5-3-2019

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F. Matthew Mihelic
University of Tennessee Health Science Center

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Experimental Evidence Supportive of the Quantum DNA Model

F. Matthew Mihelic

University of Tennessee Graduate School of Medicine

fmihelic@utmck.edu

ABSTRACT

The DNA molecule can be modeled as a quantum logic processor in which electron spin qubits are held coherently in each nucleotide in a logically and thermodynamically reversible enantiomeric symmetry, and can be coherently conducted along the pi-stacking interactions of aromatic nucleotide bases, while simultaneously being spin-filtered via the helicity of the DNA molecule. Entangled electron pairs can be separated by that spin-filtering, held coherently at biological temperatures in the topologically insulated nucleotide quantum gates, and incorporated into separate DNA strands during DNA replication. Two separate DNA strands that share quantum entangled electrons can be mitotically divided into individual cells, and thus into two individual cell cultures. Initial experiments to validate the quantum DNA model have shown correlations in the depolarizations between separated cloned neuronal cell cultures, and additional investigations are indicated for further validation.

Key words: quantum logic, DNA, neuron, laser, depolarizations, phase correlations, phase lock

1. Introduction

DNA has been theoretically modeled as a quantum logic processor in which entangled electron spin states can be coherently held at biological temperatures. Neuronal cells can depolarize at up to 200 times per second, and the depolarizations of neuronal cells, along with many other cellular processes, are controlled in part by the DNA in the nuclei of those cells. Pilot experimental research at the University of Tennessee Graduate School of Medicine has provided empirical support for modeling the DNA molecule as a quantum logic processor that influences the depolarization patterns of neuronal cells. In this quantum DNA model entangled electrons are held coherently within the quantum logic processing of the DNA in living cells, and experimental studies have provided correlations between cells in separated cell cultures that support modeled theoretical quantum entanglement between those separated cultures.

2. Historical Perspective

In 1944 Erwin Schrödinger intuited that adaptation was necessary for life, and that quantum "leaps" of electrons between energy states were necessary for adaptation to occur. He theorized that the genetic material of the cell must therefore be in the form of some sort of "aperiodic crystal", because only a crystal could maintain the coherence times necessary for biological systems, and also because a simple repeating crystal could not contain enough information for the biological system. [1] Schrödinger himself thought that the "aperiodic crystal" would eventually turn out to be some sort of protein, but in 1953 Watson and Crick, admittedly influenced by Schrödinger and utilizing techniques of x-ray crystallography, determined that the "aperiodic crystal" was the DNA double helix. [2] Watson and Crick had discovered the structure of the quantum mechanics of the logic of life's adaptations, but until now there has not been a viable theoretical mechanism of that system's quantum mechanical function.

In 1948 Linus Pauling had described electron resonance in 3-dimensional aromatic molecular arrangements, and since then others have specifically described this in the DNA molecule. [3] Experiments to determine the resistance to electron transport along the longitudinal axis of the DNA molecule have provided no clear picture of the electron transport capacity of DNA, but rather, have provided widely varying results with different experiments showing different results ranging from non-conducting [4] to semiconducting [5] to metallic

conducting [6] to superconducting [7]. Such inconsistent results might be considered as an expected harbinger of quantum logic.

In 2011 Göhler, et al. described electron spin-filtering by DNA [8], in that while spin-down electrons moving longitudinally along the right-handed twist of the DNA molecule passed unimpeded, spin-up electrons were inhibited in longitudinal conduction by a length of DNA consisting of as few as twenty nucleotide base pairs. Electron spin filtering by an organic molecule was certainly a counter-intuitive concept, but they concluded that DNA was a very efficient electron spin filter at room temperature.

In 2013 this author published a theoretical model of how biological quantum logic can take place in the DNA molecule. [9] This current paper briefly summarizes the results of research designed to validate that quantum DNA model.

