How Schrödinger's mice weave consciousness

Max Myakishev-Rempel [1,2], Ivan V. Savelev [1,2]

1: DNA Resonance Research Foundation, San Diego, CA, USA (http://dnaresonance.org)

2: Localized Therapeutics, San Diego, CA, USA

Email: max@dnaresonance.org

ABSTRACT

This paper continues the series of papers on DNA resonance signaling. Previously the authors proposed that DNA is involved in the work of mind directly and immediately via the network of optical fibers. The authors proposed the mechanism of signal transduction in DNA via a sequence-specific resonance between the clouds of delocalized charges in the base stack. It was computationally demonstrated that certain repetitive patterns of delocalized charge clouds were evolutionarily enriched in various genomes. Here, the authors propose that natural quantum computation in DNA in living cells is based on the tautomerization of basepairs and involves coordinated oscillations of hydrogen-bond protons and aromatic electrons. The authors expand the ORCH-OR theory to include the collapse of the wave function of aromatic electrons in purines and propose that such collapses and expansions produce the experience of consciousness and the perception of time. The above mechanisms are supported by an observation that the majority of the psychoactive drugs are aromatic and the suggestion that they modify the aromaticity of DNA by binding to it. Quantum mechanical considerations for the collapse of aromaticity by double proton transfer in basepairs are discussed in terms of the collapse of the wave function, loss of delocalization, and the dynamic balance between coherence and decoherence in DNA.

Background

The role of DNA in the work of the mind is currently thought to be limited to protein-coding genes, which are dynamically regulated and which, in turn, regulate the levels of proteins which in turn regulate the work of the brain. This mechanism is indirect, slow, and seems insufficient to explain the complexity and speed of our thinking. Previously, we suggested that there is a much faster and more direct mechanism by which DNA is involved in the thinking process (Savelyev et al., 2019). It involves charge oscillations in DNA and the exchange of electromagnetic signals between cell nuclei via a network of microtubules and other fibers. This way, the old picture of slow and indirect involvement of DNA in the work of the mind, is supplemented by a model of the direct and fast signaling between DNA of all nuclei of the body via electromagnetic waves. This conceptual transformation could be likened to the supplementation of the old snail mail of the old world with the instantaneous connection of billions of people into one constantly active internet network via electromagnetic waves.

Subcellular thinking structures

The exclusivity of the neuronal signaling mechanism for thinking is challenged by simple organisms that don't have neurons or have only a few neurons. The nematode *Caenorhabditis elegans* has only 302 neurons but displays several complex behaviors including predator escape and mating. Some single-cell organisms having no neurons also demonstrate the ability of learning and complex behaviors. Moreover, free-living single-cell ciliates such as *Stentor roeselii* are capable of learning (Dexter et al., 2019) as well as *Plasmodium*, which is a

single large cell with many nuclei (Dussutour et al., 2010). Paramecium, a single cell organism can swim, learn, display complex behaviors, and sexually reproduce (Maegawa, 2017). This demonstrates that there are subcellular structures capable of thinking and making decisions (Maegawa, 2017).

DNA resonance signaling

The theory development leading to DNA resonance signaling has a long history. The role of electric fields in morphogenesis was developed by Mathews (Mathews, 1903), Morgan (Morgan and Dimon, 1904), Lund (Lund, 1917), and others over 100 years ago. The existence of the morphogenetic field was proposed nearly 100 years ago (Gurwitsch, 1922). It was proposed that the morphogenetic field is produced by the union of the cells of the organism, this field guides the development of the shape of the body and regulates the function of each part and organ. Consider a modern analogy: our car drivers use GPS navigators to tell them where they are and our centralized systems such as UBER wirelessly guide the drivers where to go. Similarly, it was proposed that the body generates a morphogenetic field, which tells every cell where it is and what to do. The existence of the morphogenetic field was experimentally demonstrated by independent groups (Gurwitsch, 1988; Volodyaev and Beloussov, 2015). In these experiments, perturbing one of the chemically separated biological samples lead to measurable effects in another (Cifra et al., 2011; Scholkmann et al., 2013; Trushin, 2004; Xu et al., 2017). The electromagnetic oscillations in the cells were proposed to be driven by the constant chemical energy flux and were estimated to be in the millimeter-wave region (Frohlich, 1988).

Miller and Web proposed that genomic DNA is the main source and receiver of the morphogenetic field, allowing the genomic program to direct the morphogenesis directly via a holographic electromagnetic field (Miller et al., 1975; Miller and Webb, 1973). Moreover, it was proposed that through the same field, the genomic DNA of brain cells is directly involved in the work of the mind (Miller et al., 1975). Hameroff proposed that microtubules in axons work as light guides and are transmitting information in neurons thus explaining the high speed and bandwidth of the mind (Hameroff, 1974). We combined and expanded the ideas of Miller, Webb, and Hameroff by suggesting an electromagnetic information transfer between the DNA in the nucleus, microtubules in the cytoplasm, and the fibers of the extracellular matrix in the fascia (Savelyev et al. 2019).

An important factor for the theory of genomic biofield is to consider the dissipation and scattering of electromagnetic signals in the tissues. Thus, two models should be considered for the exchange of electromagnetic signals between the DNA of cell nuclei: (1) the field model in which the genomes radiate an electromagnetic field in all directions and (2) the fiberoptic model (Savelyev et al., 2019) where the genomes exchange the electromagnetic signals via the network of microtubules and other fibers. For an analogy of the field model, consider smartphones sending signals in all directions and contacting cell towers in any direction: this information exchange is less specific and much of the signal is wasted. For the analogy of the fiberoptic model, consider broadband modems connected to internet hubs via fiberoptic cables: this exchange is specific, there is little interference and loss of the data, and the information transfer rate is much higher. So far, the experimental evidence is published only for the field model (Cifra et al., 2011; Scholkmann et al., 2013; Trushin, 2004; Xu et al., 2017). In these publications, the field and information transfer was demonstrated, yet the role of DNA in its generation and reception was not tested. We find it likely that both field and fiberoptic models coexist side by side, some signals are exchanged via microtubules and some signals are exchanged via the field.

The fiberoptic model (Savelyev et al., 2019) has the advantage that it minimizes data loss and crosstalk: information can be exchanged between specific locations without loss, contamination, and crosstalk. Importantly, the fiberoptic model perfectly corresponds to the meridians in Traditional Chinese Medicine. Although scarcely known in the west, there is a substantial body of experimental evidence that there exists a system of signaling that exchanges electromagnetic signals via fiberoptic-like tubular structures of fascia tissue that wraps and penetrates the whole body and thus, is perfectly placed to regulate the body's growth and health (Bai et al., 2011; Maurer et al., 2019). We proposed that the genome copies of each cell of the body are

vibrationally coupled with the signaling system of meridians in the fascia and thus are linked into one fiberoptic network (Savelyev et al., 2019). The frequencies of the waves in this network may be in the infrared and millimeter-wave regions (Savelyev et al., 2019).

