Music and the Modeling Approach to Genetic Systems of Biological Resonances

(GENETIC SYSTEM AND VIBRATIONAL MECHANICS)

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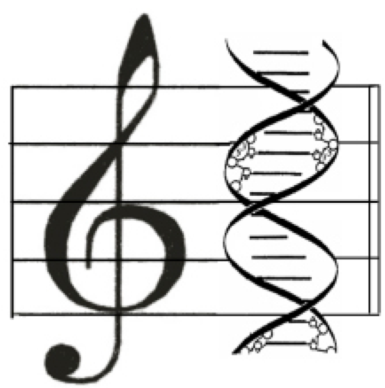
 

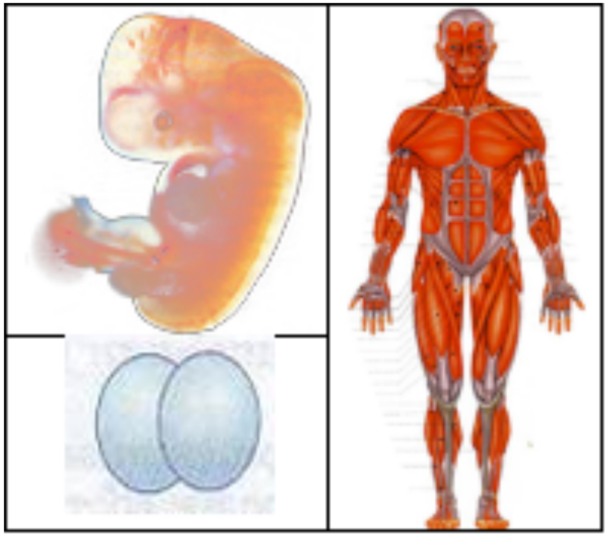
Living bodies possess **innate ability to use acoustic resonances**, reproduce resonant frequencies of speech, singing and musical instruments, and **use resonances as carriers of information.**

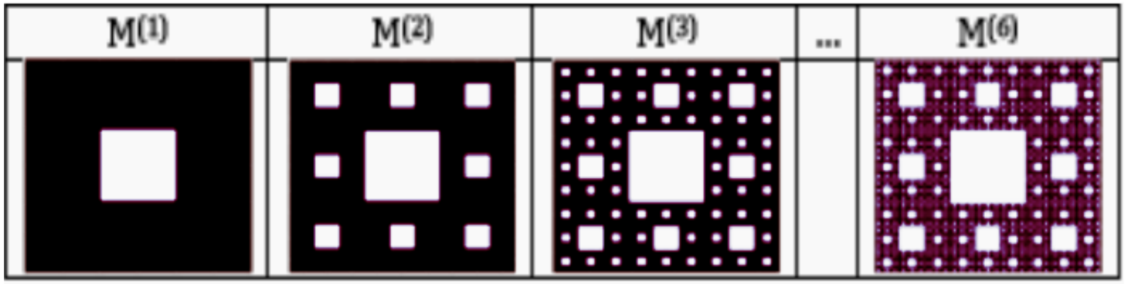
Any living organism is a great chorus of coordinated oscillatory processes (mechanical, electrical, piezoelectric, biochemical, etc.), which are connected with their genetic inheritance along chains of generations. Since ancient times, chrono-medicine believes that all diseases are the result of disturbances in the ordered set of oscillatory processes.

From a formal point of view, **a living organism is an oscillatory system with a large number of degrees of freedom. Resonances in such a system can serve as mechanisms for harmonization and ordering of its set of oscillatory processes**.

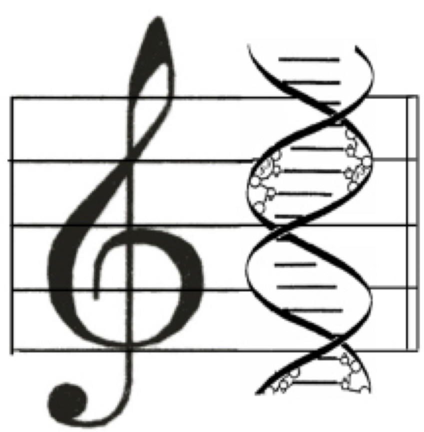
Theory of oscillations uses **mathematics of matrices** to study resonant characteristics of systems with many degrees of freedom. **We use matrices to study genetic phenomena**.

Growth of the organism from embryo to adult increases the number of degrees of freedom, but **coordination of oscillatory processes is conserved in each stage of development**. A geometric space, which can be used for modeling the increasing degrees of freedom, should increase its dimensions correspondingly.





According to the classics of structural linguistics (Roman Jakobson et al.), our linguistic language did not come out of nowhere, but it is an extension and superstructure of the genetic language, which is the oldest among all languages.



This presentation puts forward author's conception of a key role of special sets of resonant frequencies in genetics and genetic phenomena (the conception of resonant genetics). We'll try to show some our results, which speak in favor of the following:

1) Genetic alphabets are systems of resonances; respectively, the genetic code is the code of systems of resonances;

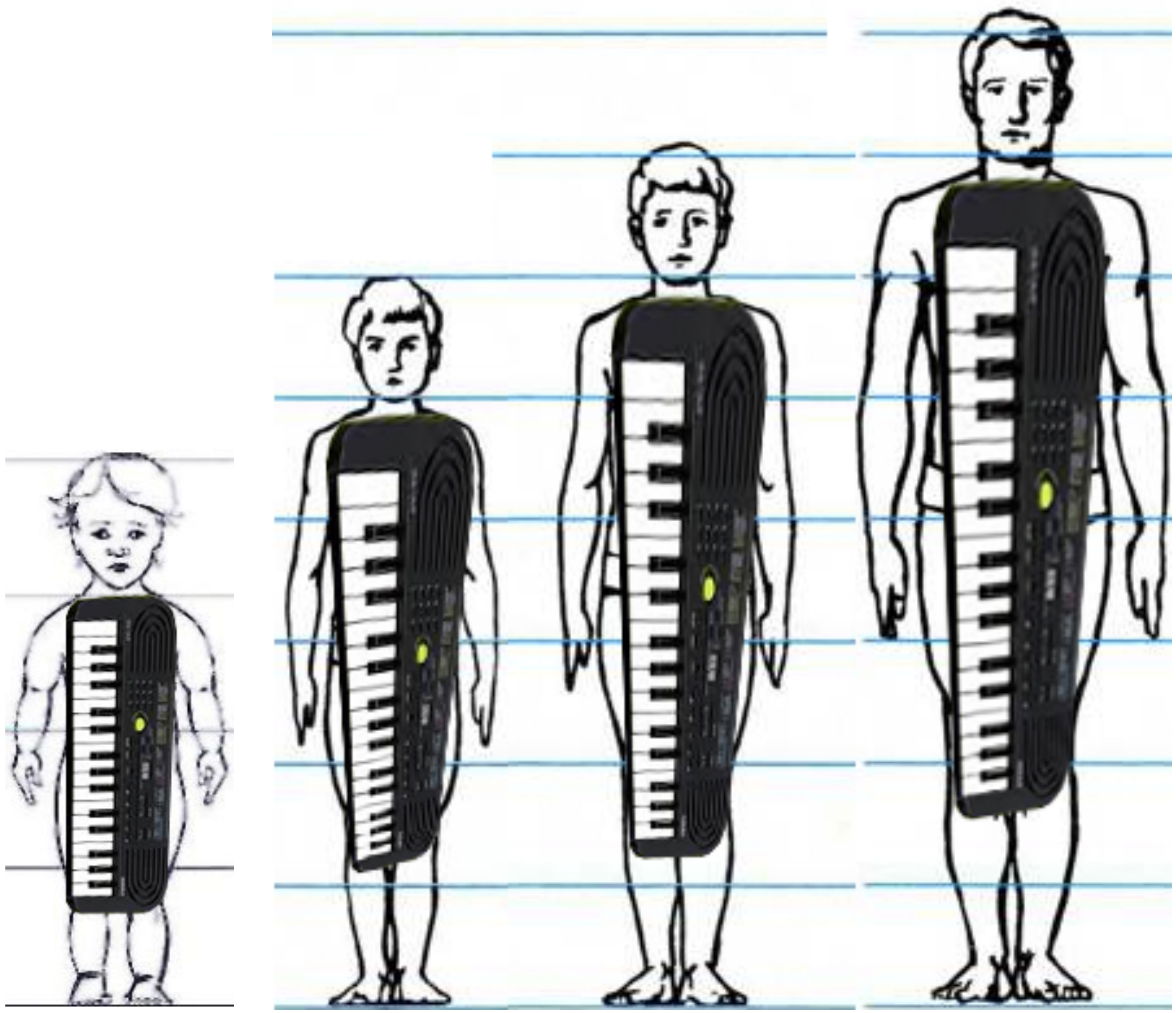
♀ \ ♂	AB	Ab	aB	ab
AB	AABB	AABb	AaBB	AaBb
Ab	AABb	AAbb	AaBb	Aabb
aB	AaBB	AaBb	aaBB	aaBb
ab	AaBb	Aabb	aaBb	aabb