3. Quantum DNA Model

The DNA molecule has properties that allow it to act as a quantum logic processor. An electron or its quantum state can be coherently conducted or quantum teleported longitudinally along the coherence provided by the pi-stacking of the aromatic nucleotide bases of the DNA molecule. [10] As an electron or its quantum state is conducted or teleported longitudinally along the DNA molecule it is simultaneously subject to an electron spin filtration effect that is brought about by interaction of the helicity of the DNA molecule with the spin of the electron [11], and this provides the means for selective deposition of an individual electron, or the reading of an individual electron state, into a specific individual nucleotide quantum gate as determined by the electron spin direction and the coherence distance along the DNA molecule. Quantum logical operations in DNA occur via a quantum logic gate capability in each nucleotide that is provided by a logically and thermodynamically reversible Szilard engine function [12] of the deoxyribose moiety through which coherent electron spin is held in an enantiomeric symmetry between the C2-endo and C3-endo enantiomers in the nucleotide. The symmetry break that provides for quantum decision in the system is determined by the spin direction of an electron that has an orbital angular momentum that is sufficient to overcome the energy barrier of the double well potential separating the C2-endo and C3-endo deoxyribose enantiomers. The energy barrier of that double well potential [13] is appropriate to the Landauer limit of the energy necessary to randomize one bit of information, thereby enabling chirality determination by electron spin at an energy level appropriate to quantum logical operation. [14] The individual nucleotide quantum gates are held in coherent concatenation through the pi-stacking interactions of the nucleotide bases in the DNA molecule, and longitudinal coherence distances can be affected by deoxyribose enantiomeric selection that can bring about a change in the orientation of the nucleotide's base by a change in the N-glucosidic bond angle. The crystalline nature of the DNA molecule allows for extended temporal coherence of the system through its precisely designed nanospace which limits the degrees of freedom upon which entropic factors such as temperature or solvation can have any effect, and within which inherently fault-tolerant topological quantum logic operations can take place.

4. Experimental Design

Figure 1. Cell cultures.

An initial culture of rat neuronal stem cells was grown for one week and split into two separate culture dishes that have microelectrodes on the bottom to monitor cellular depolarizations. The separated cultures were then grown for three more weeks.
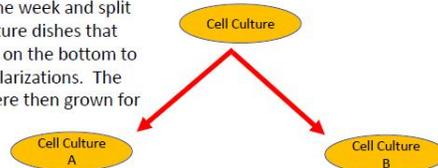
A microelectrode array (MEA) culture dish. Note the small dot in the center that contains 64 microelectrodes in an 8x8 array within one square millimeter. Also note that there are 16 tiny wires on each of the four sides that connect to the 64 microelectrodes.
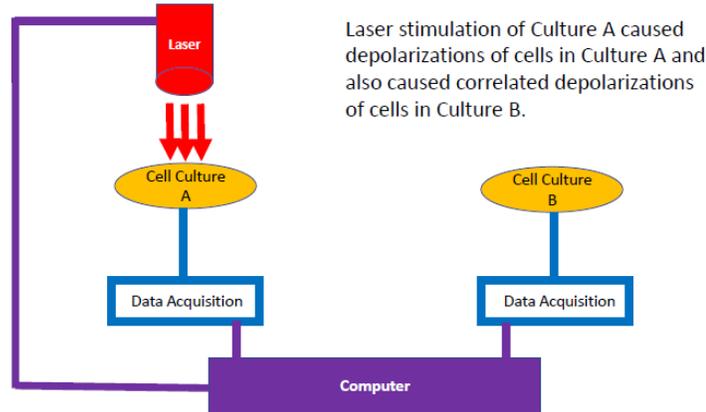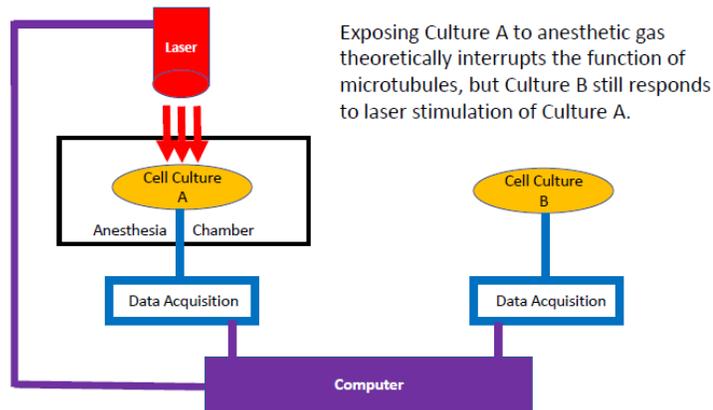
Figure 2. Phase I Experimental Design.