For the genome copies to communicate via electromagnetic waves, DNA fragments should be able to resonate in a sequence-dependent manner. Although mechanical oscillations in DNA have been proposed (Scott, 1985; Volkov and Kosevich, 1987), we reasoned that the mechanical oscillations would be damped by the viscosity of the nucleoplasm. Instead, we proposed that there must be oscillations of delocalized charges in the nucleobase stack which would be protected from dumping by the DNA backbone. Specifically, we predicted the existence of proton and electron clouds in the base stack. Then we modeled their approximate shapes and published the evidence for evolutionary selection and conservation of certain sequences that code for specific shapes of electron and proton clouds in the base stack (Savelev and Myakishev-Rempel, 2020; Savelyev and Myakishev-Rempel, 2019). Thus, based on the genomic data from various species, we provided the initial evidence for the existence and sequence-specificity of resonance signaling in DNA.

Further, in this model, the key resonators, transmitting, and receiving antennas are repetitive elements in DNA that comprise over 50% of our genome. The vibrational information is coded in positions of repetitive elements, variations within them, and in their flanking sequences. The repetitive elements work as radios by converting biomolecular information into electromagnetic wave messages and back. They create an interference pattern of waves that is united between all cells of the organism, guides its development, and is an integral part of the work of the mind. The wave signals that are received by the DNA resonance elements are guiding the expression of genes and chromatin dynamics. Much in this model remains to be proven, in our previous publications (Savelev and Myakishev-Rempel, 2020; Savelyev and Myakishev-Rempel, 2019) we only provided the initial statistically significant evidence for the evolutionary selection for certain electron and proton cloud patterns, which suggests the existence of DNA resonance signaling. In this paper, we will further develop the aspects of this model that shed light on the role of DNA in the co-creation of consciousness.

Our main focus here will be on the hydrogen bonds and electrons in tautomeric forms of the DNA basepairs. The main question we asked was: which charged particles are delocalized in the basepairs and how do the shapes of delocalized charge depend on the DNA sequence? The ultimate goal here was to understand the sequence dependence of the delocalized charge clouds as oscillators that potentially mediate electromagnetic signaling in the body.

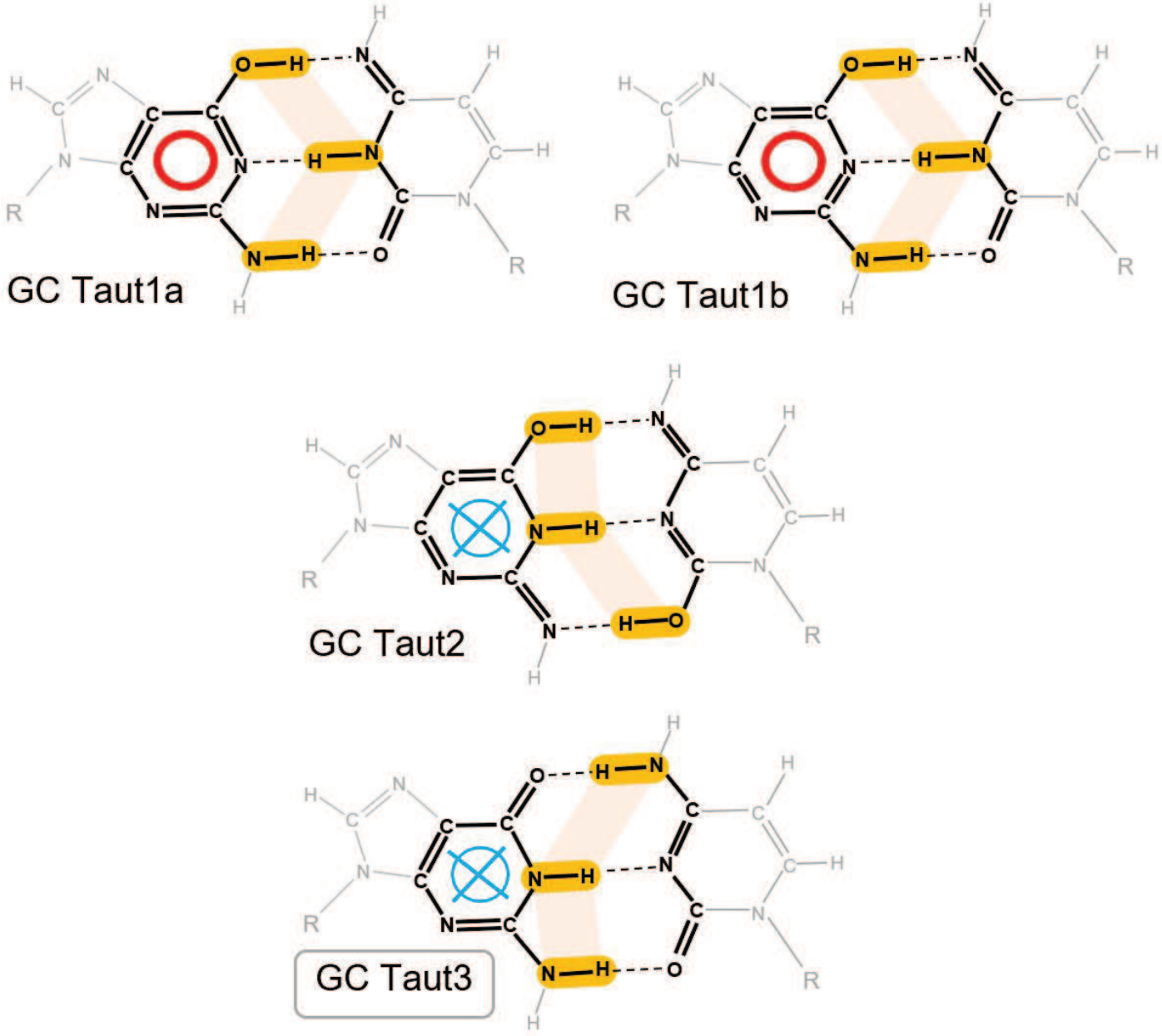


Fig. [GC] Tautomeric forms of GC basepair. *The hexagonal heterocycles of purines are called here "the central ring" and labeled with circles. The uncrossed circles signify aromaticity and the crossed-out circles signify the loss of aromaticity. The remaining heterocycles are not aromatic. The black lines signify the structures that undergo tautomerization and grey lines signify the structures that stay unchanged during tautomerization. Links to the backbone are shown as "R".*

The normal coexistence and interconversion of tautomeric forms of normal Watson-Crick basepairs are known from experiments in model systems (Abou-Zied et al., 2001), Fig. [GC].

From the classical chemistry perspective, the tautomers naturally transform into each other with the frequencies of 10 GHz and higher. From the quantum chemistry perspective, the tautomeric forms coexist in the state of quantum superposition until they are measured or chemically forced to make a choice in which state they exist. Both classical chemistry and quantum chemistry perspectives are true at the same time. As you can see in Fig. [GC], it takes two proton relocations to switch the basepair from Taut1 to Taut2, from Taut2 to Taut3, and from Taut3 to Taut1. You can also see that each switch between forms Taut1, Taut2, and Taut3 is also accompanied by electron relocations. As one positively charged proton jumps one step, two or more electrons in a chain jump one step each towards this proton to rebalance the electrical charge and keep the charge of each of the bigger atoms neutral.

