From Photosynthesis and Magnetoception to Psychopathology, Free Will and Consciousness: Advances in Quantum Biology and Questions for the Future

Guest Editorial
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Over the ten years that NeuroQuantology has been operating, significant strides have been made in advancing our understanding of quantum processes in the biological world, but despite these advances, many questions remain unanswered, particularly when it comes to NeuroQuantology (NeuroScience + QuantumPhysics) and the hard problem of consciousness, leaving many mysteries to be explored over the next ten years.

Ideas from the Last Decade of Quantum Biology

The last decade has produced some significant work showing how quantum effects can occur in biological systems, with advances in three areas utilizing three of the key ideas from quantum physics having been particularly prominent in the media, although often with a certain amount of controversy:

1. Superposition in Photosynthesis

The superposition of a particle, enabling it to exist in a number of different states or locations simultaneously, is an idea that has been used to study how photosynthesis operates. Photosynthesis is an exceptionally efficient process, and it seems that this efficiency is made possible by the fact that superpositioning and coherence allow photons striking light absorbing molecules such as chlorophyll to try all possible routes through to the reaction center simultaneously, before settling for the optimal path.

2. Entanglement in Magnetoreception

Quantum entanglement is one of the ideas that has been used to help explain how birds manage to navigate over extraordinary distances using the earth's magnetic fields as a guide. It has been suggested that entanglement could be occurring within molecules in the birds' eyes, creating an image of the magnetic field that the birds can align themselves with as they fly. The entanglement is created when light striking the birds' eye splits the molecule into a pair of free radicals, each of which has an intrinsic spin that can be reoriented by the magnetic field, but that remains briefly correlated with the other half of the pair as they drift apart.

3. Tunneling in Smell Perception

The idea that a particle can tunnel or pass through an energy barrier, apparently disappearing on one side and then reappearing on the other, has been applied to the problem of understanding how the sense of smell operates. Traditional theories have depended on the idea that a molecule's shape determines its interaction with the smell receptor and therefore its scent, but there are certain molecules that seem to disprove this theory. An alternative theory based on quantum physics suggests that the smell receptors do not detect the molecule's shape, but rather react to subtle energy changes experienced by electrons that disappear from one side of the receptor, tunnel through the molecule, and then reappear on the other side.

Questions in Quantum Neuroscience for the Next Ten Years

The last decade has also seen some significant advances in our understanding of the brain, from research into how quantum computation might create consciousness through coherence in microtubules, to calls for the emergence of a new field of quantum psychiatry to use our understanding of quantum effects in the brain to help tackle mental illness. The progress in this field was perhaps made most apparent by the bringing together of researchers who have been investigating different aspects of quantum neuroscience at the Quantum Paradigms of Psychopathology symposium, in March 2010. Discussions focused on the manner in which quantum effects might not just be occurring in the healthy brain, but also creating pathological symptoms, including mental illnesses such as depression and schizophrenia. Advances in understanding these processes might not just help to unravel the functioning of the brain, but also provide the greatly needed new methods for the diagnosis and treatment of these conditions that are also driving other efforts to map and understand the brain.

How well these efforts will succeed may depend on how willing we are to integrate different approaches, since mapping the neuronal pathways in the brain might not reveal much about how it functions, particularly when it comes to major questions such as the generation of consciousness and the concept of free will. If the ideas of people like Roger Penrose prove to be correct, consciousness may arise not just from the complex arrangement of neural circuits, but from quantum effects produced in the brain tissue, and free will may only be made possible by the existence of quantum phenomena. Even believers in a more traditional neural explanation of the hard problem may still hold out hope that quantum physics will help provide an explanation for consciousness, since, it may require a quantum computer to simulate biological processes at the level of complexity that is occurring in the brain to produce consciousness. NeuroQuantology (NeuroScience + QuantumPhysics) could prove to be the key to some of the biggest science projects of the next decade.

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