Anesthetic Action and "Quantum Consciousness"

A Match Made in Olive Oil

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ANESTHETIC gases block consciousness selectively, sparing nonconscious brain activities, and thus their specific action could unravel the age-old mystery of how the brain generates, or mediates, consciousness. In this issue, Li *et al.*[1] make a significant contribution to our understanding of both anesthesia and consciousness, showing that an isotope of the anesthetic xenon (^{129}Xe) with the quantum property of nuclear spin 1/2 is significantly less potent than xenon isotopes without spin, despite identical chemical actions. Li *et al.* suggest that the xenon nuclear spin antagonizes its own anesthetic action by promoting consciousness, and that consciousness involves quantum brain processes, thus supporting a genre of theories known as "quantum consciousness."

"In which proteins do anesthetics act to erase consciousness?"

"Quantum" implies the strange physics governing very small scales, but with large-scale implications *via* field effects, "nonlocal entanglement" (separated particles are somehow connected over space and time, in what Einstein called "spooky action at a distance"), coherence (multiple particles condense into unitary entities, governed by a wave function), and quantum superposition of multiple coexisting possibilities (used in quantum computing, with information as quantum bits, or "qubits," of both 1 and 0 collapsing to either 1 or 0 as the solution).

"Spin" is a particular quantum property related to angular momentum, or torque with a magnetic moment at discrete, quantized levels. Atoms with imbalances of protons and neutrons can have nuclear spin, and such particles ("fermions," obeying the Pauli exclusion principle) have half integer quantized spin values: 1/2, 3/2, 5/2, and others. These spin states can entangle—be intimately connected with—other spin states, although separated in space and time. When one member of an entangled pair is perturbed, the other "feels it," and responds immediately.

"Quantum consciousness" theories suggest that entanglement, coherence, and quantum computing occur in the brain, offering potential solutions to challenges in cognitive neuroscience, *e.g.*, the "binding problem." In conscious vision, perceptual information for an object's shape, color, motion, and meaning is processed at different times in different areas of visual cortex (V1, V2, V3, and so forth). Yet somehow, the disparate content is "bound together" in unified scenes, *e.g.*, a red kite flapping in the wind. More generally, auditory, tactile, olfactory, and visual sensory modalities, along with memory and feelings, all apparently processed in different brain locations at different times, are also bound together, integrated, in unified conscious perceptions. (Indeed, Mashour[2] has suggested "unbinding" as the key effect of anesthetic action.) Einstein's "spooky action at a distance"—entanglement—may quite literally bind and integrate disparate brain content into unified conscious moments, like frames in a film or video. Sequences of such moments can give rise to our familiar stream of consciousness.

In addition to nuclear spin entanglement, quantum dipole oscillations among π electron resonance clouds in membrane and cytoskeletal proteins have been implicated in consciousness, and are apparent targets of anesthetic action.[3] Taken together, entanglement, coherence, and superposition from nuclear spin and electron cloud dipoles in critical brain proteins can account for (1) binding; (2) precise brain-wide synchrony; (3) ultrafast, massively parallel quantum computing (*e.g.*, in microtubules); (4) anesthetic action; and (5) a link to fundamental aspects of the universe.[4]

But quantum consciousness proposals have been dismissed and disregarded because technologic quantum computers are disrupted by thermal vibrations, and must operate near absolute zero temperature. Delicate quantum

Image: A. Johnson, Vivo Visuals/J. P. Rathmell.