Importantly, for the idea of this paper, although the two 6-atom and one 5 atom-rings in the basepair look similar and have alternating double bonds, only one ring is aromatic, the 6-atom ring of the purines A or G, further called "the central ring". Its aromaticity is classical and characterized by the unification of 6 pi electrons of the ring into one delocalized cloud. The other two rings don't have enough pi-electrons to create a delocalized ring and therefore are not aromatic.

The key observation of this paper is that the central ring is only aromatic in Taut1 and is not aromatic in Taut2 and Taut3. This happens because the relocation of protons causes the relocation of electrons and the ring loses an electron ***in the middle*** to a proton that attaches to the purine ***in the middle***. In Taut1, the electrons of the central ring exist in a superposition of two configurations Taut1A and Taut1B.

A similar dependence of the aromaticity of the central ring on the relocations of protons is observed in the classical Watson-Crick's basepair AT, Fig. [AT]

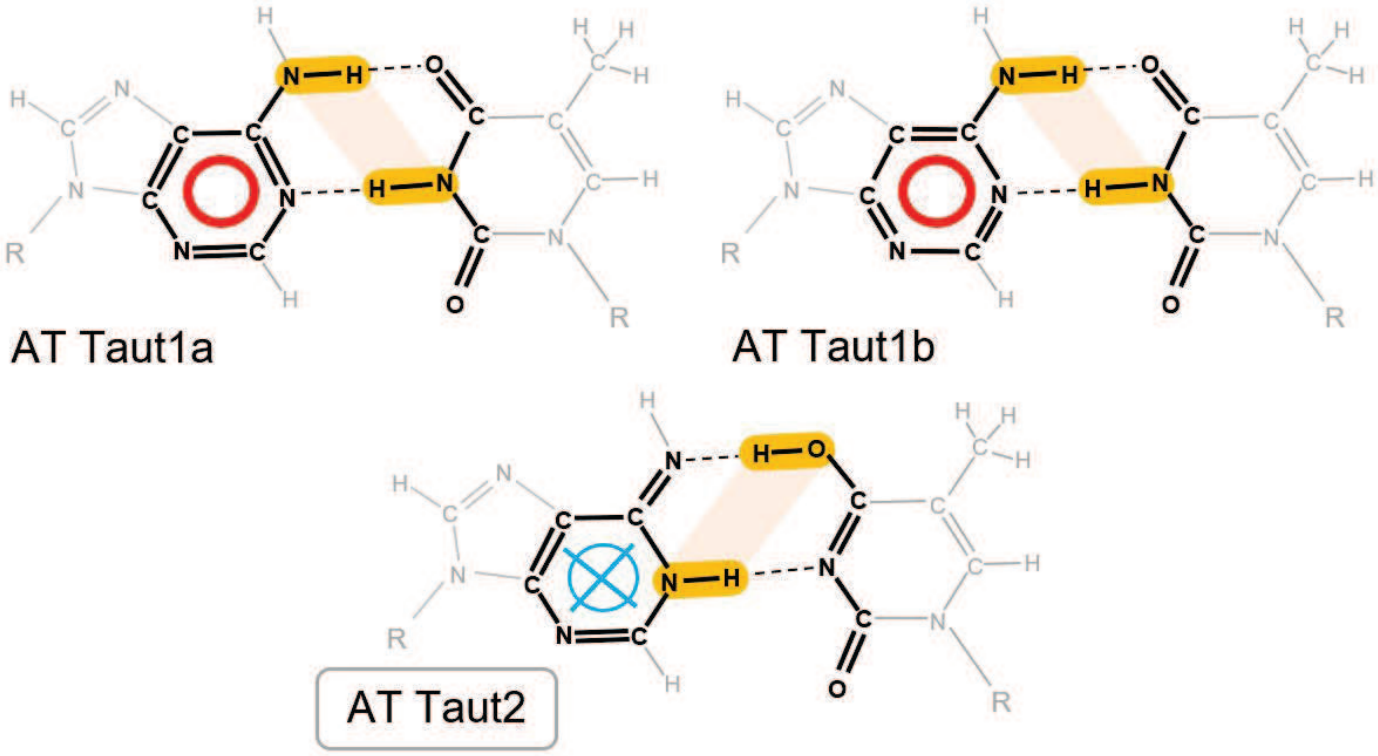


Fig. [AT] Tautomeric forms of basepair AT.

The main difference is that in AT, there are only two forms Taut1 and Taut2. The form Taut1 enables aromaticity and the form Taut2 disables it.

Once we realized that the central ring gains and loses the aromaticity from the jumping of protons, we attempted to connect this phenomenon with the role of DNA in the work of the mind. Previously, we constructed a model in which resonances in DNA are united over the entire organism by a network of microtubules and thus participates in the regulation of morphogenesis and the work of the mind. Here, the phenomenon of locking and unlocking the aromaticity of the central ring reminded us of spinning and stopping a roulette wheel or throwing dice. It is well known that in the aromatic state the 6 pi electrons are delocalized forming a stable ring that freely spins. The spinning of the ring creates a magnetic moment and vice versa, applying a magnetic field to the electron ring spins it (Ref). Previously, we proposed a model in which DNA is thinking as an electronic machine by spinning its aromatic rings (Polesskaya et al., 2018). The stacked aromatic rings are attracted via a known effect of aromatic ring stacking and their magnetic moments unite thus stabilizing the system. The switches can happen by reversing the rotation and correspondingly the polarity of

the rings. The attraction of rings spinning in the same direction and magnetized in the same direction could straighten the DNA, while repulsion of the rings spinning in the opposite directions and magnetized in the opposite directions could bend or expand the DNA. Therefore applying ultrahigh-frequency alternating voltages to the DNA could control its supercoiling.

Uncoiling of selected regions happens in DNA to achieve gene expression. Loops containing multiple genes are uncoiled by gyrases, the genes are transcribed and then the loops are coiled back. Similarly, the coiling of DNA happens during the process of replication. Thus regulation of coiling is an essential process in gene and chromatin regulation. We suggest that possibly, in addition to gyrases, the cell uses alternating voltages of high frequency to control the coiling and uncoiling of DNA, or more precisely, DNA this way controls its own coiling.

Now, let's return to the observation that the proton jumps lock and unlock the spinning electron rings of the central ring. This could be a natural mechanism for the ability of DNA to think. The proton jumps cause the collapse and expansion of the wave function of the aromatic electrons of the central ring. Or in other words, the proton jumps force these aromatic electrons to localize and delocalize.

Such "collapses of the wave function" were proposed to be the mechanism underlying the work of mind and consciousness (Shimony, 1997; Shimony and Cushing, 1994). On the molecular level, this idea was developed by Hameroff (Hameroff, 2003)for microtubules. Here, we propose that it is DNA and more specifically, the localization and delocalization of aromatic electrons in the central rings of purines is a mechanism for our thinking process.

