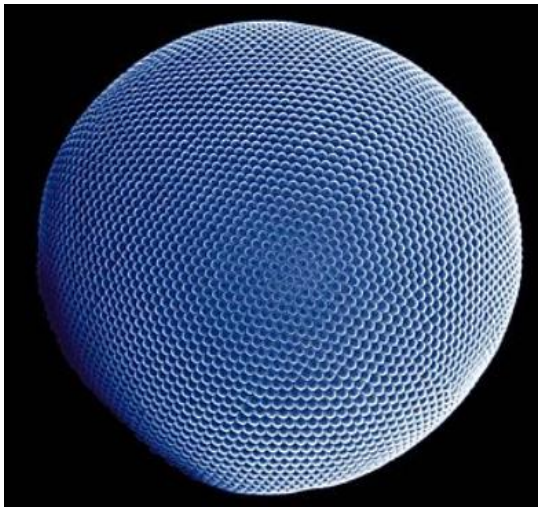


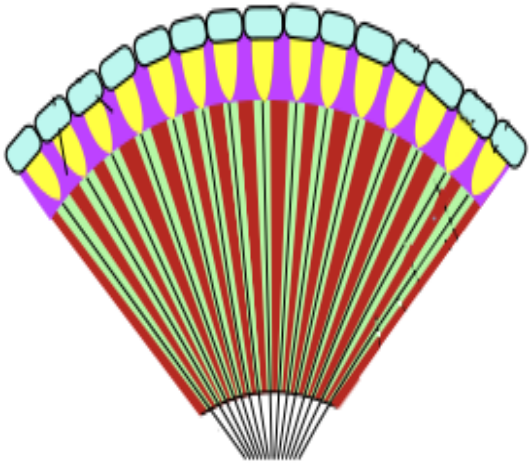
It should be noted that the beams of an[illegible]s carry not only information signals but [illegible], participating in its tranfering and redistribution.

Given these unique emergent properties of antenna arrays, it can be expected that organisms are forced to use them in their life activity. The presented doctrine confirms this expectation on a set of examples of the structure and functioning of inherited physiological systems based on antenna arrays and their energy waves.

Let’s show some examples of such inherited systems. Considering these examples, one should remember that electrical and vibro-mechanical oscillations in living bodies are closely connected because many tissues are piezo-electrical (nucleic acids, actin, dentin, tendons, bone, etc.).

Complex faceted eyes

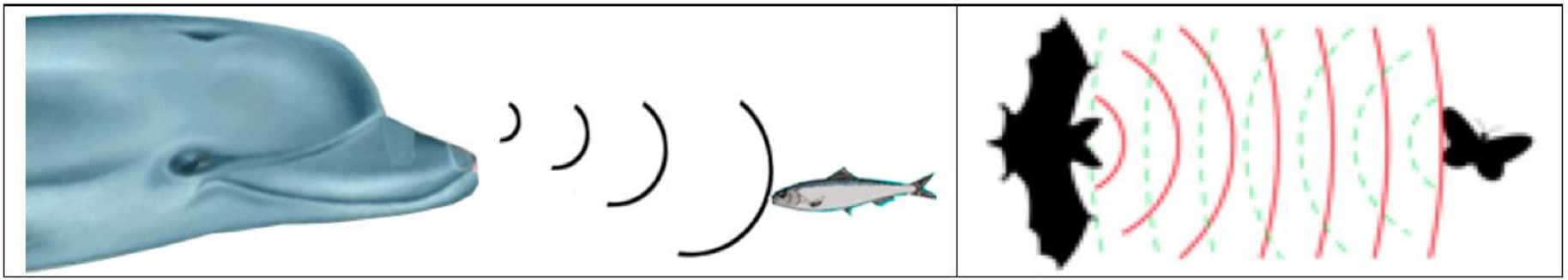




Insects and some other invertebrates receive visual information through complex faceted eyes, which serve as bio-antenna arrays for receiving electromagnetic waves. They are formed by special structural units - ommatidia. The image perceived by such eyes "recalculated" from the numerous ommatidia. For example, faceted eyes of dragonflies have up to 30,000 ommatidia.