Laser stimulation of Culture A caused depolarizations of cells in Culture A and also caused correlated depolarizations of cells in Culture B.

Figure 3. Phase II Experimental Design

Exposing Culture A to anesthetic gas theoretically interrupts the function of microtubules, but Culture B still responds to laser stimulation of Culture A.

The model of biological quantum logic in the DNA molecule implies that entangled electrons can be shared between separate strands of DNA and held coherently as those separate strands of DNA are shared between dividing cells. The work of Pizzi, et al. from 2004 thru 2009 indicated that some sort of non-local communication existed between separated cloned cultures derived from neuronal stem cells, even though the researchers took great care to shield the cultures from any electromagnetic interference that might have given false results. [15] [16] Such non-locality was theorized to be consistent with the quantum DNA model, and so an experiment was planned to demonstrate non-local communication between separated cell cultures in a manner that would confirm quantum coherence of entangled particles (ostensibly electrons) in the separated cell cultures. [Figure 1.] Theoretically, entangled electron pairs can be separated by spin-filtering, held coherently at biological temperatures in the topologically insulated nucleotide quantum gates, and incorporated into separate DNA strands during DNA replication. Two separate DNA strands that share quantum entangled electrons can be mitotically divided into individual cells, and thus into two individual cell cultures. In order to demonstrate this, a culture of rat neuronal stem cells was started and grown for one week, and then the culture was split into separate cell culture dishes that each had arrays of microelectrodes on the bottom of the dish that would contact individual cells in culture. The cells were then grown on the microelectrode arrays for another three weeks. After that time, the cells in the microelectrode array culture dishes were connected to electronic equipment to measure the depolarizations of the cells that were in contact with the microelectrodes. The cell cultures were spaced twelve to eighteen inches apart and were monitored for cellular depolarizations. Cell culture A was exposed to laser pulses that induced cellular depolarizations in cells in culture A, but correlated depolarizations were also found in cells in culture B. [Figure 2.] This indication of non-local communication between cells in the two separated cultures supports the hypothesis that there is quantum entanglement between particles (ostensibly electrons) shared between the separated cultures.

Non-local communication was demonstrated in the first part of the experiment, and the second part of the experiment sought to isolate the source of that entanglement to the nucleus of the cell where the DNA is located. Stuart Hameroff and Roger Penrose had previously made a good argument that the microtubules in cells functioned via quantum mechanical effects that could be interrupted by general anesthetics. [17] Because microtubules provide communication between the nucleus and other cellular components, it was hypothesized that microtubules function as "quantum wires", and that if that microtubule communication was interrupted by a general anesthetic, and if at the same time non-local communication between cells in separated cell cultures could still be demonstrated as it was in the first part of the experiment, then the source of the entanglement between cells would be theoretically localized to the nucleus, and also that microtubules would be ruled out as a source of non-local entanglement communication. [Figure 3.] So the hypothesis of the second part of the experiment was that if, while culture A was subjected to a general anesthetic to interrupt microtubule function, it was stimulated with laser pulses that induced cellular depolarizations that were correlated with depolarizations of cells in culture B, then such results would indicate that the source of the entangled communication between the cells would be the nucleus which contains the DNA.

The experimental system built to carry out the experiments was able to monitor eight data channels simultaneously. Three data channels were used to monitor cells in culture A, four data channels were used to monitor cells in culture B, and one data channel was used to monitor laser pulse timing. The 10 mW 650 nm laser was pulsed every half second for 50 miliseconds, and this was done 10 times over 5 seconds as the cellular depolarization data was obtained from three electrodes on the microelectrode array monitoring culture A and four electrodes on the microelectrode array monitoring culture B. The time interval between measurements on each electrode was one millisecond. Then the system would shift to simultaneously monitor the next 3 electrodes in culture A and the next 4 electrodes in culture B while the laser was pulsed again 10 times over 5 seconds. This continued for a total of 16 iterations in each experimental run, with each iteration providing simultaneous monitoring of 3 electrodes in culture A and 4 electrodes in culture B, for a total of 48 electrodes checked in culture A and all 64 electrodes checked in culture B over the 16 iterations. Between each five second iteration there was a varying time interval of between 30 and 60 seconds, during which the system transferred information from data acquisition to the computer. As an example of information comparison, Figure 4 is a display of some iterative sample data showing conventionally expected asynchronous depolarizations of neurons in seven data channels, along with the laser pulse timing in the eighth data channel.