[intuition vs logic]

Furthermore, consider an analogy between the localization of electrons and making a choice and between the delocalization of electrons and intuition. Terrence McKenna suggested that it was the evolution of hominids from gathering to hunting that forced us to develop our logical mind. He suggested that it is our predatory nature that requires us to logically create plans and execute them, otherwise, we wouldn't survive. This makes modern civilization prefer logic over intuition and action over passivity. McKenna noted that primitive tribes have a different mindset which is much more passive and intuitive. Consider also that ego, logic, and choice-making are considered in popular culture as left-brain and masculine qualities, these would correspond to the localized state of aromatic electrons and the loss of aromaticity in our model. Similarly, selflessness, intuition, and passivity are in popular culture attributed to right-brain and feminine qualities, although the extent of brain asymmetry is exaggerated in the popular culture (Corballis, 2014), these would correspond to the delocalized state and aromaticity of central ring electrons in our model.

Moreover, when in the DNA sequence multiple purines follow each other, Fig. [Purines], their aromatic rings are attracted by the stacking forces and their magnetic moments would tend to unite and face in one direction. This would likely create a delocalized cloud of aromatic electrons spanning this stretch of purines and thus create a structure prone to charge oscillations. Since stretches of purines are frequent in the genome, we suggest that chains of purines would create antennas that would allow for wireless communication between the parts of the genome and between the genomes of all cells in the body. Thus, the delocalized state of electrons in purine stretches would allow for organism-wide resonances and nonlocal communications which nicely match the intuitive state of mind. Conversely, the collapse of the wave function and the loss of aromaticity in purine stretches would correspond to the logical way of thinking and making choices.

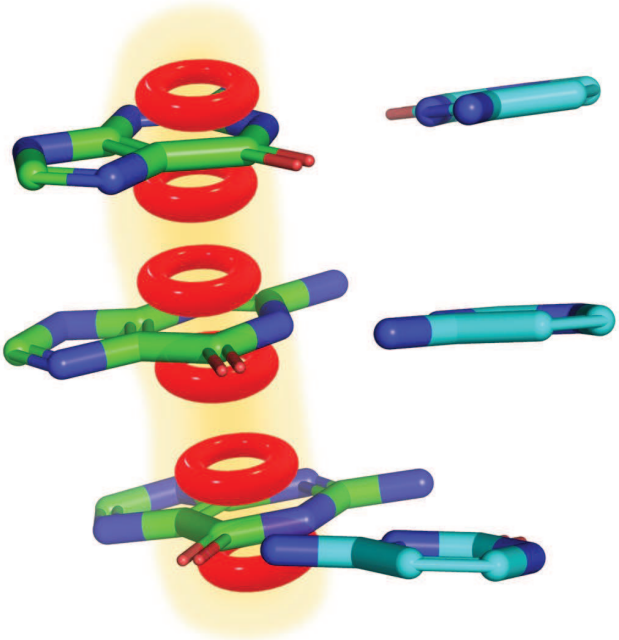


Fig. [Purines] Aromatic electron rings are merged in a purine stretch.

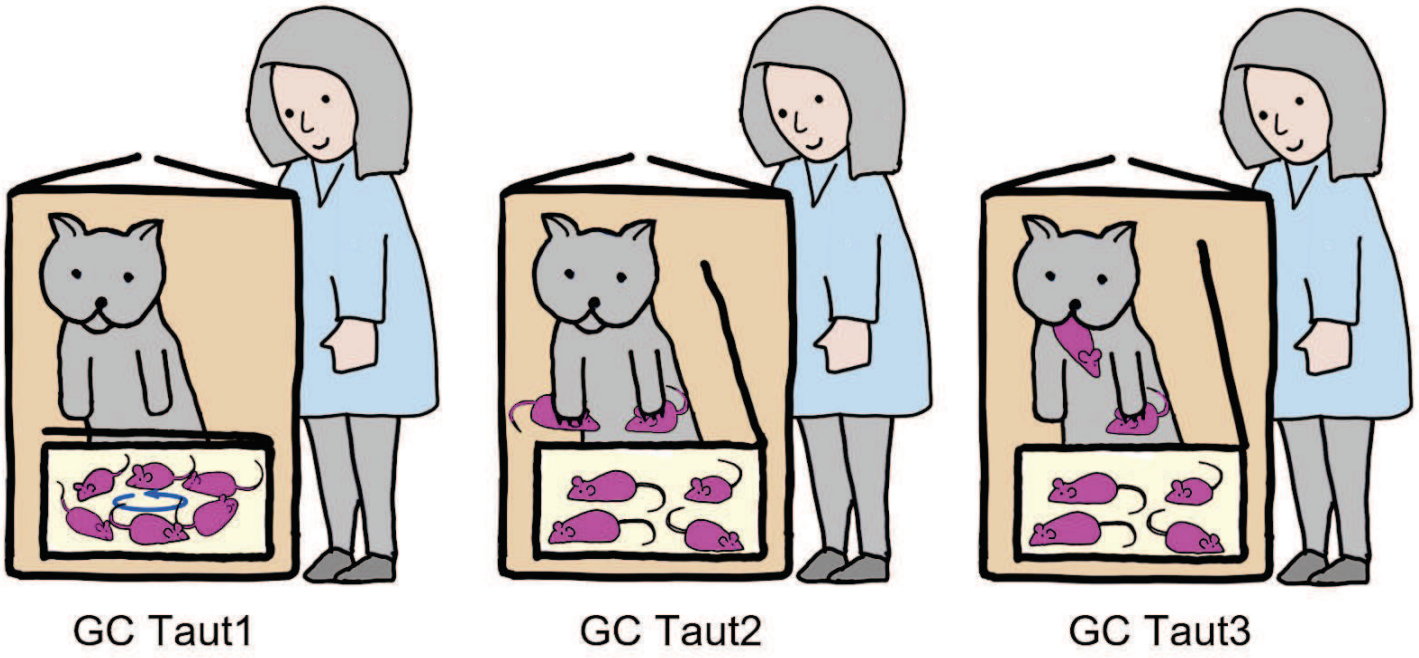
Schrödinger's mice

One peculiarity of the delocalization of charges in the basepair shown in Fig. [GC], is that not only electrons are delocalized, but also protons. Quantum delocalization of protons in basepairs is known from molecular dynamic calculations (Pérez et al., 2010). Since they are 800 times heavier than electrons, their delocalization is also less pronounced, but still, is real. Both protons and electrons exist in the state of delocalization, quantum superposition, and obey Heisenberg's uncertainty principle. In the basepair's natural state and outside observer not only can not say the position of electrons of the central ring but also the position of the protons of the hydrogen bonds - the electrons are fuzed together in a double electron ring above and below the central ring and protons are delocalized into a probability cloud spreading along the hydrogen bond. From a quantum mechanical perspective, the tautomer's shown in Fig. [GC] are superimposed on each other and co-exist at the same time. Yet, from a chemistry perspective, the basepair switched between 3 tautomers with a frequency of around 10 GHz. Both perspectives are true and coexist at the same time.