(These images are taken from Internet in free access sites)

Inherited phenomena of biological echolocation

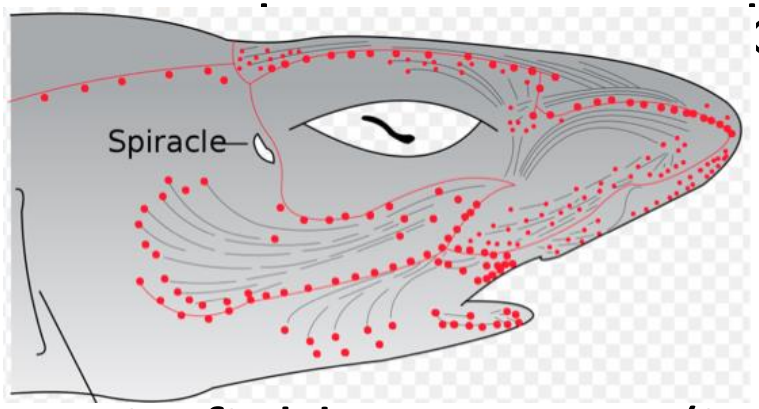


Many organisms have an innate ability to echolocation based on directed rays of a wave nature. Due to the mechanisms of echolocation, for example, dolphins and bats are able to recognize not only the distance to the target but also the dimensions and shape of the objects they track, by analogy with how active digital antenna arrays (Smart Antennas) make it possible in technology. A dolphin's body has many hydroacoustic receptors, which form a multi-element broadhand hydroacoustic receiving antenna.

(These images are taken from Internet in free access sites).

Inherited phenomena of biological electrolocation

Electrolocation is also widespread with the generation and reception of electric fields for solving by organisms many vital tasks of a search, evaluation, and communication nature. In active electrolocation, the animal senses its surrounding environment by generating electric fields and detecting distortions in these fields using electroreceptor organs. These organs are distributed throughout the body, forming bio-antenna arrays, the cumulative readings of which are processed by body.



The arrangement of electromagnetic field receptors (in red) on the shark's head, which form a receiving bio-antenna array (from Wikipedia).

Inherited sets of bio-photon crystals

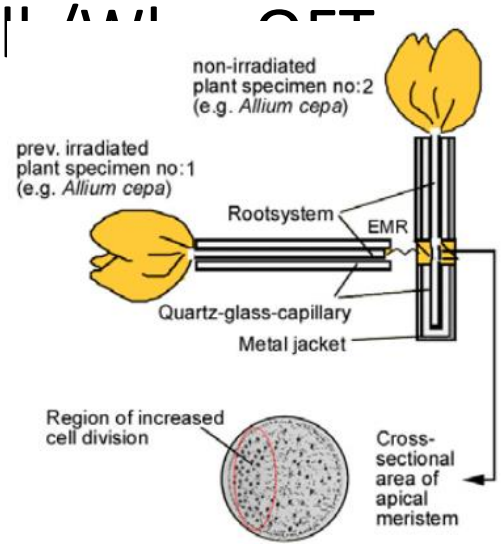
Figures: Photonic crystals form heritable species patterns on butterfly wings and peacock feathers.

Modern technologies actively use photonic crystals to control the spatial distribution of photon beams. A photonic crystal is a periodic optical nanostructure that affects the motion of photons. Many animals in nature responsive photonic crystals in their intelligent-like activities for camouflage, signaling, etc.

Photonic crystals are related to the topic of nanoantenna arrays in two ways: 1) Nanoantennas are often referred to as nanodevices that allow the scattering of radiation in a given direction; photonic crystals and their arrays are such devices; 2) The location of many photonic crystals as a screen next to the nanoantenna can change its functional characteristics.

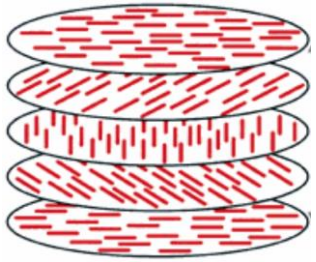
One of the biological examples of directed electromagnetic radiation is mitogenetic radiation, discovered in 1923 by A.G. Gurwitsch in experiments on cell proliferation of an onion [Beloussov LV., Voeikov V.L., Martynyuk V.S. *Biophotonics and Coherent Systems in Biology*. Springer, 2007].