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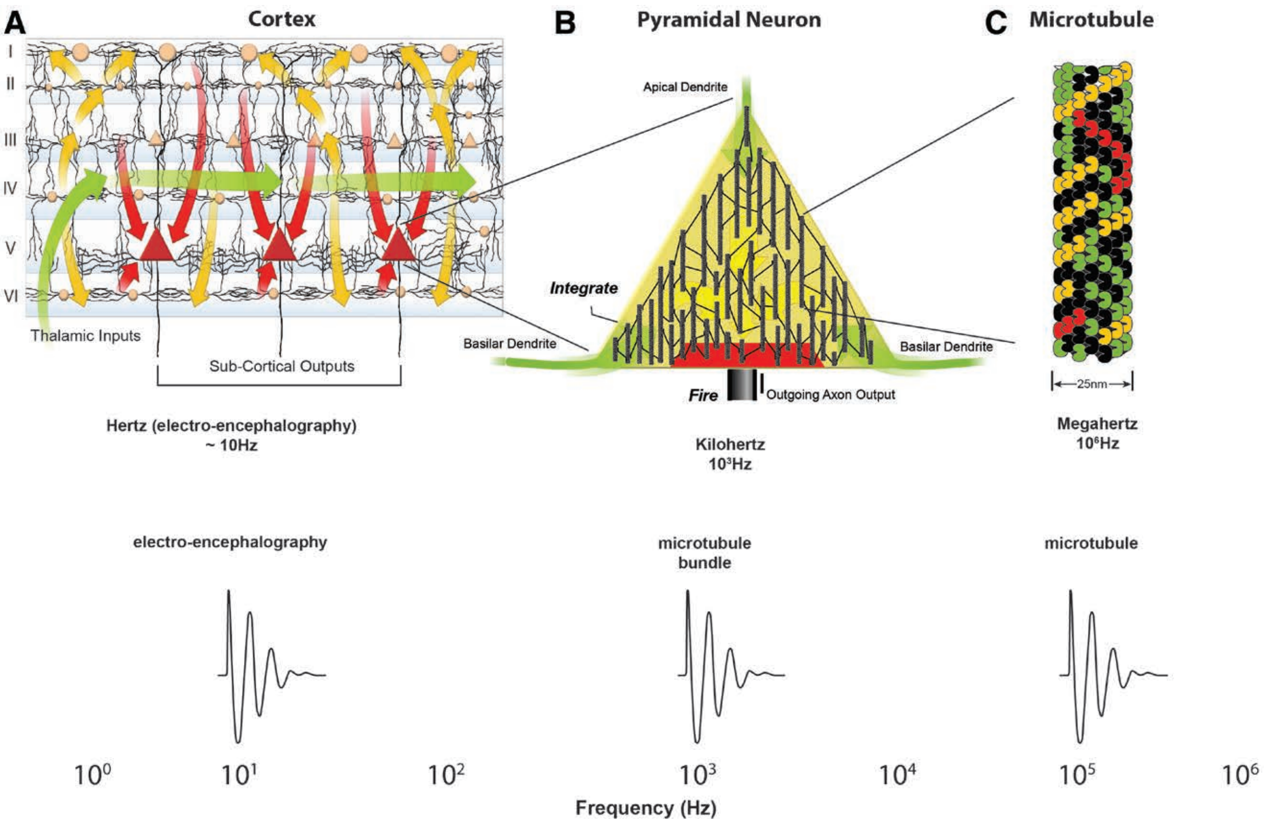

Fig. 1. Top three levels in a six-level recursive brain hierarchy. (*A*) Cerebral cortex, with thalamic inputs processed in three waves through six cortical layers before converging on layer V pyramidal neurons. (*B*) Cell body of pyramidal neuron with internal networks of microtubules. (*C*) Single microtubule comprised of peanut-shaped tubulin proteins.

processes in the "warm, wet, and noisy"[5] brain would surely "decohere"—be drowned out—by chaos in the aqueous biologic milieu. Or would they?

Anesthesia to the rescue! In the nineteenth century, gases with diverse chemical structures were found to reversibly render humans and animals immobile, unresponsive and unconscious. Seeking a unifying factor, Hans Meyer (1899) and Charles Overton (1901) discovered that anesthetic potency correlated strongly with gas solubility in a nonpolar, "hydrophobic" lipid-like medium akin to olive oil. Potency is quantified by the ED50 (effective dose producing immobilization in half the population), which, for volatile anesthetics, came to be known as the minimum alveolar concentration. The solubility binding involves weak quantum dipole couplings (van der Waals London forces[6]) between electron outer shells of anesthetic molecules, and, *e.g.*, "π electron resonance" clouds of aromatic amino acid rings inside certain brain proteins.

