ORDERED WATER LAYERS IN BIOLOGICAL SYSTEMS

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Occupying about 70 % of the cellular volume, water creates specific environment for biophysical and biochemical processes in living cells and their structures. Cellular structures expose charged hydrophylic surfaces at which water forms ordered layers up to 0.5 mm thick with strongly modified properties compared to bulk water [1, 2]. Among others, ordered water exhibits reduced fluctuations of binding between water molecules, lower electrical conductivity, and may act as a donor of electrons.

Oxidative processes in a eukaryotic cell occur in mitochondria, organelles providing essential energy resource of the cell. Ordered water layers at electric potential regions around outer membranes of functional mitochondria and at macromolecules and structures with charged surfaces provide a low-loss environment in which electric and electromagnetic signals can propagate and we assume the whole cell can act as a cavity resonator. In a number of multicellular organisms, cells are interconnected by tubulin nanotubes which are likely to act as waveguides. A tissue created by interconnected cells can be understood as a unified cavity system with orchestrated signals and functions. If oxidative energy production in mitochondria is reduced below a certain critical value, the ordered water layers around mitochondria repolarise and electrons are released from the layers [1, 3]. Free electrons then form a conductive cloud which can efficiently damp electric and electromagnetic signals generated in the cell [3]. As a result, the cell with disturbed electromagnetic activity can be detached from the concerted signalling within the tissue and begin its independent activity as a cancer cell.

Due to a strong coupling between water molecules, ordered water also exhibits decreased noise level. Compared to human-built electronic devices, biological systems use extremely low signal levels. For example, the total energy draw of a human brain is about 25 W, energy draw of individual cellular structures such as microtubules can be estimated about 10^{-16} W. Reliable processing of extremely low signals requires operation at extremely low noise levels. Ordered water layers shield sensitive signal-processing structures from outside noise. The main protective features of water and their origin will be overviewed.

Due to extensive amount of charged surfaces in biological structures, practically all water in a cell is ordered. Understanding the properties of ordered water layers and their disturbances can explain essential activities such as signal processing in living structures as well as origin of various pathological states.

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References:

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