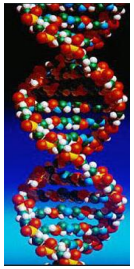
This radiation is considered as associated with the ultraviolet range of electromagnetic waves. Its directionality was discovered by Gurwitsch himself, and then confirmed in independent experiments by other authors. The following image is taken from https://biophysics.sbg.ac.at/tal[illegible]tters-BP.pdf:



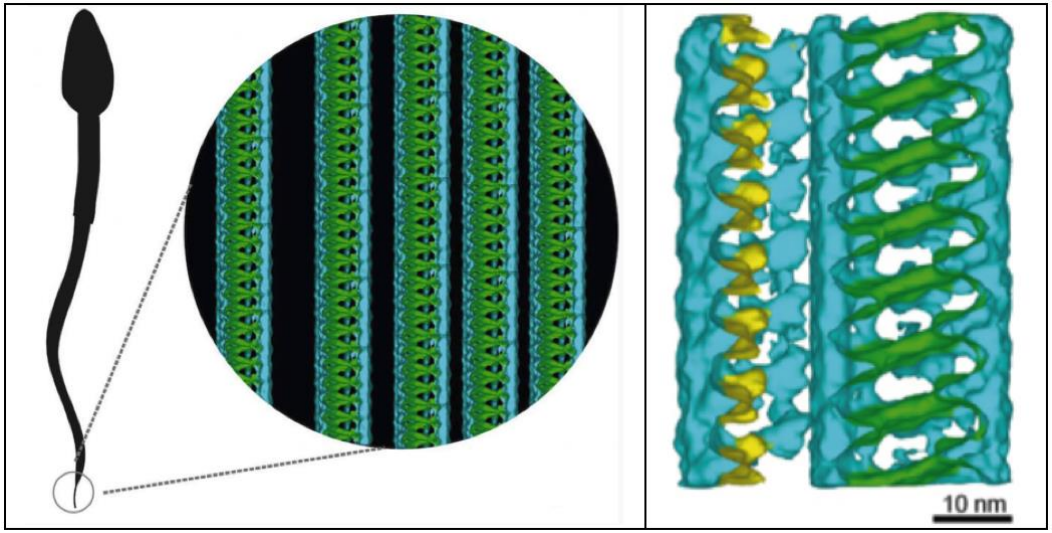
Inherited systems of liquid crystals

DNA and RNA, some proteins, membranes and cytoskeleton of cells are liquid crystals, which can also form nano-bioantenna arrays. Of particular interest for biological research are liquid crystals called chiral phases or twisted nematics. For these crystals, the direction of the orientation of molecules in successive layers changes in a spiral.

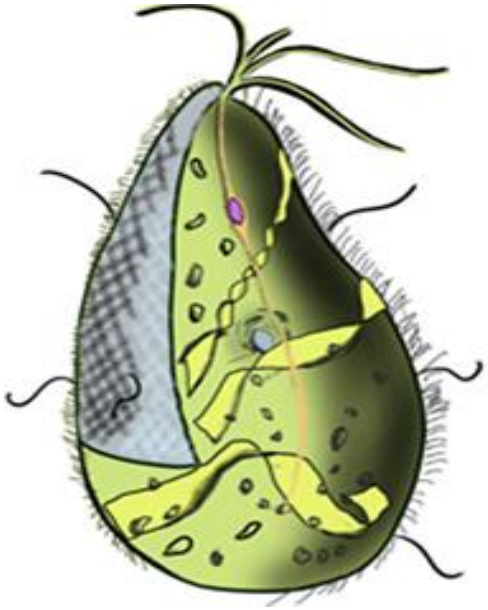




Nanoantennas based on DNA are already used in scientific technologies: scientists at the University of Montreal in Canada have created glowing nanoantennas from DNA molecules to track the relationships within proteins. These nanoantennas are capable of fluorescence and can absorb radiation at one wavelength and emit light at a different frequency depending on the molecular environment [Harroun et al., 2022].



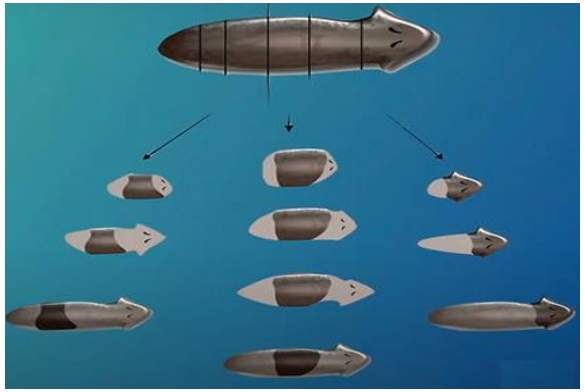
An analogue of a spiral antenna in a form of left-handed helices was discovered by Swedish scientists in the tail of a spermatozoon. These authors speculate that these helical structures in particularly can «play a role in controlling the swimming direction of spermatozoa» that is play a role of antennas for communication with environment [Zabeo et al., *Scientific Reports*, 2018]. But it is known that the directional properties of a helical axial radiation antenna can be determined by considering the spiral as a linear antenna array consisting of many emitters in form of its turns [Voskresensky et al., 2006].



