The role of Quantum computation in molecular interactions in biological cells

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Abstract: We propose that the interacting molecules in a living cell are databases of quantum superpositions and scan each other for biologically relevant interactions. We discuss our hypothesis in view of the recent findings in which a 100X100 dimensional entangled quantum system has been created and the study in which it has been shown that global symmetry is not essential for fast quantum search

One of the authors of this paper has proposed a role for quantum computation in biological systems in several articles (Grover, 2011a, 2011b, 2011c, 2014, Grover and Grover 2011, Grover et al. 2013 a, 2013b). It has been proposed that quantum computation is involved in biological systems at all levels in biological systems from the elementary particles to the whole organism (Grover et al. 2014, Communicated). Thus it is possible that right from elementary particles to the entire biological organism all the entities (in fact this can be extrapolated to the entire universe) behave as quantum entities. Superposition is an important concept in quantum physics and refers to the phenomenon in which a given entity can exist in more than one state at the same time. A very famous example is that of Schrodinger's cat which is dead and alive at the same time. Also according to this concept elementary particle can be at two positions at the same time. Thus all the entities in a biological organism and the biological organism itself exist in a state of superposition, unless a measurement is made on them (according to one of the theories). Similarly in quantum computation a 'qubit' (analogous to bit) can exist in three states 0,1 and 0 and 1 superposed together. (In contrast, in digital computation bits can exist in two states 0 and 1). It is notable that in a quantum superposition the different states (0, 1 and 0 and 1 superposed) are entangled and consequently ultrafast communication is possible between these states.

A lot of time and money is being spent on development of quantum computers. Scientists have devoted considerable effort to create a network of superposed particles which are also entangled. To increase the efficiency of quantum computation the approach that has been traditionally undertaken is to increase the number of entangled particles. Using this approach the scientists have been able to create an entanglement of 14 particles. It is possible however to have superposition of more than 3 states (This would be closer to reality in biological systems). Till recently the record for maximum number of superposed dimensions for a pair of particles has been 11. However Krenna et al. 2014 have broken this record and have created an entangled state of 103 dimensions from just a pair of photons. Thus one of the authors of this paper has joked that the cat exists in superposition of dead and alive states in addition to 101 more states. This is an important development from the view of increasing the efficiency of quantum computers and quantum cryptography. However from our perspective the development shows that the entities in the biological cells from elementary particles to biological organisms themselves can exist in a superposition of multiple dimensions and perform extremely fast and efficient computing. Moreover this points out to the possibility of non-local communication in biological cells which may be very important in living organisms (Grover et al. 2014, communicated)

Let us turn our attention to the molecules in a living cell. The molecular interactions in the cell are very important from replication (interaction between DNA molecule, DNA polymerase and several other protein factors), transcription (interaction between DNA, RNA polymerase and several transcription factors), translation (interaction between RNA, ribosomes and several protein factors), RNA splicing (interaction between mRNA,snRNA, splicing factors) and so on. We propose that in each of these interactions each molecule behaves as a "database" of entangled superpositions (superposition of more than three states is possible, see earlier). Thus several databases (interacting molecules) scan each other, the conformations essential for the interaction are selected and finally the interaction takes place. It was believed earlier that such a 'scanning' of the database is possible only if the database to be searched is symmetric. However a recent study by Janmark et al. 2014 has shown that the global symmetry is not essential for fast quantum search. This supports our theory of involvement of quantum phenomenon in biomolecular interactions since the scenario in a biological cell is far from globally symmetric.

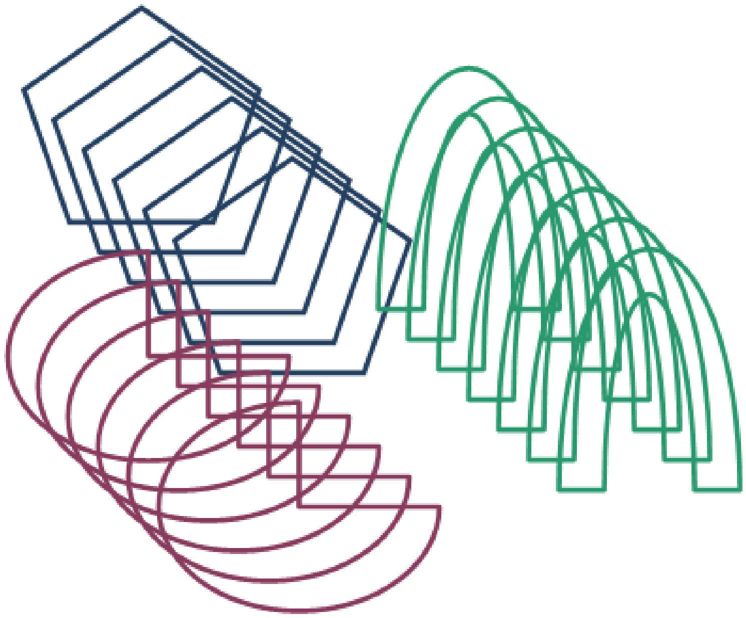

Fig.1: Quantum computation in molecular interactions in living cells.

In biological cells each interacting molecule acts as a database of entangled superpositions, scans the database of the interacting molecules and selects the appropriate conformation.

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