Stuart Hameroff's Theories Regarding Microtubules as the Seat of Consciousness

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This article is about how a doctor named Stuart Hameroff has contributed to a theory about the biological nature of consciousness. Hameroff is an anesthesiologist at the University of Arizona Health Sciences Center in Tucson, Arizona. His work is possibly relevant to Rolfing® practitioners because it helps show how human body tissue may "think."

People who practice body therapy and mind-body disciplines often use the term "cellular consciousness." Upon hearing this, many reasonable persons dismiss this phrase as hyperbole. Stuart Hameroff has spent his professional career examining cellular consciousness, literally. His discoveries, along with those of theoretical physicist Roger Penrose, support many people's observation that the body has intelligence distributed throughout its tissue, that is, that there is local intelligence of a highly complex nature in all parts of the body.

Students of structural integration are already familiar with the theory that connective tissue serves the body as a semi-conductive circuit, from the writings of James Oschman. Reading Hameroff's book you come across many of the same reference sources documenting the microscopic structure of connective tissue as you do when reading Oschman.

Hameroff's particular contribution concerns cells, and in particular, the cytoskeletal component of cells called microtubules. Cytoskeletal means literally, 'skeleton of the cell,' and that is what it looks like. This network was not even noticed until the early 1970's when electron microscopists switched to a fixative that did not dissolve it. Microtubules make up the main trunk pieces of this skeleton and between these trunks are microtubule associated proteins that connect them to each other. Microtubules are the cell's nervous system and circulatory system.

The internal microtubule structure consists of hollow cylinders, the walls of which are lined with arrays of what Hameroff describes as "corn kernels arranged in a hexagonal lattice." These "corn kernels" are small enough and geometrically arranged so that Hameroff and Penrose have theorized that they form a computer-like data processing system. In fact, a photograph taken by an electron microscope of a microelectronic switch from a computer, looks exactly like a photograph of a microtubule. The substance of this geometry rather than being made out of silicone, as it is in a computer, is formed in water, highly ordered water.

On a behavioral level, microtubules are observed to be gravitationally and spatially sensitive. In some single celled creatures they extend through the cell membrane and act as pseudopods to propel the cell. Microtubules may be the smallest unit of intelligence within the body and may, in fact, be the source of what we call conscious experience.

In nerve cells (neurons) the microtubules are arrayed in parallel, as opposed to other body cells where they are arranged in a radial pattern. Since nerve cells do not divide, the centriole, which plays a key role in cell division, is not evident. This specialized parallel arrangement in the neuron organization facilitates quantum and computational coherence. Quantum coherence is a phenomenon that can only occur among objects that are very tiny and appropriately organized.

Large objects exist in our human centered world as just those—large objects. When we leave home in the morning, we expect it to be there when we get home at night, relatively unchanged and in the same location. Very tiny objects don't conform to these assumptions about matter. At an atomic level, particles can also be waves (energy), and they aren't precisely in one location. In other words, if your house was at the atomic level, it might not be in the same place when you got home, and it might not even be a house anymore.

The beauty of the atomic scale is that it has this unfixed, non-computable quality and thus it seems to express a mysterious independence from our

familiar deterministic world. Atomic particles seem to live a "you can't pin me down, and if you do you won't see my wholeness" kind of existence. The smaller the particles the longer they can exist in the place of all possibilities. The larger the particles or objects are the more instantly they look and act like solid matter and the less time they can exist in a quantum state. To stop a quantum event, all a human needs to do is observe it. Then it becomes fixed. Thus, we humans can infer quantum events from indirect evidence and mathematical proofs but the wholeness of the event cannot by definition be observed. Observation creates fragmentation and shows us only a piece. This is convenient for consciousness theorists since consciousness itself is proposed to have this unobservable quality.

The quantum physics point of view is relevant to microtubules because they are small enough to behave in this mysterious, indeterminable way—what is termed "non-computable." Roger Penrose was looking for some event in the human body that had this quantum quality and Hameroff provided the answer in the form of microtubules.

The quantum activity that takes place within the microtubule is a binary event involving a free electron in the sub-unit of the microtubule earlier referred to as the corn kernel, and more properly referred to as a tubulin protein sub-unit. The electron can slide back and forth making the tubulin protein unit an information bit that is polarized in one position or another: An event that can be represented as 0 or 1. This event, however, is at the level of an electron and thus, has quantum non-predictability.

This electron movement occurs continuously in the microtubules of all the cells in our human body. One way to make the polarization fixed is to introduce medical anesthetics into the body which causes all those electrons to freeze in place, and in this condition conscious awareness is turned off, without any damage to the body's cells. Anesthesia merely suspends the quantum event that Hameroff suspects constitutes consciousness. It is this reaction to anesthesia that first inspired Hameroff to consider the microtubule as being important to his inquiry.

