



*Extended Abstract*

## **The Genetic Code, the Golden Section and Genetic Music**

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### **Introduction**

The Moscow P. I. Tchaikovsky Conservatory has recently created a special “Center for interdisciplinary research of musical creativity”. One of the main tasks of this center is to study genetic musical scales from different aspects including new opportunities for composers and for musical therapy. This lecture is devoted to scientific aspects of the genetic musical scales, which are based on symmetric features of molecular ensembles of genetic systems. These musical scales were revealed in a course of symmetrologic study of representations of molecular-genetic ensembles in a united form of mathematical matrices (Kronecker or tensor families of genetic matrices). This study has disclosed a relation between genetic system, golden section and Fibonacci numbers, which play role in the hierarchical system of these musical scales and which are known in biological phyllotaxis laws and in aesthetics of proportions. Fibonacci numbers are also used in different branches of informatics, for example, they are the base of «Fibonacci computers» ([http://www.goldenmuseum.com/index\\_engl.html](http://www.goldenmuseum.com/index_engl.html)). Some historical and biological aspects of musical harmony are also considered.

### **Main part**

From ancient times, understanding the phenomenon of music and creating musical structures were associated with mathematics. The creator of the first computer G. Leibniz wrote: “*Music is a secret arithmetical exercise and the person who indulges in it does not realize that he is manipulating numbers*” and “*music is the pleasure the human mind experiences from counting without being aware that it is counting*” ([http://thinkexist.com/quotes/g\\_wilhelm\\_leibniz/](http://thinkexist.com/quotes/g_wilhelm_leibniz/)).

It can be mentioned that thoughts about the key significance of musical harmony in the organization of the world exist from ancient time. For example, Pythagoreans thought about musical intervals in the planetary system and in all around. J. Kepler wrote the famous book *Harmonices Mundi*, etc. Modern atomic physics found the harmonic ratios in spectral series by T. Lyman in the

atom of hydrogen, which has been named “music of atomic spheres” by A. Einstein and A. Sommerfeld. The importance of Pythagorean ideas about a role of musical harmony was emphasized also by the Nobel prize winner in physics R. Feynman. Some classicists of crystallography emphasized a connection between crystal structures and musical harmony (C.S. Weiss, J. Grassman, V. Goldschmidt, etc.). Taking into account that E. Schrödinger named living bodies as “aperiodic crystal”, one can suppose that biological structures are also connected with musical harmony. Achievements of molecular biology have led to the new understanding of life itself: «*Life is a partnership between genes and mathematics*” [1]. From this point of view, attempts to reveal possible connections between musical harmony and living organisms can be focused to structures of molecular ensembles of the genetic code. The human brain does not possess a special center of music. The feeling of love to music seems to be dispersed in the whole organism. It is known that different emotions belong to inherited biological phenomena. Charles Darwin has revealed that all the chief expressions exhibited by man are the same throughout the world and that, with much probability, such expressions are innate (<http://www.bbc.co.uk/news/magazine-15600203>). It seems that many aspects of musical harmony also belong to inborn feelings and are connected with genetic phenomena.

The range of human sound perception contains an infinite set of sound frequencies. Pythagoras has revealed that certain mathematical rules, based on integers, allow separating - from this infinite set of frequencies - a discrete set of frequencies, which determine a harmonic sound set. In other words, certain combinations of sounds from this set are perceived by living organisms as pleasant for hearing (consonances). In addition, Pythagoras has linked the phenomenon of the harmonic sounds with the parameters of a physical object: oscillation frequencies of stretched string, the length of which is varied in accordance with appropriate numerical rules. However, these revelations by Pythagoras say nothing about the fact that other discrete sets of sound frequencies may exist, which will also form harmonic sets of sounds.

This lecture describes some results of studying symmetry properties of the genetic coding system by means of matrix representation and analysis of molecular ensembles of the genetic system. The results reveal that sets of parameters of this molecular genetic system are related to the well-known Pythagorean musical scale and also to a hierarchy of special mathematical sets. This hierarchy is called as “Fibonacci-stage scales” or “pentagram scales” because its structures are connected with Fibonacci numbers, the golden section  $\varphi = (1+5^{0.5})/2 = 1.618\dots$  and with the factor  $\varphi^2$ , which exists in regular 5-stars (pentagram) as a ratio between sides of the adjacent stars entered in each other. These mathematical scales can be interpreted and used as the base of a new system of musical scales, because appropriate sets of sound frequencies possess harmonic properties for human hearing. According to our assumption, it seems essential that these musical systems are connected with the molecular-genetic system. Our researches of the genetic code have inspired the authors together with their colleagues not only to research new musical scales but also to create a few musical instruments based on these new scales. Special software on the computer language Python to produce appropriate musical products was also created. A group of specialists from different fields of science, medicine and culture participate also in these works. Initial results of the wide study testify into a favor of good perspectives of this direction for science, culture and musical therapy (see some details in [2]).

One can remind additionally that the pentagram was used by the Pythagoreans who considered it as the emblem of perfection and health. Pythagoreans swore by it and used the pentagram as a distinctive sign of belonging to their community. The value  $\varphi^2$  is also well known in genetically inherited phenomena of phyllotaxis. The golden section is presented in 5fold-symmetrical objects of biological bodies (flowers, etc.), which are presented widely in the living nature but which are forbidden in classical crystallography. It exists as well in many figures of modern generalized crystallography: quasi-crystals by D. Shechtman, R. Penrose’s mosaics, dodecahedra of ensembles of water molecules, icosahedral figures of viruses, etc. The theme of golden section in genetic matrices seems to be important because many physiological systems and processes are connected with it. It is

known that proportions of a golden section characterize many physiological processes: cardiovascular processes, respiratory processes, electric activities of brain, locomotion activity, etc. The golden section is investigated for a long time in phenomena of aesthetic perception as well.

## Discussion

In our opinion, the aesthetic aspects of genetic music are connected not with a mechanical resonance of molecular structures under direct influence of sound waves but with informational aspects, which provide an effect of (not yet identified way of) recognition of a kindred language under during listening genetic music. This effect of recognition can be provided by biological algorithms of signal processing inside organisms. For example, in the case of pentagram music from the outside world, our organism can recognize those ratios, on which its genetic system and the whole inherited physiology are built, and the organism responds positively to this manifestation of a structural kinship of the outside world with its own genetic physiology. This positive reaction can be compared with mutual understanding between two persons when they begin to talk in the same language (if they talk in different languages, mutual understanding and interactivity don't arise though these persons can speak more and more loudly and energetically).

The described facts about relations of the genetic systems with musical harmony are essential for the problem of genetic bases of aesthetics and inborn feeling of harmony [3]. According to the words of R. Feynman about feeling of musical harmony, "*we may question whether we are any better off than Pythagoras in understanding why [stressed] only certain sounds are pleasant to our ear. The general theory of aesthetics is probably no further advanced now than in the time of Pythagoras*" [4, Chapter 50].

Evolution of musical culture and contemporary music reflects dangers and hopes of our times. The impact of music on the general population is increasing due to new developments in science and technology. Musical therapy is one of musical applications, which is popular around the world and which has a social value. Understanding the biological basis of music perception and opportunities for further development of musical culture has social value and it should use data of contemporary science. Our data about connections of the genetic coding systems with musical harmony can be useful for this understanding.

## References

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