2) Punnet squares, describing traditionally poly-hybrid crossing of organisms under the laws of Mendel, are an analogy to "tables of inheritance of eigenvalues" in tensor families of matrices of vibrational systems;

3) Alleles of genes from Mendel's laws can be interpreted as eigenvalues of matrices, which represent vibrational systems with many degrees of freedom (eigenvalues λ_i of a vibrational system are equal to square of its resonant frequencies $\lambda_i = \omega_i^2$) ;

4) Some known inherited phenomena can be modeled on the base of the conception of resonant bioinformatics, including the main psychological law of Weber-Fechner, morphogenetic laws of phyllotaxis, etc.

A new slogan can be proposed: **any living body is a musical instrument** (a synthesizer with an abundance of rearrangements of resonant modes).

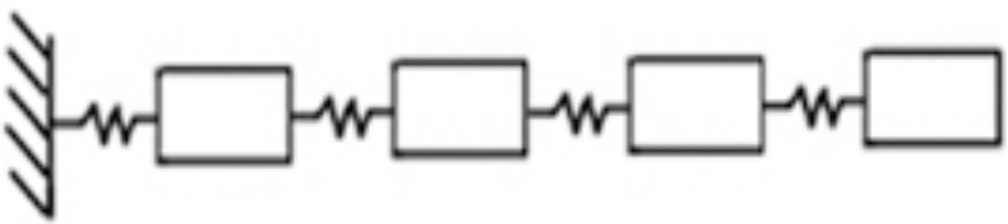


All natural objects - both living and others - have resonant properties. Whether there is a specificity of biological sets of resonant properties, which are inherited genetically? The presentation shows the author’s model approach, the results of which give evidences in favor of **the specificity of the biological system of inherited resonant frequencies**. More precisely, living organisms can differ with special inherited tensor-matrix systems of resonances in them.

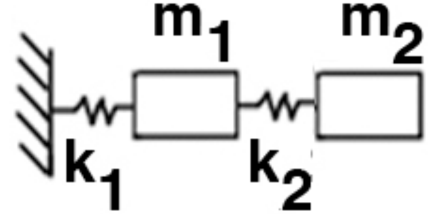
MATRICES AND RESONANCES

Matrices are endowed with a remarkable property of displaying resonances. Physical phenomenon of resonances is familiar to everyone. The passage of the signal "s" through the acoustic system A, which is represented by the matrix A, is modeled by the expression y = A*s. If the input signal "s" is a resonant tone, then the output signal "y" repeats it up to a scale factor λ: y = λ*s. In the matrix, the quantity of resonant tones corresponds to its size and to the quantity of freedom degrees of the system, which it represents.

In vibration theory these resonant tones are called **eigenvectors** of the matrix, and the scale factors $\boldsymbol{\lambda_i}$ are called its **eigenvalues**, a set of which is a spectrum of the system A (or the matrix A). Frequencies $\boldsymbol{\omega_i = \lambda_i^{0.5}}$ are called the **resonant (or natural) frequencies** of the vibrational system, and the corresponding eigenvectors are called its own forms of oscillations.



An example of a vibration system from the book: Gladwell G.M.L. *Inverse problems in Vibration*. London: Kluwer Academic Publishers, 2004:



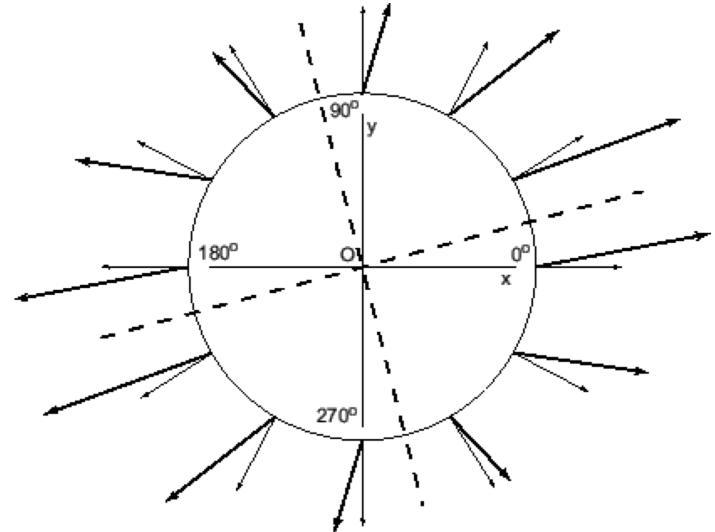
k_1, k_2 - the stiffness of the springs; m_1, m_2 - mass of the weights. The system of equations for free vibrations of the object is:

$$\begin{vmatrix} k_1 + k_2 - \lambda^* m_1, & -k_2 \\ -k_2 & , k_2 - \lambda^* m_2 \end{vmatrix} * \begin{vmatrix} x_1 \\ x_2 \end{vmatrix} = 0$$

Eigenvalues λ_1 and λ_2 of the matrix:

$\lambda_{1,2} = \omega_{1,2}^2 = \{(k_2*m_1+k_1*m_2+k_2*m_2)\pm((k_2*m_1+k_1*m_2+k_2*m_2)^2 -4*k_1*k_2*m_1*m_2)^{0.5}\}/2*m_1*m_2$

$$A = \begin{vmatrix} 4, & 0.6 \\ 0.6 & 2 \end{vmatrix}$$



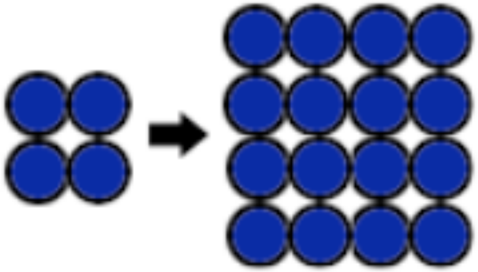
Let us remind the essence of the eigenvalues and eigenvectors by means of the matrix A, which acts on vectors [x, y]. Almost any vector is transformed into a new vector [x, y]*A with changing its direction. The exception are those "eigenvectors" [x, y], which belong to two orthogonal dotted lines; they conserve their direction under action of the matrix A, but their lengths are changed because of certain eigenvalues. To find eigenvectors and eigenvalues of a matrix A, a "characteristic equation" det(A-λE)=0 is used in theories of mechanical, electrical and other oscillations at macroscopic and microscopic levels.