Even more puzzling is the dependence of the central ring aromaticity on the tautomers. Only tautomer Taut1 enables the central ring to become aromatic, while Taut2 and Taut3 disable the aromaticity of the central ring. Yet, all three tautomers coexist at the same time and are in a state of quantum superposition. This paradox is unresolvable from the perspective of the deterministic logic of the macroworld, so it only can be accepted as a gimmick of the quantum world. To illustrate the paradox let's expand the analogy of Schrödinger's cat. For the sake of kindness, let's have a live cat in the box without a threat to its life, Fig. [Mice]. The cat can exist in 3 positions Taut1, Taut2, and Taut3 corresponding to 3 tautomers of the GC basepair. For the outside observer, the position of the cat is unknown, until the observer opens the box. Now, the cat also is an observer and this represents Taut1. The cat observes a smaller closed box containing a self-spinning carousel with 6 mice representing 6 electrons of the central ring. The mice have numbers on their t-shirts. The spinning of the wheel represents the delocalization of the electrons. The cat once in a while opens the smaller box and grabs two mice from the carousel and the remaining 4 mice hide in 4 corners. This represents the loss of aromaticity. If the cat grabs the 2 mice with two paws, this represents his second position and Taut2. If the cat grabs the 2 mice with the right paw and the mouth, this represents his third position and Taut3. The cat reads the numbers

of the mice and lets them go switching back to the first position Taut1 and the 6 mice again start spinning on the carousel.

Therefore, we can see that the quantum effects (uncertainty, delocalization, and superposition) are embedded. The human observer observes a cat which observes the mice. What is fascinating in this model is that the mice are delocalized (superimposed and uncertain) only when the cat is in the position Taut1. In the other two positions, the mice are fixed, localized, their positions are certain. Therefore the human observer observes a delocalized cat that observes the delocalization of mice only part-time.



Schrödinger's mice as an analogy of tautomeric states of GC basepair. *The human observer is observing a closed box with a Schrödinger's cat. The cat is alive in all three superimposed states: Taut1, Taut2, and Taut3. In Taut1, the cat is observing a closed smaller box containing 6 mice which are numbered and spinning in a circle. In the state Taut2, the cat has opened the box and grabbed two mice with two paws. Only at that point, the numbers of the mice become visible to the cat. The state Taut3 is the same as Taut2 except the cat grabbed the mice with one paw and the mouth.*

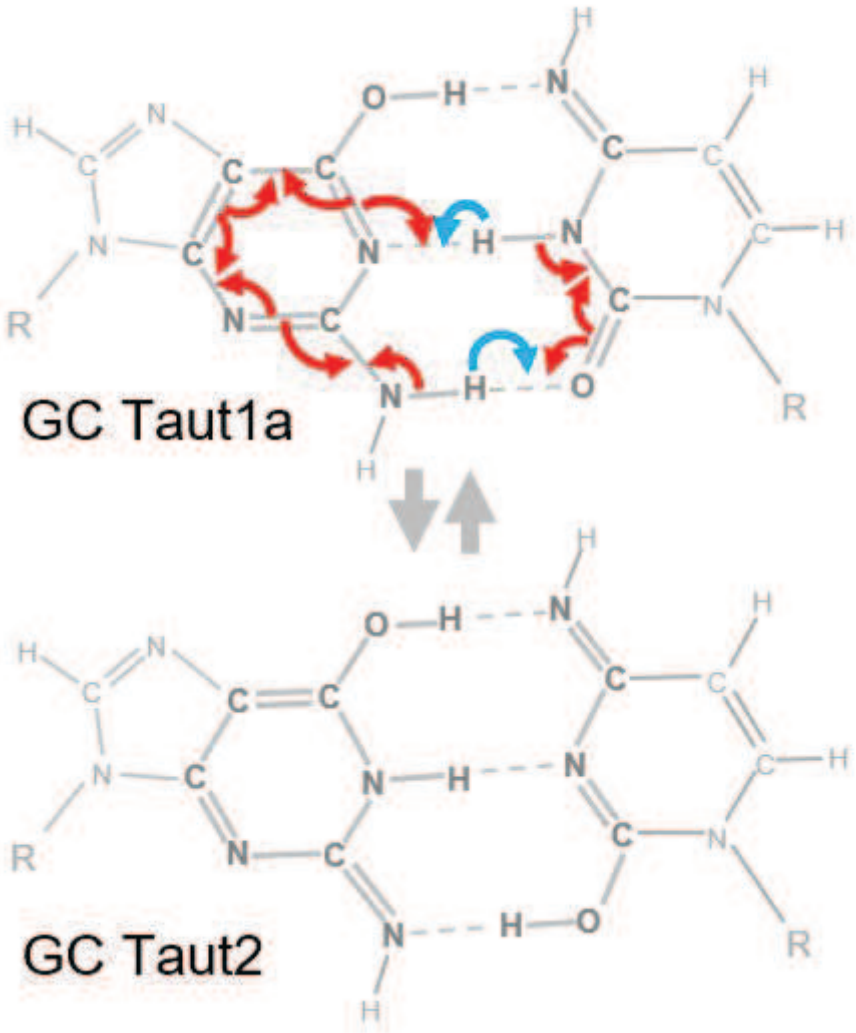


Fig. [Electrons]

[proton clouds]

In addition to electron clouds in purine stretches, we predicted the existence of delocalized proton clouds (sometimes called proton wires) spanning multiple nucleotides in the DNA chain and obtained preliminary evidence for their existence, Fig. [Protons A] (Savelev and Myakishev-Rempel, 2020).

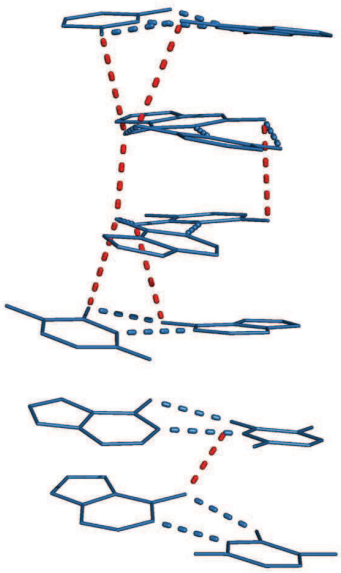


Fig. [protons] Proton wires span multiple bases (red)

According to this model, proton clouds also serve as antennas for wireless communication alongside with proton clouds. This way we have an interplay of partially overlapping delocalized positive proton and negative electron clouds that are attracted to each other and oscillate in harmony or disharmony with each other (Polesskaya et al., 2018; Savelev and Myakishev-Rempel, 2020; Savelyev and Myakishev-Rempel, 2019). Their oscillations would only partly overlap in frequency since protons are 800 times heavier than electrons.

Now, consider the interplay and coordination between these oscillations of delocalized charge clouds spanning multiple basepairs and oscillations between tautomeric forms in each basepair, Fig. [Protons]. These oscillations would be linked to each other in at least two ways: delocalization of central ring electrons will provide electrons for the electron clouds and jumps of the protons within the basepair would affect strongly the structure of the proton clouds since these share the protons with the basepairs.

This crude model gives us a glimpse into the sophisticated machinery that we suggest underlies the thinking intuitive and logical process of our DNA, of us, and of all life. The verification of this crude model will require spectroscopic studies and quantum electrodynamics modeling.