Figure 4. Information Presentation Example.
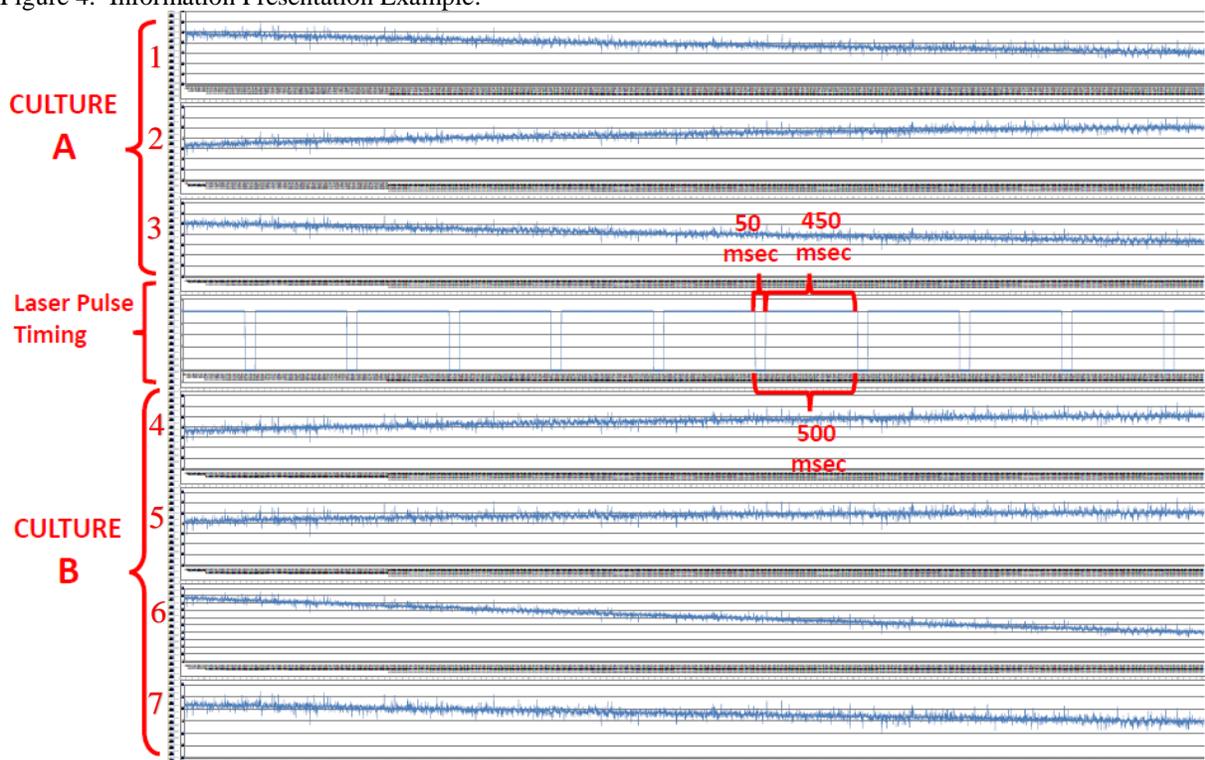
5. Experimental Findings

Several iterations of experimental monitoring during laser stimulation showed correlated depolarizations between cells in the separated cultures, and Figure 5 is one such interesting example. While not all experimental iterations showed significant findings, several things are of note in the iteration shown in Figure 5. First, note the sustained oscillatory depolarizations present in A-1, that one must conclude were induced by the pulsed laser stimulation since no previous reports of such oscillatory depolarizations could be found in an extensive literature search. Also note that similar sustained oscillatory depolarizations were also induced in culture B, even though only culture A was exposed to the laser. Particularly note that in B-4 oscillatory depolarizations begin between the fourth and fifth laser pulses, and that there is a noticeable change in the wave form in B-4 with each laser pulse beginning with the fifth one (as designated by the red arrows). Remember that the laser was not hitting culture B, but only hitting culture A. In iterations in which the initiation of oscillatory depolarizations was seen in culure B, the oscillatory depolarizations generally started on or after the fourth laser pulse.