This presentation examines the spectra of (2^n*2^n)-matrices, which are generated by tensor products of original (2*2)-matrices and which are used to model some genetic phenomena and structures. The tensor product of matrices are widely used in mathematics, computer science, coding theory, physics, etc.

ABOUT THE TENSOR PRODUCT OF MATRICES

The tensor (or Kronecker) product of matrices, denoted $\otimes$, is used for algorithmic generation of spaces with higher dimensions on the basis of spaces with smaller dimensions [http://en.wikipedia.org/wiki/Tensor_product].

It resembles the increase of degrees of freedom in ensembles of biological cells of growing organism.



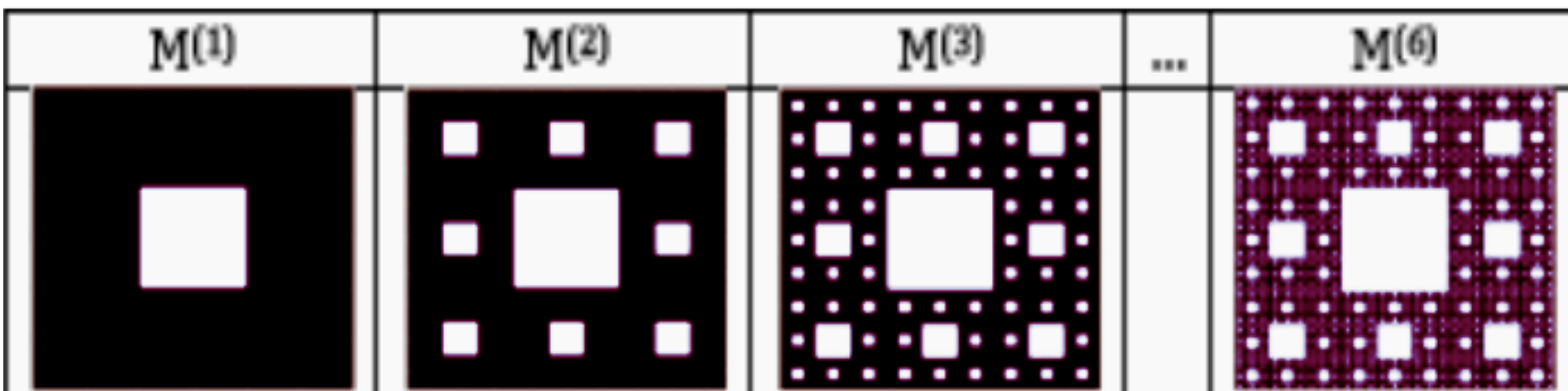
Definition: If V and W are square matrices of order n and m respectively, then their tensor product is the matrix **Q=V⊗W=||v_ij*W||** with the higher order m*n.

For example, the tensor product of two (2*2)-matrices gives a single (4*4)-matrix:

$$\begin{vmatrix} a, b \\ c, d \end{vmatrix} \otimes \begin{vmatrix} k, p \\ r, s \end{vmatrix} = \begin{vmatrix} a* \begin{vmatrix} k, p \\ r, s \end{vmatrix}, & b* \begin{vmatrix} k, p \\ r, s \end{vmatrix} \\ c* \begin{vmatrix} k, p \\ r, s \end{vmatrix}, & d* \begin{vmatrix} k, p \\ r, s \end{vmatrix} \end{vmatrix} = \begin{vmatrix} ak, ap, bk, bp \\ ar, as, br, bs \\ ck, cp, dk, dp \\ cr, cs, dr, ds \end{vmatrix}$$

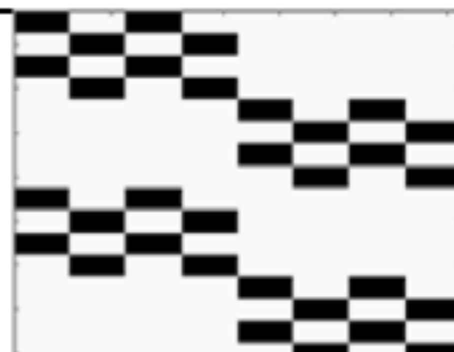
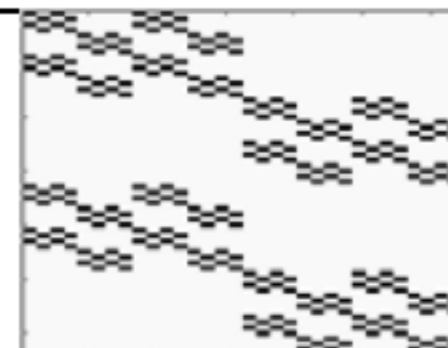
The tensor product has the property of inheritance of mosaic structure of the initial matrix under its tensor exponentiation. It generates **fractal patterns**. For example, the tensor powers (n) of the matrix M generates a family of matrices $M^{(n)}$ with known fractal mosaics of Sierpinski carpet:

$$M=\begin{vmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 1 \end{vmatrix}$$



Changing an initial matrix allows you to get a lot of fractals on the base of its tensor powers:

M	M	$M^{(2)}$	$M^{(3)}$
0 1 1 0 1 0 0 1 1 0 0 1 0 1 1 0			

M	M	$M^{(2)}$	$M^{(3)}$
1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1			

TABLES OF TENSOR INHERITANCE OF EIGENVALUES OF VIBROSYSTEMS and PUNNET SQUARES FROM GENETICS

For us more important that the tensor product of matrices has the **property of "inheritance" of eigenvalues of initial (or "parental") matrices**: if parental matrices V and W have their eigenvalues λ_i and μ_j respectively, then all the eigenvalues of their tensor product **Q=V⊗W** are equal to $\lambda_i * \mu_j$. Features of such inheritance of eigenvalues of parental matrices in cases of the tensor product of matrices can be conveniently represented in the form of "**tables of a tensor inheritance of eigenvalues of the matrices**".

Below tables show two simplest cases, conventionally referred to as monohybrid and dihybrid cases of a tensor hybridization of vibro-systems. In the first case, the tensor product of two (2*2)-matrices V and W, which have the same set of eigenvalues A and a, gives the (4*4)-matrix Q=V⊗W with its 4 eigenvalues A*A, A*a, a*A, a*a (see the left table).

In the second case, the tensor product of (4*4)-matrices, having the same set of eigenvalues A*B, A*b, a*B, a*b, gives (16*16)-matrix with 16 eigenvalues, representated in the tabular form (the right table).

		Maternal spectrum V	
		A	a
Paternal spectrum W	A	AA	Aa
	a	aA	aa

		Maternal spectrum			
		AB	Ab	aB	ab
Pat. sp.	AB	AABB	AABb	AaBB	AaBb
	Ab	AABb	AAbb	AaBb	Aabb
	aB	AaBB	AaBb	aaBB	aaBb
	ab	AaBb	Aabb	aaBb	aabb

We have noted that **these tables of inheritance for spectra of vibro-systems are identical to known Punnet squares for poly-hybrid crosses of organisms** (Figures show Punnet squares for monohybrid and dihybrid crosses of organisms):

		Maternal gametes	
		A	a
Paternal gametes	A	AA	Aa
	a	aA	aa

		Maternal gametes		
		AB	Ab	aB
Pat. gam.	AB	AABB	AABb	AaBB
	Ab	AABb	AAbb	AaBb
	aB	AaBB	AaBb	aaBB
	ab	AaBb	Aabb	aaBb

In genetics from 1906 year, Punnet squares represent Mendel's laws of inheritance of traits under poly-hybrid crosses. But **instead of eigenvalues of matrices of vibro-systems, in Punnet squares exist similar combinations of dominant and recessive alleles of genes** from parent reproductive cells - gametes.