Function

The above interactions were limited to the base stack or remote signaling between the base stacks. Let's now consider the ways how the localization and delocalization of central ring electrons can communicate with the biochemical processes outside of the base stack. Consider collective delocalization of electrons in the stretch of purines. This would make the purines aromatic and attract each other via stacking interactions. This could shrink and bend the double helix thus affecting the structure of DNA which in turn could change gene expression especially if the changes are happening in a gene promoter. Similarly, jumps of protons in basepairs could create proton clouds spanning multiple bases and this would also shrink and bend the double helix again leading to changes in chromatin structure and gene expression. Another way of affecting biochemistry is via electromagnetic oscillations. Charge oscillations that we suggest occur in electron and proton clouds spanning multiple bases can add together and their lower harmonics in the MHz-GHz range can induce ultrasound waves in the nucleoplasm. The frequency of 214 MHz corresponds to the sound wavelength of 7 um, the size of the nucleus. 750 GHz corresponds to the sound wavelength of 2nm, the diameter of the double helix. DNA comprises a large part, about 1.5% of the nucleus mass. If a large part of the genome creates harmonized oscillations, these oscillations would create a moving sound interference pattern within the nucleus according to the theory of cymatics, reviewed in (Meijer and Geesink, 2016). This way the genome

could move itself using cymatic propulsion and control the movements of the proteins inside the nucleus. The reverse would be also possible - the interaction can be bidirectional - the DNA could sense the environment by interacting with the wave patterns and adjust it at will.

The binding of proteins and nucleosomes to a DNA locus will radically change its vibrational properties and thus biochemical information would be converted to wave information that DNA is delivering. Conversely, the charge oscillations in DNA will modify its preference for binding nucleosomes and proteins and thus would affect the biochemical activity of a DNA locus. Moreover, charge oscillations could drive the opening and closing of chromatin thus directly controlling gene transcription.

[Aromaticity]

The key feature of the proposed molecular mechanism for thinking and consciousness involves the oscillation of aromaticity in DNA. The importance of aromaticity for thinking and consciousness has been consistently brought up by Hameroff during the past several decades (Hameroff et al., 2014). Classically, the psychoactive effects are being explained via binding of the drugs to proteins and blocking neurotransmitter reuptake, inhibiting neurotransmitter synthesis and inhibiting enzymes. In addition, 50 years ago, it was proposed that psychoactive substances being predominantly aromatic, work by binding to DNA and changing its aromaticity and quantum delocalization of electrons (Smythies et al., 1970). Smythies pointed out that most of the psychoactive drugs contain aromatic groups similar to nucleobases, easily penetrate via cellular and nuclear membranes and can bind to DNA either via intercalation or via hydrogen bonds (Smythies et al., 1970). Miller highlighted the significance of electron delocalization and aromaticity in DNA for the phenomena of life" (Miller et al., 1975). Hameroff observed a correlation between the aromaticity strength of anesthetic compounds and their potency (Hameroff et al., 2014).

In Fig. [Aromatics] we illustrated the aromaticity of the main psychoactive substances, their similarity to nucleobases and listed them according to the types of aromatic groups they contain. Also included are two intercalating substances: ethidium and SYBR Green for which psychoactive effects are unknown.

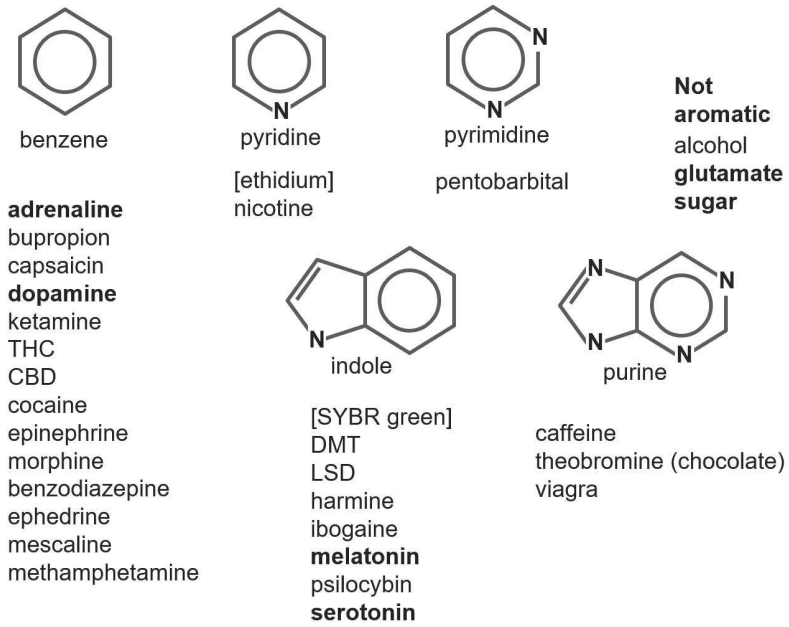


Fig. [Aromatics] Aromatic groups and exogenous and endogenous psychoactive substances classified by the aromatic groups they contain. *In bold are endogenous psychoactive substances. In square brackets are intercalating substances widely used in DNA research for which psychoactive properties are unknown. Only benzene, pyridine, pyrimidine, indole and purine groups are shown, all the psychoactive substances listed underneath contain not shown here additional, sometimes also aromatic radicals or rings.*

Stability of tautomers and frequency of tautomerization.

Classical Watson-Crick keto-amine tautomeric forms (GC-Taut3 and AT-Taut1, marked with continuous border on Fig. [Stability]) are more stable than enol-imine forms (dotted border) (Pérez et al., 2010). The frequency of tautomerization was estimated using fluorescence spectroscopy in model systems (Abou-Zied et al., 2001; Pérez et al., 2010) and molecular dynamics calculations (Brovarets' and Hovorun, 2015, 2014; Ol'ha and Hovorun, 2018) and range from 10^4-10^{14} Hz, typically 0.1-10 GHz. Further understanding of tautomerization of basepairs in DNA can be done using two-dimensional Fourier-transform infrared spectroscopy Consider that tautomerization could be aperiodic or subject to complex oscillations, so the frequency estimate doesn't necessarily imply regularity in oscillations. The lifetime of more stable (keto-amine) tautomers is estimated to be about 100 times longer than of less-stable (enol-imine) tautomers, so the oscillations have a character of short pulses. We have also noticed that aromaticity loss in GC and AT pairs goes in opposite directions, Fig. [Stability]. The more-stable GC form (GC-Taut3) has a lowered aromaticity and it occasionally pulses into a less-stable GC Taut1 which is fully aromatic, that is the largely nonaromatic GC undergoes occasional short aromaticity bursts. The more-stable AT form (AT-Taut1) is fully aromatic and it occasionally pulses into a less-stable GC Taut1 with lowered aromaticity, that is the largely aromatic GC undergoes occasional short aromaticity losses.