Figure 5. Laser Stimulation of Culture A.
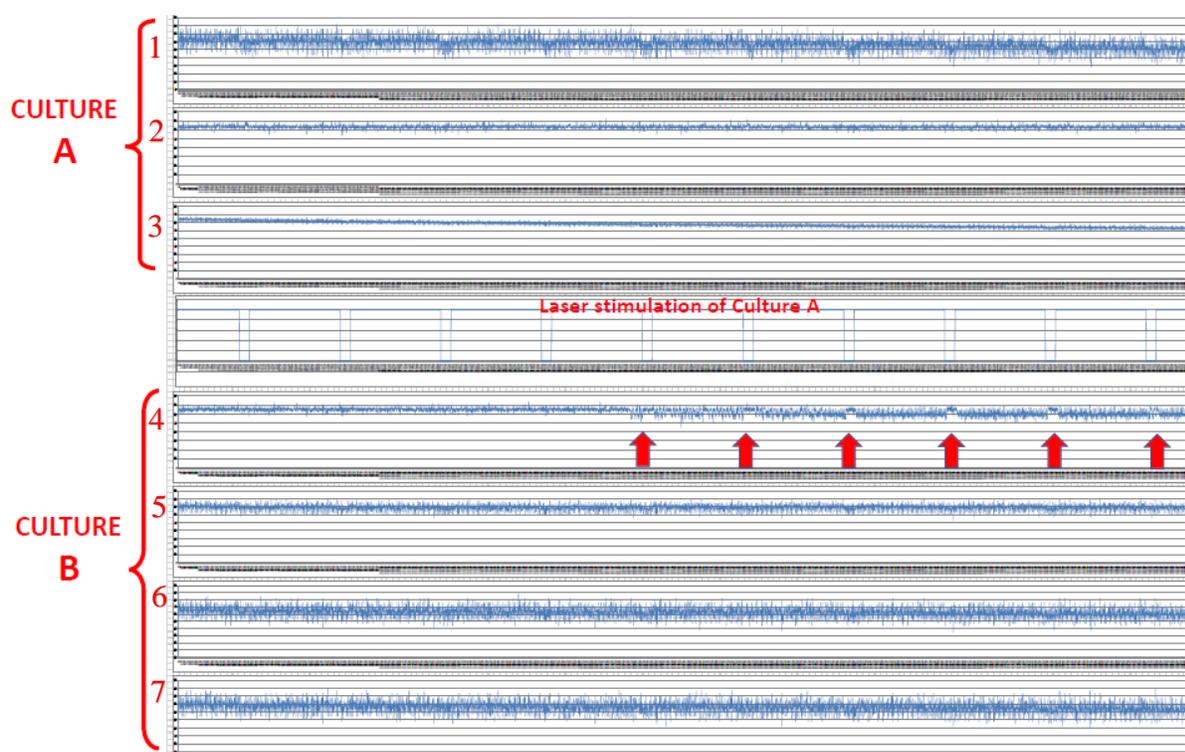
In the first part of the experiment, the pulsed laser had the effect of inducing sustained oscillatory depolarizations, but when culture A was exposed to general anesthetic gas (isoflurane) in the second part of the experiment, the laser had the effect of terminating the oscillatory depolarizations in culture B. An example of this effect can be seen in Figure 6. Even though culture A was anesthetized by exposure to isoflurane gas for 30 minutes, cells in culture B still responded to laser stimulation of culture A, as indicated by the red arrows at B-5 and B-7. This supports that concept that the source of quantum entanglement between cells in separated cultures is in the nucleus, and not in the microtubules (or connected to the nucleus by the microtubules).