This formal analogy - between Punnet squares of combinations of alleles and tables of tensor inheritance of eigenvalues of matrices of vibrosystems - generates the following idea:

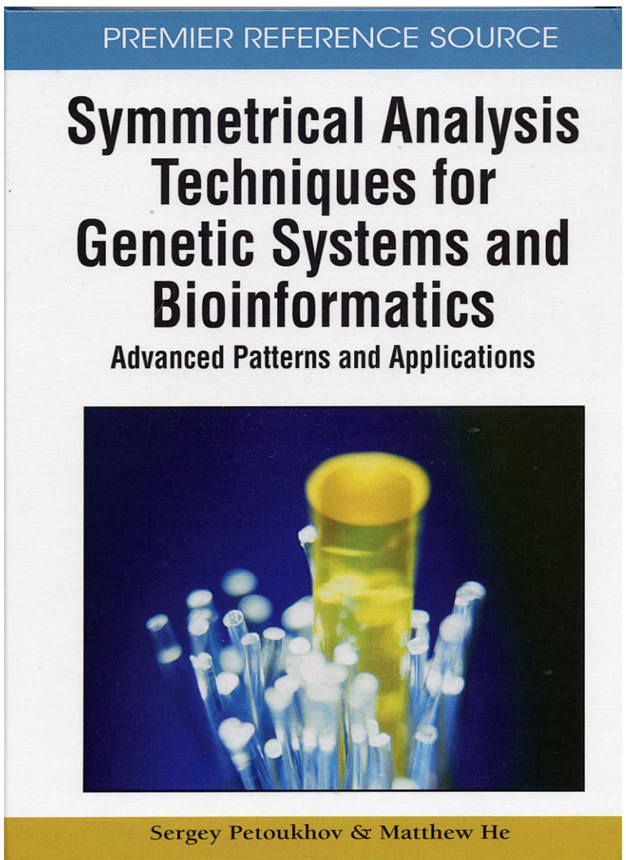
- **alleles of genes and their combinations can be interpreted as eigenvalues of (2^n*2^n)-matrices from tensor families of matrices of oscillatory systems**. For genetic systems, this approach focuses an attention on the possible importance of a particular class of matrix spectra (or mutually related resonant frequencies) from tensor families of matrices, which play in biology the role of "matrix archetypes."

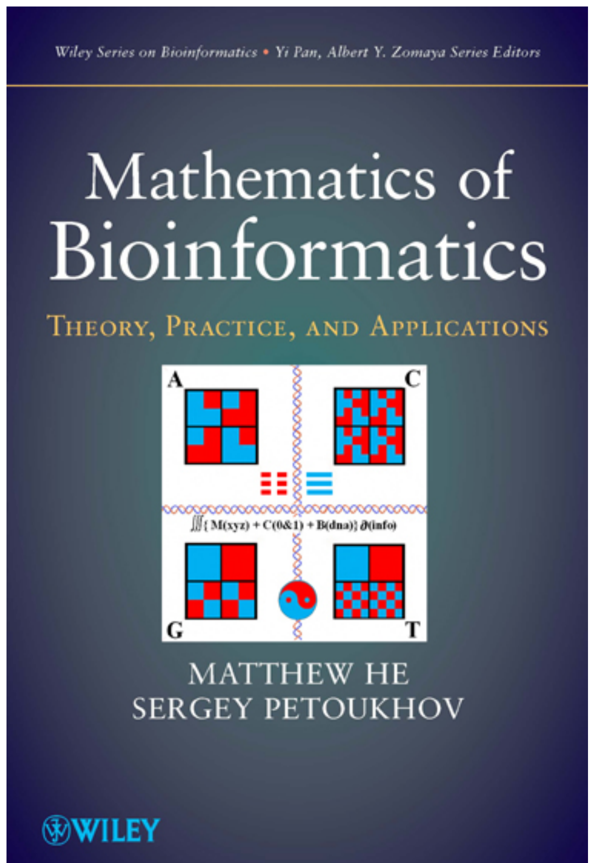
GENETIC ALPHABETS AND TENSOR SYSTEMS OF RESONANCES

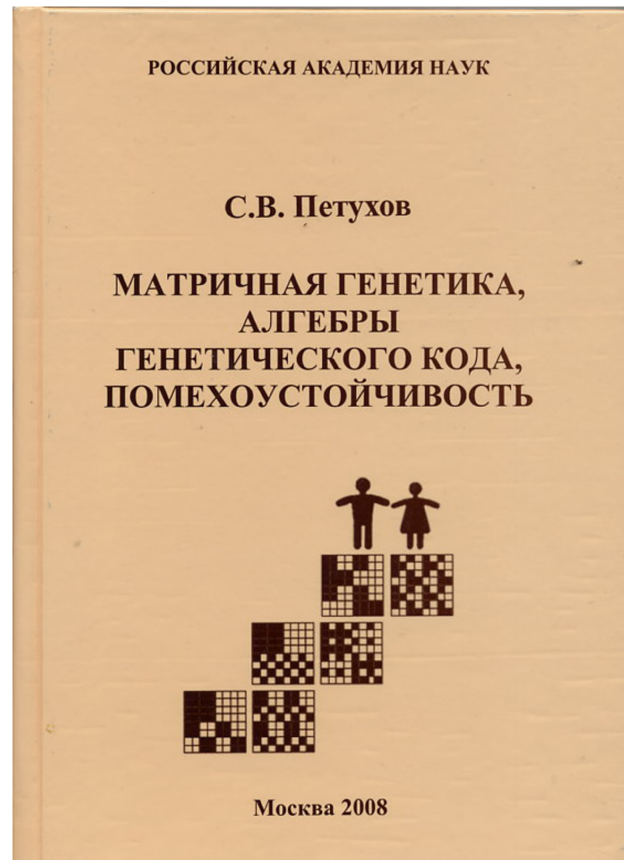
Science has led to a new understanding of life itself: **«*Life is a partnership between genes and mathematics*»** [Stewart I. Life's other secret: The new mathematics of the living world. 1999, New-York: Penguin].

But what kind of mathematics is a partner with the genetic code and defines the structure of living matter? Trying to find such mathematics, the author has got results about connections of the system of genetic alphabets with matrix formalisms of theory of noise-immunity coding.