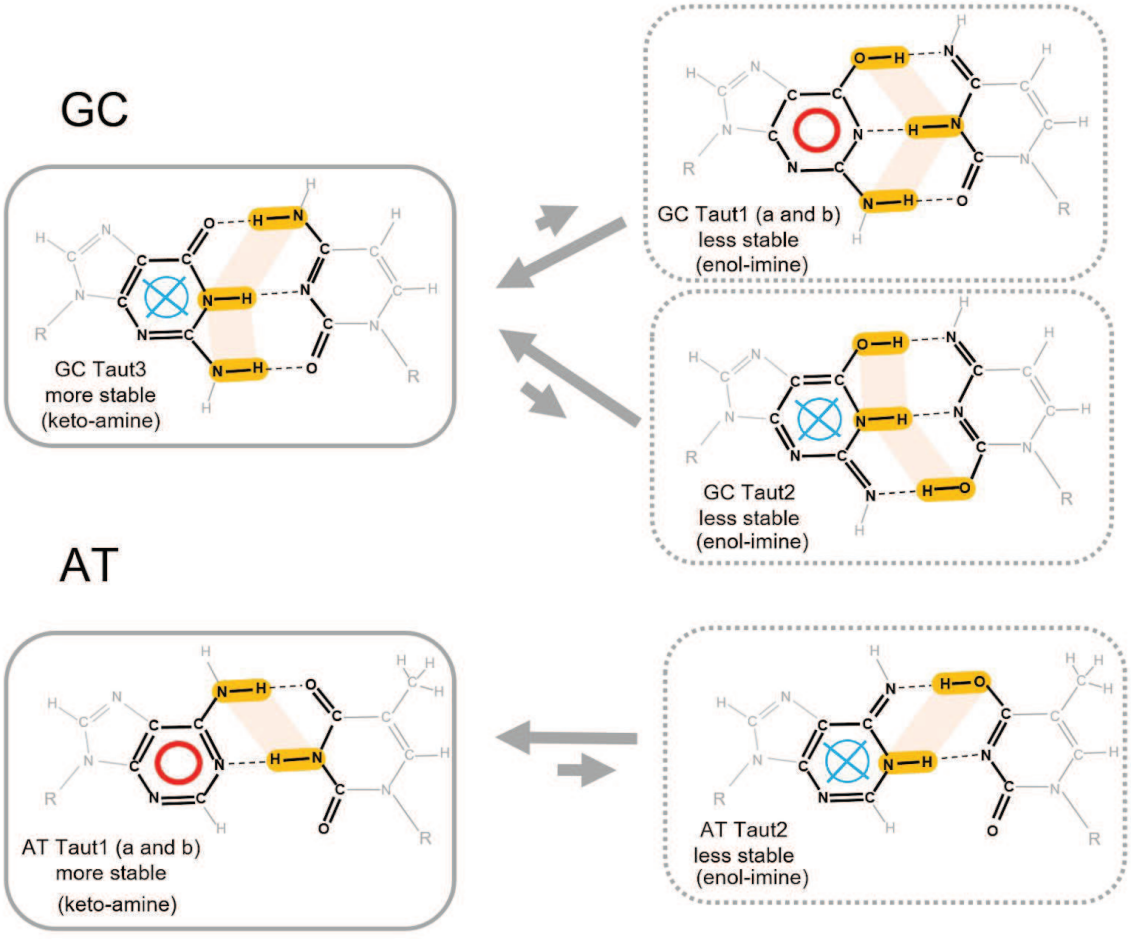


Fig. [Stability] Stability and aromaticity oscillations of purine tautomers in basepairs.

Among functionally important and abundant genomic elements, genomic polyA tracts and CpG islands stand out. PolyA tracts are important for viruses and transposons and often a deletion of polyA tracts impairs gene function (Guerrini et al., 2007). CpG islands are typically located in genes and gene promoters and are

involved in the regulation and activation of gene transcription (Deaton and Bird, 2011). Based on the above observation of opposite character of aromaticity oscillations between GC and AT basepairs, it is possible to predict that polyA tracts should have a uniform stack of pi-electron rings of adenines which are 99% of the time in aromatic state and occasionally, 1% of time lose the aromaticity. Since the pi electrons in the basestack are organized in a periodic structure, they very likely exist as an organized electron cloud and their aromaticity loss might be coordinated within the polyA tract. Both high aromaticity of the uniformly periodic basestack and occasional coordinated loss of aromaticity might have an effect on their oscillatory and biomolecular function due to possible effects on DNA structure, packing of chromatin, binding of nucleosomes, and protein factors.

Just the opposite should happen to CpG islands made exclusively of GC basepairs. They should exist in a reduced aromaticity state for 99% of the time and collectively burst into an aromatic state 1% of the time. This could also affect their DNA resonance signaling and also biomolecular functions.

Coordination of aromaticity oscillations

There are several mechanisms that would predict coordination between aromaticity oscillations within stretches basepairs in DNA. First, aromatic pi-electron rings of purines unite into a periodic pattern especially when the sequence is periodic such as in tandem genomic repeats. The stacking of pi-electron rings is thought to be responsible in part for the experimentally observed high electrical conductivity of DNA in physiological conditions (Kratochvílová et al., 2013). Second, as we previously published, basepairs are likely bound by delocalized proton wires made of longitudinal hydrogen bonds (Savelev and Myakishev-Rempel, 2020) which could also coordinate tautomerization and aromaticity oscillations. Third, the excitations caused by tautomerization could be transmitted via the sugar-phosphate backbone and lead to coordination between basepairs. Therefore, it is likely that aromaticity oscillations are coordinated within stretches of basepairs. Since both stacking of aromatic electron rings and the formation of longitudinal hydrogen bonds depends on DNA sequence, the coordination of aromaticity oscillations would also be highly sequence-dependent. Various sequences would provide different aromaticity oscillation patterns. The aromaticity oscillation pattern of a specific DNA fragment would be defined by the interplay of aromatic pi-electron stacks and proton wires, which would be highly variable. Yet, identical sequences may have identical aromaticity oscillations patterns and synchronize with each other thus providing a mechanism for resonance signaling.

Epigenetic regulation

Methylation of cytosine bases, the most frequent epigenetic mark, doesn't change the DNA tautomerization formulas described above, but would certainly affect the tautomerization rates and stability. In particular, methylation is predicted to favor aromatic rings stacking interactions (Kabeláč and Hobza, 2007) and thus should favor aromatic tautomers and their stacks.

Penetration of aromatic molecules and binding to DNA

Indole derivatives such as melatonin, harmine (Vignoni et al., 2014) and ibogaine migrate into the nucleus and bind to DNA. Small aromatic molecules such as psychoactive substances listed in Fig. [Aromatics] easily penetrate the cell and nuclear membranes (Lafayette et al., 2017). Most of them bind to DNA (Rescifina et al., 2014). Other indole derivatives also bind to DNA (Lafayette et al., 2017). Hallucinogen ibogaine enters the nucleus and regulates gene expression (Marton et al., 2019). Caffeine and chocolate's theobromine bind to DNA via hydrogen bonds (Johnson et al., 2012; Nafisi et al., 2008). Cannabinol (CBN) from cannabis binds in the major groove of DNA and doesn't intercalate into it (Tian et al., 2018).