Each neuron has within it a vast quantity of microtubules within which are in turn vast quantities of tubulin sub-units. There is much more going on in the brain than neurons firing. Each neuron is itself a brain. This fact makes the brain's demonstrated capacity more understandable and makes artificial intelligence that relies on conventional circuitry very limited by comparison.

It isn't just a vast array of microtubule data slots that makes consciousness possible. Microtubules and microtubule arrays have the ability, in their wave like state, to support quantum coherence. All the microtubules are in resonance with each other in a high-energy (high frequency resonating) state. This quantum coherent state can't be objectively observed and in this state the microtubule array acts as a quantum system. The system exists in this quantum state until it collapses, which means that it punctuates its activity for a moment. Each collapse punctuates a discrete conscious event. It can collapse if it is observed, that is, influenced by the environment, or it can collapse on its own. When it collapses on its own the result is not predictable and Penrose claims that some intrinsic quality of the Universe determines it.

The implication is that there is a quality of consciousness that is an expression of the quantum resonance of the Universe and it expresses itself through this part of a biological system. Another implication that Hameroff notices is that consciousness rather than being a continuous stream is in fact a rapid flickering series of discrete bits, which reminds him of the Buddhist description of consciousness.

Brain size is an issue as well. Quantum theory predicts that collapse of the quantum event occurs too quickly for conscious awareness in a single nerve cell. The single cell doesn't possess a critical mass of quantum coherence to establish self-awareness. Similarly, having ten or twenty neurons doesn't sustain consciousness. Hameroff says, "...if all the microtubules in about 100 neurons were in a quantum state for . . . half a second—a conscious event would occur."[11]

When you have hundreds of neurons, cells that have parallel arrays of microtubules, the level of complexity achieved by tiny worms and sea urchins, you have sufficient quantum coherence to predict a small quantity of self-awareness.

When life attained this level of complexity, where tiny worms and sea urchins and other similar creatures established themselves, there followed an explosion of evolutionary development about 540 million years ago that produced most of the modern phyla in only about 10 million years. Penrose and Hameroff speculate that this critical mass of consciousness was an evolutionary advantage that led to rapid proliferation of new life forms.

Another evolutionary crossroad may have occurred about two billion years ago with the origin of nucleated cells. Prokaryote cells, which exist today as blue-green algae and bacteria, gave

way to eukaryote cells that are the basis for all plants and animals. One theory, advanced by Margulis and Sagan[2], suggests that it may have been the ingestion of a spirochete by a bacterial cell that provoked innovation in the eukaryote cell. That is, one cell absorbed a different cell with an active flagella made out of cytoskeletal proteins, and the result was a cell with a complex internal skeletal structure (microtubules) that became the basis (eukaryote cells) for higher life forms. The image is similar to a human swallowing an alien with superhuman powers and the new creature, part human and part alien, could walk through walls, or at least dance all night.

The new model, nucleated cell containing microtubules and a centriole, formed out of microtubules, was a large evolutionary advantage. An example of centriole virtue is the statement by Hameroff that, "Navigation and gravity sensation have been suggested to represent a 'gyroscopic' function of centrioles (Bornens 1976) which have also been described as perfectly designed signal detectors." (Albrecht-Buehler, 1981)[33]

The implications of Hameroff's work are broad, but at this point largely unproven and not widely accepted in the scientific community. Just before cell division the microtubules appear to dissolve. This dissolution and reappearance of cytoskeletal structure in the daughter cells may also be an important clue to how life maintains adaptability.

In his article in Alternative Therapies, he observes that states of super consciousness, such as those experienced in times of emergency, or by very skilled athletes or facilitated by psychedelic drugs, may be related to the speed of the electron mobility in the microtubules, just as unconsciousness during anesthesia seems to be due to immobility of those electrons.

Hameroff is interested in these issues clinically. He does research into treatment of chronic pain, depression, and stress attenuation. The bridge between a biological view of consciousness and the field of structural integration is not immediately obvious. However, Hameroff has contributed to the reconsideration of body as the bridge between wave and particle, between energy and matter. ❑

FOOTNOTES

[1] Hameroff, S. "Consciousness and Microtubules in a Quantum World." Alternative Therapies. May 1997. P. 73.

[2] Hameroff, S. Ultimate Computing. North-Holland: New York, 1987. P. 60.

[3] Hameroff, S. Ibid. P. 66.

FURTHER REFERENCES

Freeman, D. "Quantum Consciousness", Discover, June 1994.

Penrose, R. Shadows of the Mind. Oxford: Oxford University Press, 1994.