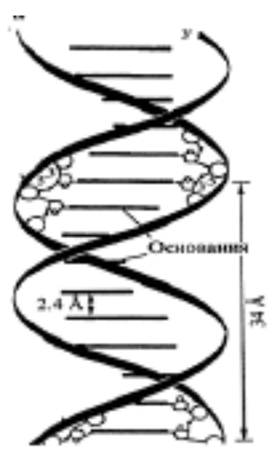
These results were published in four author's books about matrix genetics in Russia (2001, 2008) and in the USA (2010 and 2011 years) and in many thematic articles (see personal website http://petoukhov.com/)

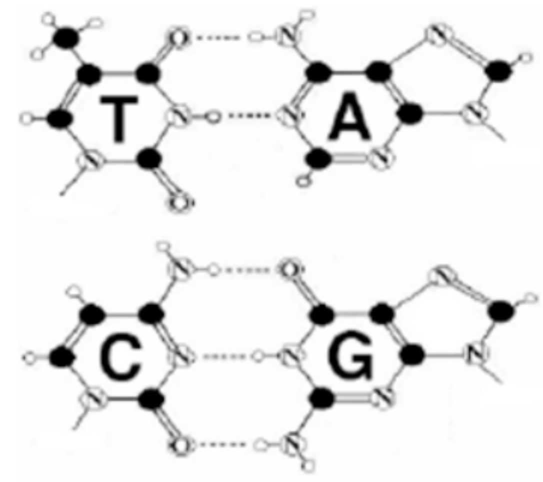






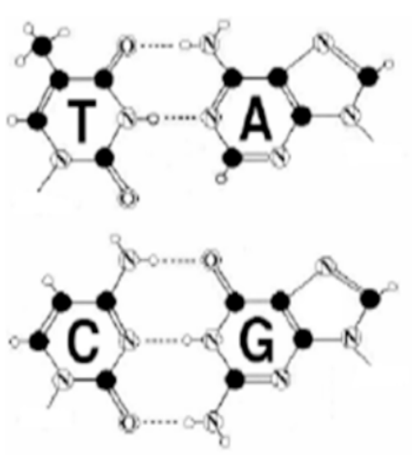
This presentation shows some results in favor of our hypothesis, that **genetic alphabets are also constructed on sets of resonances (or eigenvalues of matrices)**, which can be used, in particularly, for noise-immunity of the genetic system.



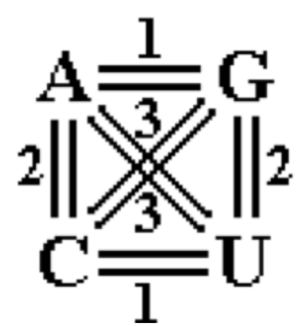


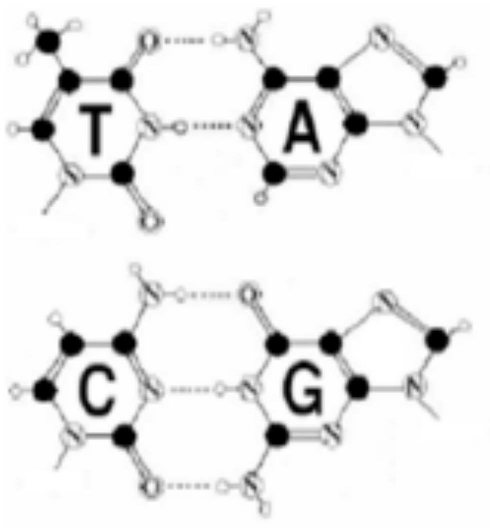
The basic alphabet of DNA contains **4 letters** (adenine A, cytosine C, guanine G, thymine T). The alphabet of **64 triplets** (or combination of three genetic letters: CGA, TAG, etc.) encode 20 amino acids (and punctuation signs), a sequence of which defines a primary structure of proteins.

Science does not know why the basic alphabet of DNA consists of four poly-atomic structures A, C, G, T of the very simple configuration. But it is known that it carries on itself the symmetric system of binary-oppositional traits. This system divides the 4-letter alphabet into various three **pairs of letters**, which are equivalent from a viewpoint of one of these traits or its absence: 1) C=T & A=G (according to the binary-opposite traits: “pyrimidine” or “purine»); 2) A=C & G=T (amino or keto); 3) C=G & A=T (3 or 2 hydrogen bonds exist in these complementary pairs).



TRAITS	G	A	T	C
1) pyrimidine (C,T), purine (A,G)	0_1	0_1	1_1	1_1
2) amino (A,C), keto (G,T)	0_2	1_2	0_2	1_2
3) complementarity (C,G) and (A,T) with 3 or 2 hydrogen bonds	1_3	0_3	0_3	1_3





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3) complementarity (C,G) and (A,T) with 3 or 2 hydrogen bonds	1_3	0_3	0_3	1_3

These binary-oppositional traits of DNA-bases A, C, G, T can be interpreted as connected with their own resonant frequencies. For example, it is obvious that purine molecules may have resonant frequencies that differ from the resonant frequencies of pyrimidine molecules. Such binary resonant characteristics, symbolised by 0 and 1, allow considering the **genetic system as a computer on resonant frequencies**.

We'll continue this natural scheme of the division of the genetic alphabet into sub-alphabets on the base of pairing letters. Let us assume that **four DNA-bases A, C, G, T are eigenvalues (or resonant frequencies) of some matrices** and so they can be located on diagonals of the corresponding diagonal matrices, for example (here index "d" means a diagonal matrix):

$$\begin{vmatrix} C, 0 \\ 0, A \end{vmatrix} = [C, A]_d \; ; \qquad \begin{vmatrix} T, 0 \\ 0, G \end{vmatrix} = [T, G]_d$$

In this case the additional information is useful: 1) any square matrix with distinct eigenvalues λ_i can be transformed into its diagonal form (due to selection of the basis), in which **all its eigenvalues lie on its diagonal**; 2) the tensor product of diagonal matrices always generates a diagonal matrix again.

$$\begin{vmatrix} C, 0 \\ 0, A \end{vmatrix} = [C, A]_d ; \qquad \begin{vmatrix} T, 0 \\ 0, G \end{vmatrix} = [T, G]_d$$

Tensor products of these two diagonal matrices $[C, A]_d$ and $[T, G]_d$ in all possible combinations in threes represent the entire set of 64 triplets in the form of diagonals of 8 diagonal matrices of (8*8) (**8 octets of the diagonals**):

$$[C, A]_d \otimes [C, A]_d \otimes [C, A]_d = [CCC, CCA, CAC, CAA, ACC, ACA, AAC, AAA]_d$$
$$[C, A]_d \otimes [C, A]_d \otimes [T, G]_d = [CTT, CTG, CAT, CAG, ACT, ACG, AAT, AAG]_d$$
$$[C, A]_d \otimes [T, G]_d \otimes [C, A]_d = [CTC, CTA, CGC, CGA, ATC, ATA, AGC, AGA]_d$$
$$[C, A]_d \otimes [T, G]_d \otimes [T, G]_d = [CTT, CTG, CGT, CGG, ATT, ATG, AGT, ATG]_d$$
$$[T, G]_d \otimes [C, A]_d \otimes [C, A]_d = [TCC, TCA, TAC, TAA, GCC, GCA, GAC, GAA]_d$$
$$[T, G]_d \otimes [C, A]_d \otimes [T, G]_d = [TCT, TCG, TAT, TAG, GCT, GCG, GAT, GAG]_d$$
$$[T, G]_d \otimes [T, G]_d \otimes [C, A]_d = [TTC, TTA, TGC, TGA, GTC, GTA, GGC, GGA]_d$$
$$[T, G]_d \otimes [T, G]_d \otimes [T, G]_d = [TTT, TTG, TGT, TGG, GTT, GTG, GGT, GGG]_d$$

It should be noted that a huge quantity $64! \approx \mathbf{10^{89}}$ of variants exists for dispositions of 64 triplets in these 8 octets. For comparison, the modern physics estimates time of existence of the Universe in $\mathbf{10^{17}}$ seconds. It is obvious that an accidental disposition of the 20 amino acids and the corresponding 64 triplets in these 8 octets will give almost never any symmetry.

But unexpectedly the disposition of amino acids and triplets, having different phenomenological properties, has a very symmetric character inside the set of formalistically constructed 8 octets. These symmetries in molecular-genetic system show a hidden regularities. We'll show briefly 3 examples of such symmetries and hidden regularities.