The Meyer-Overton correlation thus defines an intraprotein, olive oil–like medium that is "quantum-friendly," nonpolar, hydrophobic (not "wet"), and potentially suitable for quantum information processing relevant to consciousness. As for "warm," plant photosynthesis proteins use quantum coherence to transfer photon energy from sunlight through π resonance groups, facilitated by coherent mechanical vibrations, and thus are not "noisy" but rhythmic. Unlike olive oil, or bulk benzene (*e.g.*, gasoline), π resonance electron clouds in protein interiors are arrayed at, or near, the van der Waals radius, conducive to quantum interactions (*e.g.*, similar to the quantum material graphene).

In which proteins do anesthetics act to erase consciousness? Membrane ion channels and/or receptors for γ-aminobutyric acid receptor type A, glutamate, acetylcholine, glycine, and serotonin were presumed targets, but evidence failed to support unitary anesthetic action,[7] and some results point to cytoskeletal microtubules inside neurons.[8] Polymers of the protein tubulin, microtubules have quantum resonance oscillations in terahertz, gigahertz, megahertz, and kilohertz frequency ranges,[9] and are proposed to host quantum computing regulating neurons, controlling behavior and mediating consciousness.[4] Computer simulations suggest anesthetic gases dampen (and nonanesthetic gases do not dampen) tubulin terahertz resonance (proportional to anesthetic potency).[3] Other "quantum consciousness" theories involve membrane proteins, ordered water, lipids, or DNA.

Nuclear spin 1/2 is far more stable than electron cloud dipole states, and Fisher[10] has suggested that adenosine triphosphate hydrolysis can encode memory as geometric arrays of ^{31}phosphorous nuclear spin 1/2. Now Li *et al.*[1] suggest nuclear spin 1/2 antagonizes anesthetic potency by promoting factors supporting consciousness.

How? The Meyer-Overton correlation relates to electron cloud dipoles rather than nuclear spin states. Could xenon's nuclear spin affect its electron cloud, altering van der Waals forces and reducing anesthetic effect? Apparently not, it turns out. Li *et al.* calculated electron cloud polarizability for the xenon isotopes and found no change with nuclear spin.

Could xenon nuclear spin 1/2 promote consciousness directly? As Li *et al.* point out, spin 1/2 is optimal for entanglement, having the longest coherence time (lowest spin number). Hypothetically, if there were endogenous spin 1/2 states binding consciousness among nuclei of relevant brain proteins, whatever they may be, membrane, cytoskeletal, or both (a "quantum Wi-Fi"), addition of ^{129}Xe, or other spin 1/2 carrier, could increase entanglement, and consciousness, like adding more routers to improve Wi-Fi service.

But anesthetic action suggests consciousness also involves electron cloud dipole pairs. Such pairs have integer spin numbers and are "bosons," which disobey the Pauli exclusion principle and can condense into unitary coherent states. The relationship between (nuclear spin) fermions and (electron pair) bosons is unclear. Perhaps the rotational force of nuclear spin magnetic moments (torque) "tunes" or pumps quantum electromechanical activity in neuronal membrane and/or microtubule proteins to increase their vibrational frequency, the opposite of anesthetic dampening, and thus "promote" consciousness.

Quantum consciousness theories portray the brain as a multiscale hierarchy originating in quantum vibrational states at small, fast scales inside proteins in the neuronal membrane and/or cytoskeleton. These may amplify and resonate upward over many orders of magnitude (figs. 1 and 2). Rather than a computer, the brain may be more like an orchestra; rather than a computational output, consciousness may be more like music.