Antenna-like helical structures are involved in the biomechanics of coordinated movements. For example, the unicellular organism Mixotricha paradoxa moves due to the **250,000 spiral bacteria Treponema spirochetes** located on its surface, the spiral flagella of which coherently twist as a whole, providing purposeful movement.

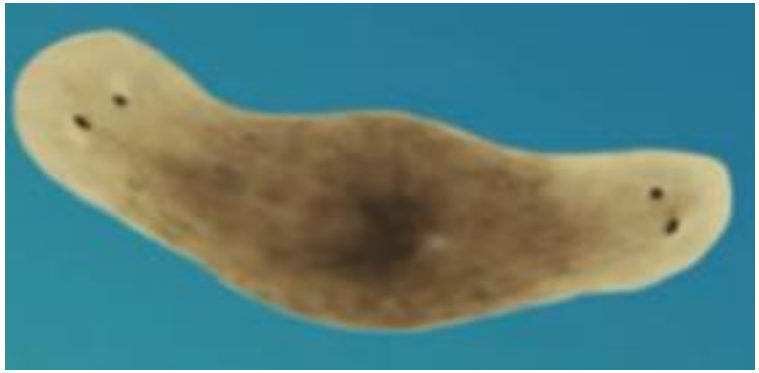
Bio-antenna arrays and regeneration phenomena

It is natural to believe that the electromagnetic activity of bio-nanoantenna arrays is involved, in particular, in the distribution of rest potentials on cell membranes, which are liquid crystals. This factor of rest potentials are important for morphogenetic processes and the regeneration as it was shown in impressive expremental works by M.Levin and his colleaques at Tufts University, USA [https://ase.tufts.edu/biology/labs/levin/]. These works were carried out on flatworms - planarians, which have a head, a true brain, etc. Planarians are known champions in organ and tissue regeneration.



(Fig. from Levin's interview https://www.youtube.com/watch?v=XheAMrS8Q1c).

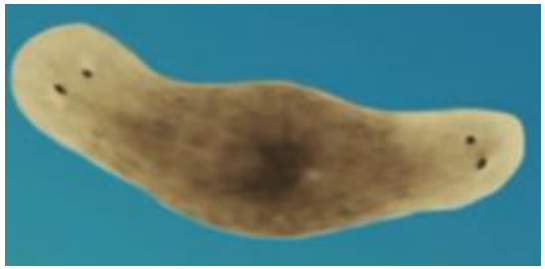
The noted works studied regeneration of amputation parts of worm's body and showed that the determination of the correct position of the organ in the worm’s body is controlled by the distribution of membrane potentials in not yet differentiated cells. Artificial changing by ionophores the typical distribution of the membrane potentials on an amputated fragment of the worm's body leads to the formation of **planarians with two heads** (one should note, that such artificial influence on liquid crystal membranes can significantly change cell systems of liquid crystal bio-antenna arrays participating in morphogenetic processes).



Two-headed worm (from Levin’s interview https://www.youtube.com/watch?v=XheAMrS8Q1c).

It is especially remarkable that if both heads are cut off from the resulting two-headed worm, then a two-headed worm is again regenerated from the remaining middle fragment. And this procedure can be repeated many times, each time receiving the regeneration of a two-headed worm.

According to Levin, this means that the memory of the correct structure of the body, which should be formed after regeneration, turns out to be radically changed, although the genome of this organism did not change and remained the same. **Therefore, the memory that tells the worm about how many heads it should have is contained not in the genome at all!**



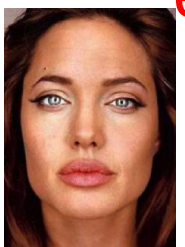
Two-headed worm (from Levin's interview https://www.youtube.com/watch?v=XheAMrS8Q1c).

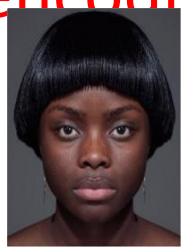
These experimental facts have led Levin to the important idea that emergent properties of an ensemble of cells are key participants of morphological and some other processes. **Multicellular ensembles are able to determine the type of morphological patterns formed, largely independently of the information in DNA**, which is essential for coding of proteins. This idea generated new experiments, in which Levin showed that the combination of cells from the skin of a frog into a single ensemble leads to the appearance of a tiny body of a completely new design. Such bodies, which are biological robots called "**xenobots**", can move, navigate a labyrinth, explore the environment, feed and heal themselves, and exhibit emergent group behavior, although they do not have a nervous system, do not have a brain, and they are simply collections of skin cells with unchanged DNAs (xenobots can live 10-14 days). These results allowed generating **Levin's concept that «*the electrical blueprints orchestrate life*»** [https://www.youtube.com/watch?v=XheAMrS8Q1c].