<u>The first example</u>. Amino acids, which are encoded by triplets, split this set of 8 octets into **pairs of neighboring octets 1-2, 3-4, 5-6, 7-8 with identical lists of their amino acids** (color symbols):

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

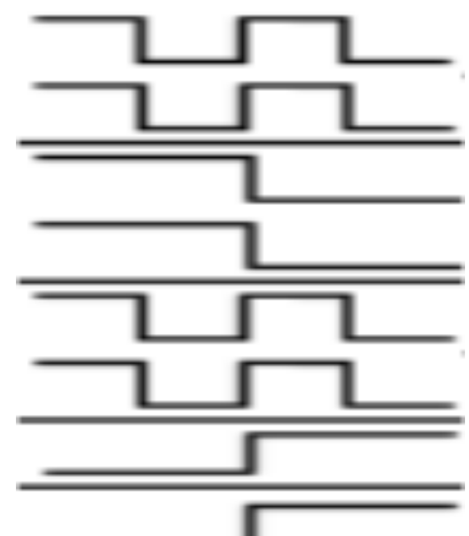
(Here the Vertebrate Mitochondrial Genetic Code is shown).

The second example of hidden regularities in the 8 octets.

It's known that the set of 64 triplets is divided into two halves: 32 triplets with so called «strong roots» (black color) and 32 triplets with «weak roots» (white color). The location of these black and white triplets inside the 8 octets suddenly gives symmetries: 1) a mosaic of each octet is anti-symmetric in its left and right halves, and it has a meander character of **Rademacher functions $r_n(x) = \text{sign}(\sin 2^n \pi x)$ known in theory of signal processing**;

2) the left (right) half of the first 4 octets has the same mosaics with the right (left) half of the last 4 octets, etc.

[CCC	CCA	CAC	CAA	ACC	ACA	AAC	AAA]$_d$
[CCU	CCG	CAU	CAG	ACU	ACG	AAU	AAG]$_d$
[CUC	CUA	CGC	CGA	AUC	AUA	AGC	AGA]$_d$
[CUU	CUG	GGU	CGG	AUU	AUG	AGU	AGG]$_d$
[UCC	UCA	UAC	UAA	GCC	GCA	GAC	GAA]$_d$
[UCU	UCG	UAU	UAG	GCU	GCG	GAU	GAG]$_d$
[UUC	UUA	UGC	UGA	GUC	GUA	GGC	GGA]$_d$
[UUU	UUG	UGU	UGG	GUU	GUG	GGU	GGG]$_d$



THE STANDARD CODE	
8 subfamilies of triplets with strong roots («black triplets») and amino acids, which are encoded by them	8 subfamilies of triplets with weak roots («white triplets») and amino acids, which are encoded by them
CCC, CCT, CCA, CCG → Pro	CAC, CAT, CAA, CAG → His, His, Gln, Gln
CTC, CTT, CTA, CTG → Leu	AAC, AAT, AAA, AAG → Asn, Asn, Lys, Lys
CGC, CGT, CGA, CGG → Arg	ATC, ATT, ATA, ATG → Ile, Ile, Ile, Met
ACC, ACT, ACA, ACG → Thr	AGC, AGT, AGA, AGG → Ser, Ser, Arg, Arg
TCC, TCT, TCA, TCG → Ser	TAC, TAT, TAA, TAG → Tyr, Tyr, Stop, Stop
GCC, GCT, GCA, GCG → Ala	TTC, TTT, TTA, TTG → Phe, Phe, Leu, Leu
GTC, GTT, GTA, GTG → Val	TGC, TGT, TGA, TGG → Cys, Cys, Stop, Trp
GGC, GGT, GGA, GGG → Gly	GAC, GAT, GAA, GAG → Asp, Asp, Glu, Glu
THE VERTEBRATE MITOCHONDRIAL CODE	
CCC, CCT, CCA, CCG → Pro	CAC, CAT, CAA, CAG → His, His, Gln, Gln
CTC, CTT, CTA, CTG → Leu	AAC, AAT, AAA, AAG → Asn, Asn, Lys, Lys
CGC, CGT, CGA, CGG → Arg	ATC, ATT, ATA, ATG → Ile, Ile, Met, Met
ACC, ACT, ACA, ACG → Thr	AGC, AGT, AGA, AGG → Ser, Ser, Stop, Stop
TCC, TCT, TCA, TCG → Ser	TAC, TAT, TAA, TAG → Tyr, Tyr, Stop, Stop
GCC, GCT, GCA, GCG → Ala	TTC, TTT, TTA, TTG → Phe, Phe, Leu, Leu
GTC, GTT, GTA, GTG → Val	TGC, TGT, TGA, TGG → Cys, Cys, Trp, Trp
GGC, GGT, GGA, GGG → Gly	GAC, GAT, GAA, GAG → Asp, Asp, Glu, Glu

Figure shows triplets with strong roots (black color) and weak roots (white color) in the Standard Genetic Code and the Vertebrate Mitochondrial Genetic Code

The third example of hidden regularities in the 8 octets.

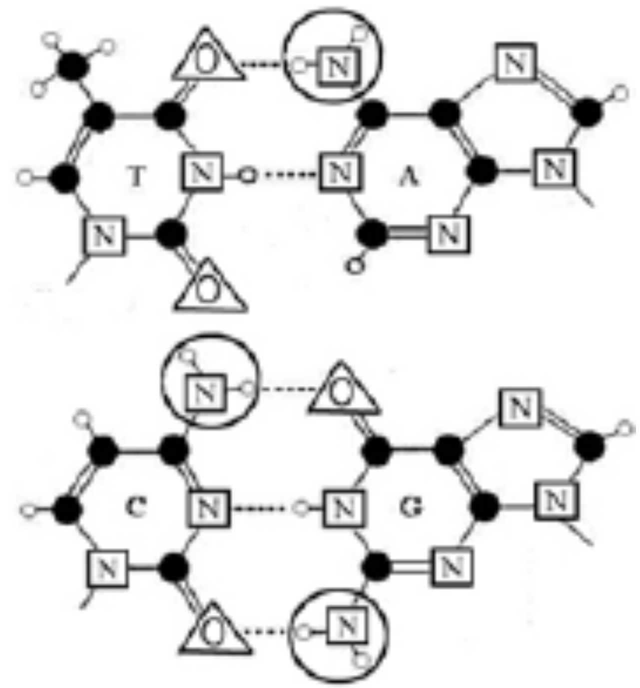
Inside the DNA-alphabet A, C, G, T, thymine T has a unique status and differs from other three letters:

1) only thymine T is replaced by another molecule U (uracil) in transferring from DNA to RNA;

2) only thymine T hasn’t the functionally important amino group NH_2.

This binary opposition can be expressed as: **A=C=G= +1, T= -1**.

In each triplet all its letters can be replaced to these numbers for representing the triplet as the product of these numbers.