Figure 6. Laser Stimulation of Culture A and Anesthesia Gas to Culture A.
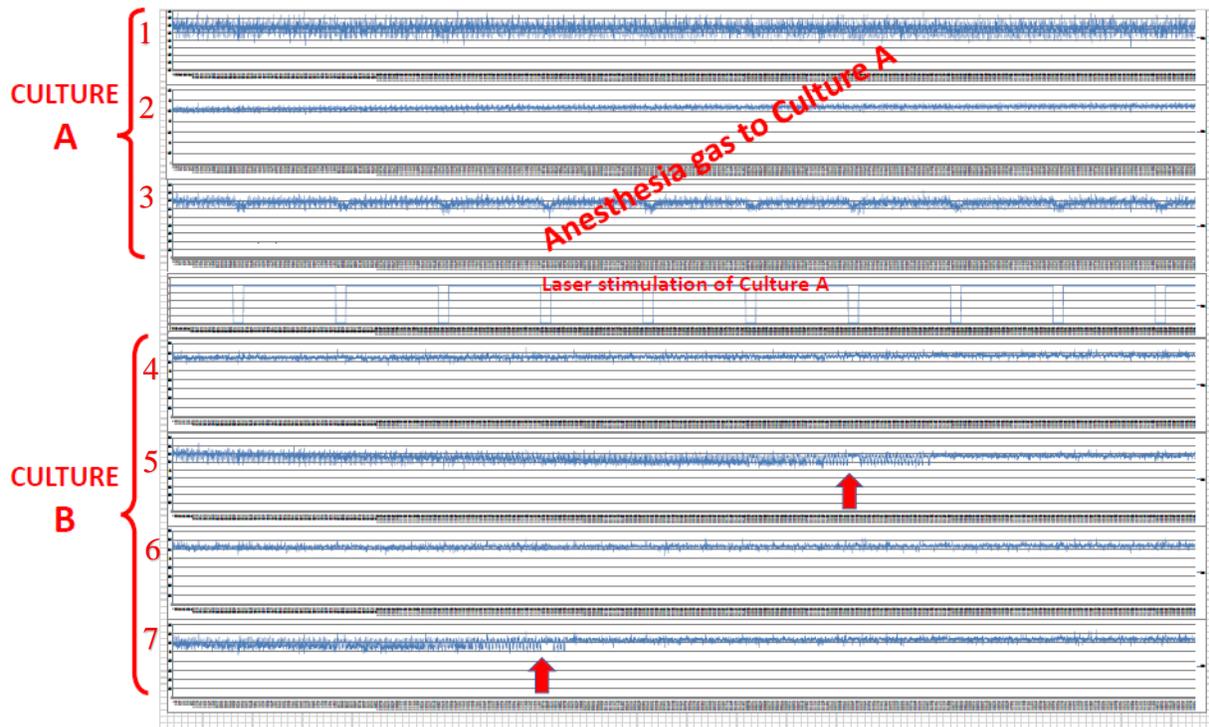
Interesting Spearman Rho correlations were obtained comparing various segments of the data from the iteration illustrated in Figure 6, and those correlations are indicated in Figure 7. The two segments that were correlated were the segment between the first and second laser pulses, and the segment between the eighth and ninth laser pulses. The red vertical lines in Figure 7 indicate the two electrodes correlated, and the red numbers at the bottom of the graph indicate the strength of the correlations of the measured depolarizations between the respective electrodes. It is of note that the oscillatory depolarizations of the cell measured at B-5 in the segment between the first and second laser pulses, had a very strong correlation with the oscillatory depolarizations of the cell measured at A-3 (0.831), but there was no significant correlation between B-7 and A-3 (0.167). This indicates that certain cells in one culture will phase lock with certain cells in the other culture, but not all of the cells will phase lock together. When the oscillatory depolarizations in B-5 were terminated by the combination of anesthetic gas to culture A and laser pulsing to culture A, as seen in the segment between the eighth and ninth laser pulses the correlation between B-5 and A-3 is no longer significant (0.171), but correlations between cells in the same culture now become significant (B-5 to B-6 at 0.411, and B-5 to B-7 at 0.408).