The work by Li *et al.* also suggests various drugs, or supplements with nuclear spin 1/2, may enhance quantum

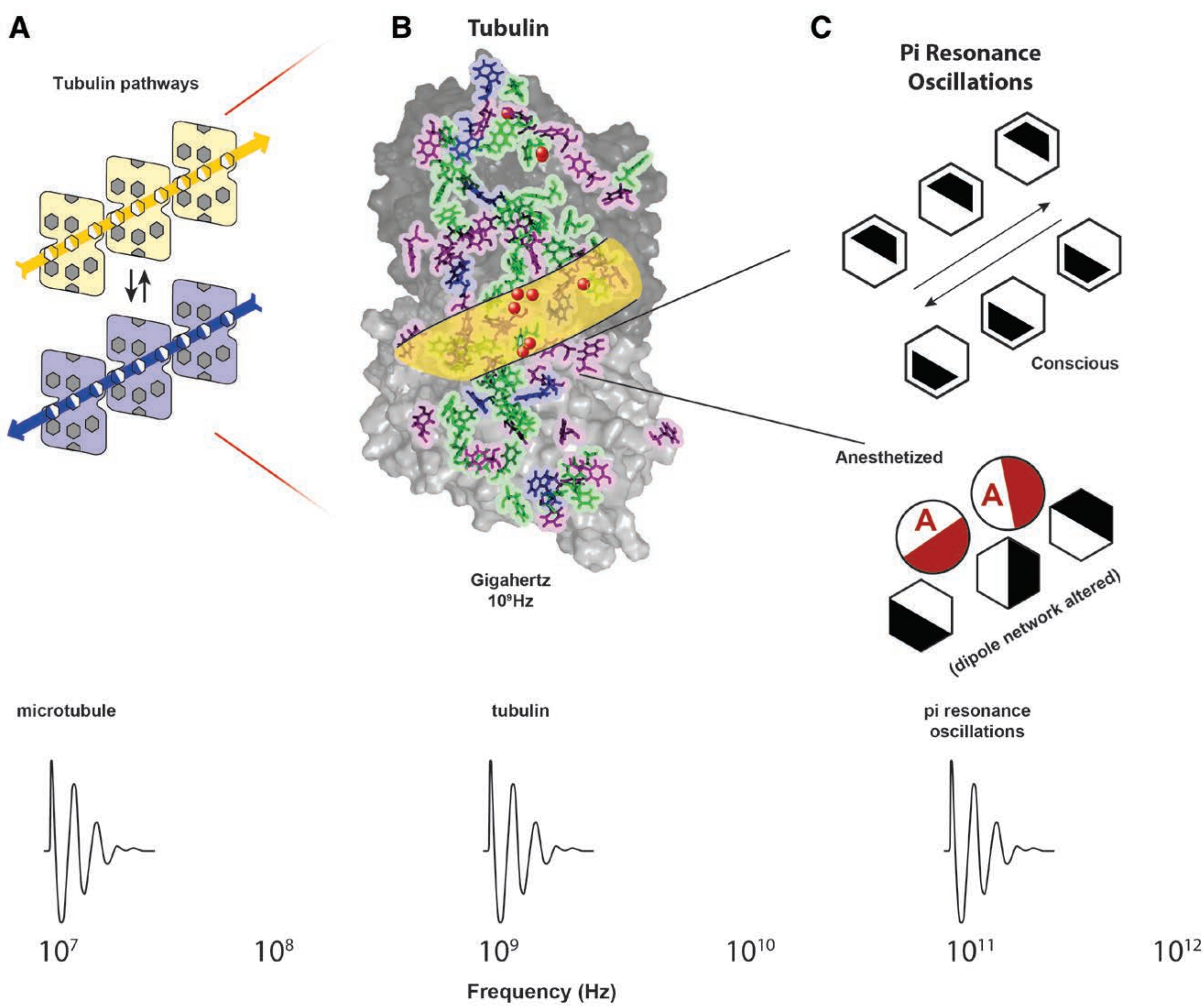

Fig. 2. Lower three levels in a six-level recursive brain hierarchy. (*A*) Schematic row of three tubulins with oscillating dipole states. (*B*) Single tubulin with its 86 π resonance rings (*red spheres* indicate anesthetic binding sites). (*C*) Schematic row of π resonance clouds with dipole states. (*Bottom*) Anesthetic dampens π resonance dipole oscillations.

brain vibrations and entanglement, possibly benefiting mental and cognitive states. The authors are to be congratulated for a significant breakthrough.

"In a spin, lovin' that spin I'm in."[11]

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Competing Interests

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