In a result, these 8 octets of 64 triplets get the numerical representation, which **coincides with the complete orthogonal system of Walsh functions for 8-dimensional space from informatics of noise-immunity coding !**

[CCC, CCA, CAC, CAA, ACC, ACA, AAC, AAA]$_d$ →	[+1, +1,+1, +1, +1, +1, +1, +1]$_d$
[CCT, CCG, CAT, CAG, ACT, ACG, AAT, AAG]$_d$ →	[-1, +1, -1, +1, -1, +1, -1,+1]$_d$
[CTC, CTA, CGC, CGA, ATC, ATA, AGC, AGA]$_d$ →	[-1, -1, +1, +1, -1, -1, +1,+1]$_d$
[CTT, CTG, GGT, CGG, ATT, ATG, AGT, AGG]$_d$ →	[+1, -1, -1, +1, +1, -1, -1,+1]$_d$
[TCC, TCA, TAC, TAA, GCC, GCA, GAC, GAA]$_d$ →	[-1, -1, -1, -1, +1, +1, +1,+1]$_d$
[TCT, TCG, TAT, TAG, GCT, GCG, GAT, GAG]$_d$ →	[+1, -1, +1, -1, -1, +1, -1,+1]$_d$
[TTC, TTA, TGC, TGA, GTC, GTA, GGC, GGA]$_d$ →	[+1, +1, -1, -1, -1, -1, +1,+1]$_d$
[TTT, TTG, TGT, TGG, GTT, GTG, GGT, GGG]$_d$ →	[-1, +1, +1, -1, +1, -1, -1,+1]$_d$

Such complete systems of Walsh functions are used in noise-immunity coding of information, for example, on the spacecraft "Mariner" and "Voyager", which transmit to Earth pictures of Mars, Jupiter, Saturn, Uranus and Neptune. Complete systems of Walsh functions form Hadamard matrices, which are used in quantum computers ("Hadamard gates") and in quantum mechanics as its unitary operators.

Complete systems of Walsh functions serve as a basis of the “sequency theory” [H.Harmut, 1977, 1989], which has led to effective decisions in radio-engineering, acoustics, optics, etc. In particular, problem of absorption of radio waves and acoustic waves, which is important for biological systems, is bypassed by means of the "sequency analysis".

$[CCC, CCA, CAC, CAA, ACC, ACA, AAC, AAA]_d$ →	$[+1, +1, +1, +1, +1, +1, +1, +1]_d$
$[CCT, CCG, CAT, CAG, ACT, ACG, AAT, AAG]_d$ →	$[-1, +1, -1, +1, -1, +1, -1, +1]_d$
$[CTC, CTA, CGC, CGA, ATC, ATA, AGC, AGA]_d$ →	$[-1, -1, +1, +1, -1, -1, +1, +1]_d$
$[CTT, CTG, GGT, CGG, ATT, ATG, AGT, AGG]_d$ →	$[+1, -1, -1, +1, +1, -1, -1, +1]_d$
$[TCC, TCA, TAC, TAA, GCC, GCA, GAC, GAA]_d$ →	$[-1, -1, -1, -1, +1, +1, +1, +1]_d$
$[TCT, TCG, TAT, TAG, GCT, GCG, GAT, GAG]_d$ →	$[+1, -1, +1, -1, -1, +1, -1, +1]_d$
$[TTC, TTA, TGC, TGA, GTC, GTA, GGC, GGA]_d$ →	$[+1, +1, -1, -1, -1, -1, +1, +1]_d$
$[TTT, TTG, TGT, TGG, GTT, GTG, GGT, GGG]_d$ →	$[-1, +1, +1, -1, +1, -1, -1, +1]_d$

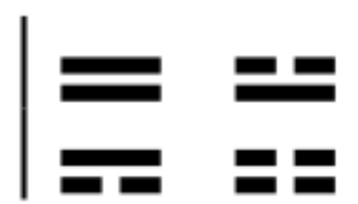
In our approach, the complete system of Walsh functions represents the genetic alphabet of 64 triplets in a form of the set of eigenvalues (resonances) of oscillatory systems with 8 degrees of freedom in each.

[CCC, CCA, CAC, CAA, ACC, ACA, AAC, AAA]$_d$ →	[+1, +1, +1, +1, +1, +1, +1, +1]$_d$
[CCT, CCG, CAT, CAG, ACT, ACG, AAT, AAG]$_d$ →	[-1, +1, -1, +1, -1, +1, -1, +1]$_d$
[CTC, CTA, CGC, CGA, ATC, ATA, AGC, AGA]$_d$ →	[-1, -1, +1, +1, -1, -1, +1, +1]$_d$
[CTT, CTG, GGT, CGG, ATT, ATG, AGT, AGG]$_d$ →	[+1, -1, -1, +1, +1, -1, -1, +1]$_d$
[TCC, TCA, TAC, TAA, GCC, GCA, GAC, GAA]$_d$ →	[-1, -1, -1, -1, +1, +1, +1, +1]$_d$
[TCT, TCG, TAT, TAG, GCT, GCG, GAT, GAG]$_d$ →	[+1, -1, +1, -1, -1, +1, -1, +1]$_d$
[TTC, TTA, TGC, TGA, GTC, GTA, GGC, GGA]$_d$ →	[+1, +1, -1, -1, -1, -1, +1, +1]$_d$
[TTT, TTG, TGT, TGG, GTT, GTG, GGT, GGG]$_d$ →	[-1, +1, +1, -1, +1, -1, -1, +1]$_d$

THE GENETIC CODE AND YIN-YANG SYSTEM OF “I CHING”

The system of molecular genetics has many analogies with the symbolic system “Yin-Yang” from the Ancient Chinese book “I Ching” (“Book of Cyclic Changes”) written a few thousands years ago. Two examples only:

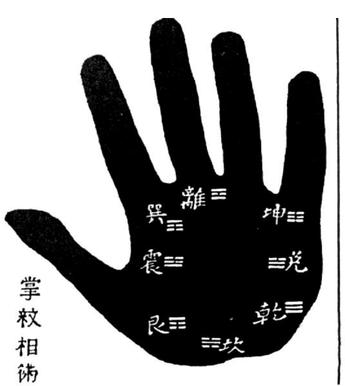
1) The **four** digrams have a basic meaning in the system of “I Ching” (**just as four letters in DNA-alphabet**): Old Yang (), Old Yin (), Young Yang () and Young Yin (). By analogy with the genetic alphabet, one can construct a (2*2)-matrix from these digrams:

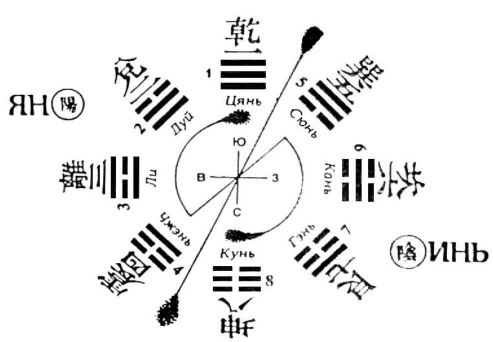


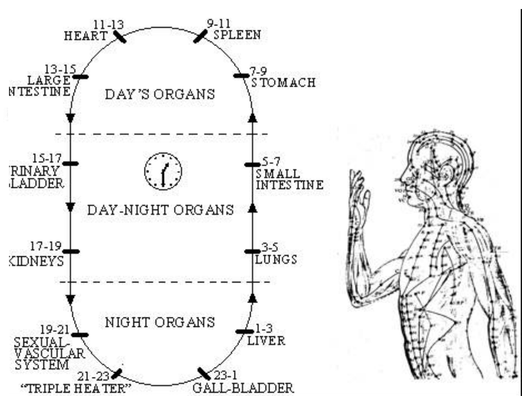
2) The third tensor power of this matrix is identical to the famous table of 64 hexagrams in Fu-Xi's order from "I Ching":