Figure 7. Correlations Between Cultures. (Same data as Figure 6 but showing correlations of cellular depolarizations between first and second laser pulses, and between eigth and ninth laser pulses.)
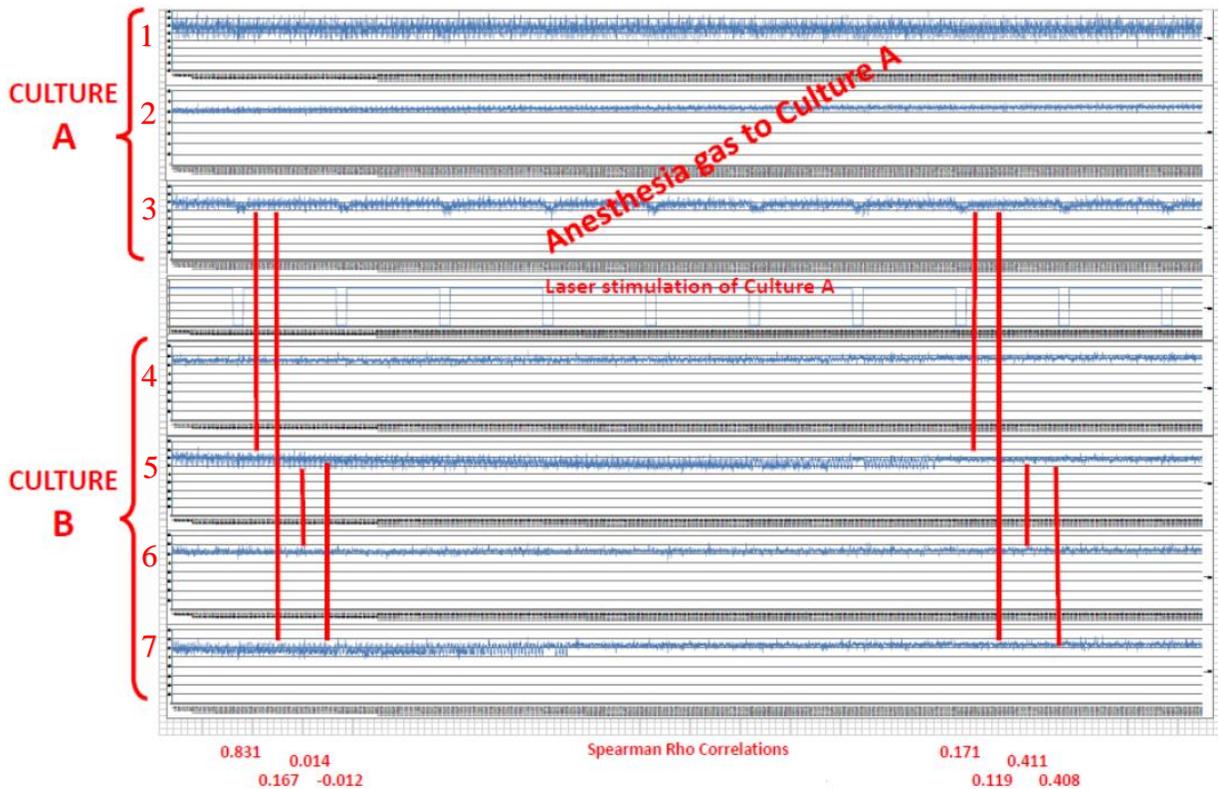
6. Discussion

The depolarization data obtained in the experimental runs is indicative of a true biological phenomenon and not the result of electromagnetic wave interference. If electromagnetic waves of greater than one millimeter wavelength were interfering with the system it would be expected that all of the microelectrodes involved would show a similar response that would be correlated with all of the laser pulses, but in the experimental data not all of the microelectrodes showed a simultaneous response. The induced cellular oscillatory depolarizations continued between the laser pulses while no laser pulse was occuring, indicating that this was a biological phenomenon. Also, when the beginning of a sustained oscillatory depolarization was observed during an experimental iteration in the non-local culture (B), such depolarizations would begin on or after the fourth laser pulse in each iteration. Most importantly, the application of anesthetic pharmacological manipulation to the local culture (A) induced a change in the type of response of the non-local culture (B) when the local culture (A) was exposed to laser pulses.

The experimental results obtained were biological responses that confirm the experimental hypotheses, and studies for further confirmation are indicated. The model of biological quantum logic in the DNA molecule is empirically supported by the demonstration of non-local communication between cells in separated cell cultures, and the point of such entanglement communication was ostensibly localized to the nucleus of the cell through the experimental runs that utilized general anesthetic. The modeling of microtubules as "quantum wires" is also supported by this. The phase locking of the oscillatory depolarizations of cells in separated cell cultures is theoretically related to correlations between entangled electrons in the DNA in the nuclei of those respective cells.

In a quantum computing system the hardware and the software are one and the same, and so quantum DNA technology will enable the use of the DNA molecule as the ultimate medium for molecular scale data storage and computation. This new paradigm of functional biological quantum logic will provide architecture and conceptual direction for practical quantum computing that will be scalable to millions of qubits and operate at room temperature.

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