Our doctrine of evolution based on bio-antenna arrays **proposes another basis point of view**. This doctrine states that just **bio-antenna arrays with their coordinated electro-magnetic waves «orchestrate life»**. This doctrine draws attention to important factors of electromagnetic waves, which are absent in the concept of «the electrical blueprints»:

- 1. Electromagnetic waves of bio-antenna arrays are involved in the operational transfer and redistribution of energy between the elements of the body;
- 2. For connections between parts of each bio-body, electromagnetic waves provide participations of magnetic and piezo-vibration components besides electrical potentials;
- 3. The types of polarization of electromagnetic waves of bio-antenna arrays are important for relationships between the elements of the bio-body since they are associated with the fundamental problem of biological dissymmetry and molecular chirality noted by L. Pasteur;

- 4) Memory and intellectual abilities are connected with bio-antenna arrays and their wave-coordinated activity;
- 5) The unique ability of antenna arrays to provide noise-resistant multi-channel operation with the extraction of weak signals against the background of strong noise allows us to rethink the phenomenal ability of organisms to work in many parallel channels with weak information signals against the background of strong noise with providing information noise-immunity. (Remind that according to Mendel's law of independent inheritance of traits, information from the level of DNA molecules dictates the macrostructure of living bodies through many independent channels, despite strong noises. For example, hair, eye, and skin colors are inherited independently of each other. So, each organism is a machine of multichannel noise-immunity encoding).





Concerning the role of bio-antenna arrays in energy flows in bio-bodies one can add that the idea of the organizing role of coordinated energy flows inside the body exists since ancient times. It is associated with Ancient Chinese ideas about a certain special energy “qi” (or “chi”), whose circulation defines human health and illnesses and which determines the existence of energy pathways called acupuncture meridians. By the impact of acupuncture needles on these meridians, these energy flows can be corrected. **It cannot be ruled out that this mysterious energy “qi” is partially or completely precisely the energy of a multitude of coordinated electromagnetic and other wave rays from bio-antenna**

The genetic code and bio-antenna arrays

The described tensor-matrix analogies between structures of stochastic organization of genomes and Smart antennas allow believing that the genetic code itself is one of the offspring of wave activity and self-organization of bio-antenna arrays, and this code is connected with other inherited physiological offsprings of bio-antenna arrays in the organism.

The secret of the structural organization and origin of the genetic code, as well as the origin of organisms, must be sought not in the random combination of the molecular elements of the genetic code, but in the emergent properties of self-organizing systems of bio-antenna arrays with their wave energy activity. Accordingly, it is not genes that are the dictators of all life activity, since they themselves are built into the energy-information coherences of bio-antenna arrays and are produced by them.

In his book "What is Life?", Schrodinger stated that the genetic material is an “***aperiodic crystal***”. The presented doctrine of energy-informational evolution continues this line of thought but significantly supplements it with the provision of the key role of bio-antenna arrays and their wave functioning. The doctrine proposes to **consider DNA and RNA as a germinal aperiodic crystal of bio-antenna arrays, which serves as a crystallization seed for aperiodic crystallization of the entire developing organism as a huge growing set of bio-antenna arrays interrelated with each other**. The processes of this aperiodic crystallization of the inherited body can be modified under the influence of the environment, nutritional conditions, stages of onto- and phylogenetic development, etc.

Erwin Schrödinger

People has long discussed the relationship between innate knowledge and knowledge acquired in the course of life. The extreme point of view is formulated in Plato's famous statement that to know means to remember, awakening, as it were, from sleep. Close to this is the widespread opinion that our body already carries in hidden forms the fullness of knowledge, whose parts come into our consciousness when they are insistently requested. But our body grows from a single fertilized cell. This original cell cannot contain all the named completeness of knowledge. Additional knowledge should come into our body from outside in the course of ontogeny. It is the ensembles of bio-antenna arrays that can serve as the system through which cosmic and planetary wave energy-information influences enter the body from the outside world; these external influences are necessary for the adequate development and replenishment of the body's knowledge.

This talk presents only fragments of our works in algebraic biology. Many other materials are available free access on the speaker's website: http://petoukhov.com/ .

Many details of the talk are in the preprint https://www.preprints.org/manuscript/202203.0100/v1 (doi: 10.20944/preprints202203.0100.v1).

Thank you very much for your attention!