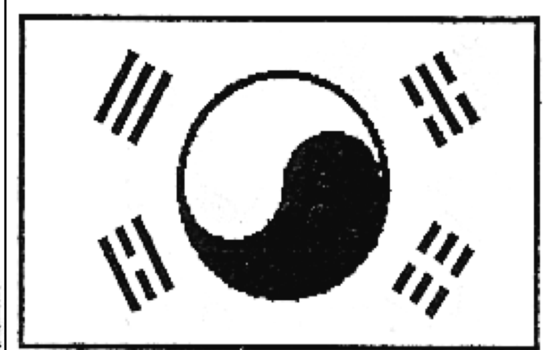
	111 CHYAN	110 TUI	101 LI	100 CHEN	011 HSUN	010 KAN	001 KEN	000 KUN
111 CHYAN	111111	111110	111101	111100	111011	111010	111001	111000
110 TUI	110111	110110	110101	110100	110011	110010	110001	110000
101 LI	101111	101110	101101	101100	101011	101010	101001	101000
100 CHEN	100111	100110	100101	100100	100011	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

Many other analogies exist between the genetic code and “I Ching”. The ancient Chinese claimed that the Yin-Yang system of "I Ching" is a universal archetype of nature, a universal classification system. They used this system as the base of their medicine, music and other aspects of their life in a connection with ideas about vibrational organization of the world. According to ancient Chinese, music is present at origin of the world and plays a cosmic role: music represents a microcosm reflecting a structure of the Universe. They knew nothing about the genetic code, but the genetic code is constructed in accordance with ”I Ching”.









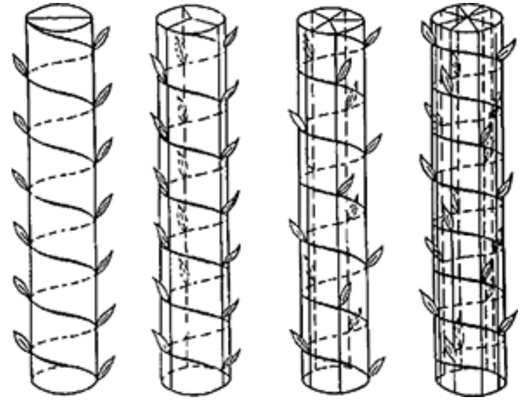
<u>The resonant approach to physiological phenomena</u>

On the base of the conception of resonant bioinformatics we have also created matrix models of some genetically inherited physiological phenomena from very different parts of physiology, for example:

1) the main **psychological** law of Weber-Fechner, which is a reason of measuring of sound volumes in a logarithmic scale in decibels, etc:

$$p = k*\ln(x/x_0)$$

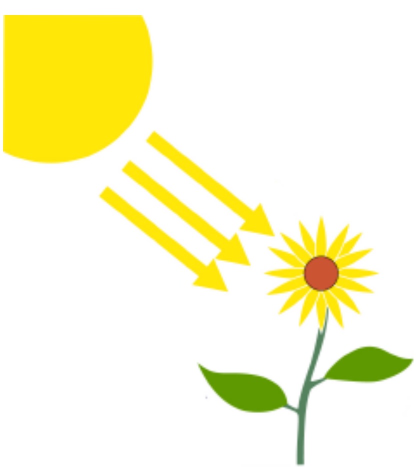
2) **morphogenetic** laws of phyllotaxis connected with Fibonacci numbers.



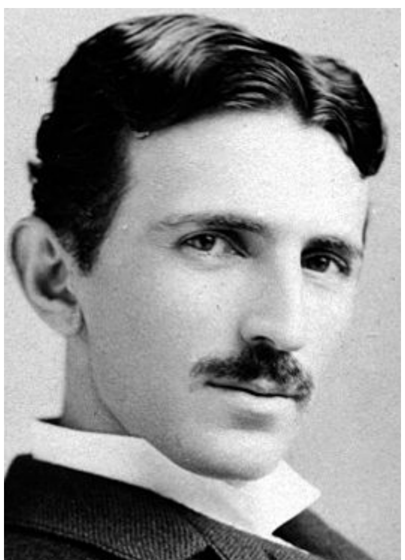
The conception of genetic resonances creates new bridges between biology and physics, where ideology of resonances is widely used. Vibrational mechanics has amazing phenomena of vibrational separation and structurization of multi-phase media, vibro-transportations, vibro-transmitting energy from one part of the system to another, synchronization of many processes (just as a synchronization of many pendulums located on a common mobile platform - http://avva.livejournal.com/2491293.html), etc. These phenomena are useful to model many biological processes (including a division of cells), which, in our opinion, are connected with vibrational mechanics. The resonant approach has many practical applications in physiotherapy, medical diagnostics, biotechnology, etc.

Taking into account the fact that a resonant interaction can provide a vibrational transfer of energy inside the system, the living organism can be seen as a resonant consumer of energy from surrounding electromagnetic waves coming from space and the depths of the earth.

Photosynthesis, which is is carried out by absorbing solar energy of light waves, it is apparently just one example of energy consumption by organisms on the basis of resonant agreements (a resonant "vampirism" of energy and information).



In living bodies mechanical and electrical oscillations are closely connected because many tissue are piezo-electrical (nucleic acids, bone, actin, dentin, tendons, etc.). Mathematics of mechanical and electrical oscillations are analogical ("electro-mechanical analogies").



Nikola Tesla considered that law of resonances is the most general law of Nature: "*All the connections between phenomena are established exclusively by all sorts of simple and complex resonances*".

In the past century, science has discovered that molecular-genetic bases of all living organisms are the same (alphabets of DNA, RNA, etc.) and that they are very simple. A hope arises that the algorithmic foundations of organisms, which obey to genetic laws such as Mendel's laws, are also very simple and are unified for all living things. Identifying these algorithms of living matter is important. We assume that the algorithms of resonant coordination and regulation of subsystems, which are associated with theory of oscillatory systems with many degrees of freedom, play one of key roles in living matter.

The author believes that the development of modern theoretical biology can go on the same way as the development of modern theoretical physics, which, according to P. Dirac, should be by the following recipe. “*Start with a beautiful mathematical theory. "If it is really beautiful, it is sure to be an excellent model of important physical phenomena. So you need to search for these phenomena to develop applications of beautiful mathematical theory and interpret them as predictions of new laws of physics "- in such way according to Dirac, the whole new physics is built - relativistic and quantum*" (quote from [V. Arnold, 2006]).

We shown that beautiful mathematical theory of eigenvalues and eigenvectors of the tensor families of matrices gives the model of important genetic phenomena and structures with revealing their deep connection with the theory of resonances of oscillatory systems with many degrees of freedom.

CONCLUSION

Received data show that many genetic phenomena can be modeled on the base of classical matrix mathematics of vibro-systems with many degrees of freedom. The conception of resonant genome and resonant genetics is put forward.

Our results give evidences in favor of the following:

1) Genetic alphabets are systems of resonances; respectively, the genetic code is the code of systems of resonances;
2) Punnet squares, describing traditionally poly-hybrid crossing of organisms under the laws of Mendel, are an analogy to "tables of inheritance of eigenvalues" in tensor families of matrices of vibrational systems;

3) Alleles of genes from Mendel's laws can be interpreted as eigenvalues of matrices, which represent vibrational systems with many degrees of freedom (eigenvalues $\boldsymbol{\lambda}_i$ of a vibrational system are equal to square of its resonant frequencies $\boldsymbol{\lambda}_i = \boldsymbol{\omega}_i^2$);

4) Some known inherited phenomena from different parts of physiology can be modeled on the base of the conception of resonant bioinformatics, including the main psychological law of Weber-Fechner, morphogenetic laws of phyllotaxis, etc.

One can find additional data on http://petoukhov.com/