Intercalation

When an aromatic small molecule intercalates into DNA, it inserts itself into the base stack as if it was an additional basepair in the DNA and its aromatic ring of pi-electrons is fuzed into the periodic set of pi-electron rings of the nucleobases (Rescifina et al., 2014). Morphine binds and intercalates into DNA (Li and Dong,

2009; Talemi and Mashhadizadeh, 2015). Adrenaline binds to DNA and may intercalate into DNA (Zheng and Lin, 2003). Hallucinogen harmine penetrates into the nucleus, binds to DNA (Vignoni et al., 2014) via intercalation (Wink et al., 1998). Serotonin and tryptamine intercalate into DNA (Hélène et al., 1971)

ORCH-OR theory

The delocalized state of aromatic electrons and protons in biological systems is described by Schrödinger's wave function. The loss of delocalization results in the collapse of Schrödinger's wave function and according to “objective reduction” (“OR”) of the quantum state this collapse is a choice and collectively these choices produce conscious awareness (Penrose, 1994). This was expanded to the Orchestrated Objective Reduction ("ORCH-OR") theory of Penrose and Hameroff (Hameroff, 1997) which proposed the key role of microtubules. There, the aromatic rings of aromatic aminoacids tyrosine, phenylalanine and tryptophan of tubulin were suggested to periodically collapse and expand producing choices and thus creating conscious awareness. Hameroff also posted online an unfinished paper suggesting the role of DNA in the process.

Here, we expand the ORCH-OR theory to include DNA. DNA and microtubules share aromatic and helical nature and their dimensions are comparable. DNA is plausible as a thinking machine since it carries the genetic code and has an efficient addressing system - it is often sufficient to know only 15 bases of the code to find a specific spot in the 3.2 billion bases of the genome. ORCH-OR theory proposes that the periodic collapse of the wave function of the aromatic aminoacids results in thinking and consciousness. Here, we propose the same for the aromatic electrons of the purines in DNA. In this process, periodically the aromatic tautomers Taut1 transform to nonaromatic tautomers Taut2 and Taut3, Fig. [GC] and back, the electrons become localized and delocalized, their wave function collapses and expands. This can take place in each of the 6.4 billion purines in the cell. This number can be multiplied by 80 billion neurons in the brain or up to 30 trillion cells of our body, considering that not only brain neurons are involved in the thinking process.

As we proposed previously (Savelyev et al., 2019), the genomes of the body located in the nuclei are informationally coupled to the microtubules located in the cytoplasm and between the cells and thus all DNA and microtubules of the body are united into one conscious network.

Hameroff also proposed that occasional wave function collapses produce time as a byproduct of creating consciousness (Hameroff, 2003). Here we expand this by suggesting that it is the experience of time and self-awareness that is produced by the wave function collapses. Non-biological objects and unidirectional processes also exist in the space-time of our universe, but we suggest that it is the wave function collapses and expansions of aromatic electrons in DNA that produce the experience of conscious awareness and sliding unidirectionally through time.

Decoherence

Decoherence is one of the key novel discoveries of the quantum mechanics of recent decades (Ball, 2018). This is a practically important concept that allows modeling the biological processes in mesoscale - the scale of macromolecules that have sizes in the shadow zone between the quantum and macroscopic worlds.

When purines transform into their aromatic tautomeric forms, their pi electrons are united into an aromatic ring and delocalize. This results in the quantum entanglement of these electrons and increases the coherence of their union. The loss of aromaticity could be caused by the Brownian motion of the nucleoplasm (DNA is constantly bumped by water and other molecules) and by infrared light which is generated by these molecules and fills our bodies. The loss of aromaticity is accompanied by localization (or de-delocalization) of electrons of the aromatic ring, decoherence and collapse of Schrödinger's wave function. Thus purines oscillate between the quantum and macrostates. The quantum delocalized coherent state occurs spontaneously whenever the electrons are left to themselves, which is possible because purines are protected from the outer nucleoplasm by the highly charged backbone of DNA. The macroscopic localized decoherent state is created when Brownian motion or infrared irradiation causes double proton transfer which pulls out an electron from the

aromatic ring and causes the ring to fall apart. This way oscillations of aromaticity in DNA provide an interface between the quantum world and the macroscopic world. The DNA can be considered a natural quantum computer and possibly receiver and transmitter of nonlocal quantum information.

Nonlocality

Thorough and well-controlled studies of Radin, Sheldrake and others demonstrate that consciousness has a nonlocal component (Bem et al., 2015; Mossbridge and Radin, 2018; Radin, 2009; Sheldrake, 2009; Storm et al., 2017). These studies suggest that not only the brain is involved in the work of the mind. Sheldrake convincingly argues that in addition to the brain, the rest of the body is involved in the work of the mind. For example, there are documented cases in which organ transplants transferred memories and character traits of transplant donors to recipients (Joshi, 2011; Liester, 2020; Pearsall et al., 2002; Sheldrake, 2009). This is in agreement with our model that unites the DNA of all the cells of the brain and the rest of the body into a single oscillator. Sheldrake also proposed that a substantial part of the human consciousness is located outside of the body in a non-local "morphic field" (Sheldrake, 2009). We suggest that coordinated oscillations of aromaticity in stretches of DNA could serve as an interface between the local macroscopic world and nonlocal "morphic field" governed by the laws of quantum physics. This nonlocality would also correspond to Bohm's implicate order of the quantum mechanical view of the world (Bohm, 1980).

Genome as a quantum computer

It has been previously proposed that the genome works as a quantum computer (Gariaev et al., 2001; Miller and Webb, 1973; Pitkänen, 2010). Here, we expanded this by adding a specific mechanism for quantum computation. The aromaticity oscillations are coordinated in stretches of DNA and are linked with oscillations of delocalized protons. Both electron and proton clouds are oscillating and they are charged, so these must result in electromagnetic attraction and repulsion which would affect the supercoiling of DNA and thus packing of DNA into nucleosomes. In short, aromaticity oscillations control the packing and unpacking of chromatin.

[Moreover, there is a theory of self-organization - self attractors, Mandelbrot. This was applied by Tobias Knotch to describe the self-organization of chromatin. There is also an interplay between coherence and decoherence, chaos and self-organization. Chromatin loops are attached to the nuclear matrix and collectively work as a quantum computer with logic and intuition (locality and nonlocality). The results are integrated by the nuclear membrane and then the information is plugged into the fiberoptic network of microtubules, actin and fibers of extracellular matrix and fascia.]

Conclusions

In summary, we were searching for sequence-specific oscillations in DNA and this brought our attention to sequence-dependent stacking of aromatic rings and delocalized protons (proton wires) stretched along the base stack and their interactions. We then noticed that tautomerization would be sequence-dependent and could serve as one of the sequence-dependent oscillators. Then we noticed that purines would oscillate between aromatic and nonaromatic states. Further, we incorporated these observations with the idea of fiberoptic signal transmission and the work of the mind.

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Author contributions

MMR developed the hypothesis and wrote the manuscript. IVS did the literature work and contributed to the discussion.

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