A re the mind and the brain different? Yes they are, even in the most elementary biological sense. A newborn child’s brain is ignorant of Roger Penrose’s three worlds: platonic, physical, and mental, and their three mysterious interconnections. A regular healthy brain develops throughout life to acquire language, perception, intelligence, emotion, aesthetics, creativity, inspiration, art, and so on. Evolution has wonderfully sculpted the human brain, the most advanced material structure on earth. The convoluted multilayered cerebral cortex in humans has markedly increased the human brain area and its specialized neurons. This cerebral cortex is designed for learning. But each brain, like a fingerprint, is different. The brain is malleable because learning acts like a tiny hammer on it.

Individual brains develop by innumerable feedbacks. These feedback loops come from the body through neural, chemical, and endocrinial networks to the hypothalamus-pituitary-endocrine axis. Feedbacks also come from upbringing, education, culture, environment, and so on. The whole process is very complex, but the end result is what we call the mind. Though the mind is not directly visible, it is assumed in theories of the mind that through introspection we can access some part of it. Philosophy of the mind is a growing discipline that does not have a distinct area of study but combines many diverse theories that emphasize empirical results.

As expected, such nascent fields produce many controversies. The two main fields in conflict are neurobiology and quantum mechanics, with specialists in multiple fields lining up on either sides. Neurobiological research is making rapid progress with new methodologies and state-of-the-art technology. It investigates and identifies different centres in the brain as well as their functioning through specific neural networks. Neurobiologists think that conscious brain activities can be explained by classical physics, chemistry, and the theory of relativity; without recourse to quantum mechanics. The massive research on consciousness has been done mainly with visual awareness. It is not possible to summarize all research and sit in judgement. But two papers, which show the rapid progress in this field, have been mainly considered, one by Francis Crick and Christoff Koch and the other by Christoff Koch and Klaus Hepp.

There is, however, no dispute between these two disciplines regarding the micro-anatomic structures and constituents, neurons, of the mammalian brain, nor about its macro-anatomic structure.

**Micro Structures in the Brain**

The brain, which weighs about three pounds, is composed of about 100 billion neurons. In addition there are glial cells that outnumber neurons. Each neuron consists of afferent connections or dendrites, and an efferent connection, or axon, which ends in a synaptic junction. There are also lateral connections between neurons. Each neuron may be connected to about 10,000 other neurons. The number of synaptic connections runs to hundreds of trillions!

There are also even smaller structures called microtubules, which are tubular structures enclosed by a membrane found within animal and plant cells. Of varying lengths, they have several functions. They help give shape...
to many cells and are major components of cilia and flagella, participate in the formation of the spindle during cell division—mitosis—and assist the movement of vesicles from the cell bodies of nerve cells towards the ends of those cells’ long extensions—axons—and back to the cell bodies.

Now, how are these microtubules connected with consciousness? There are two pieces of circumstantial evidences. First, similar microtubules are present in unicellular eukaryotic or nucleated animals, like the amoeba and paramecium, as sensory organs to guide them towards food, away from danger, and used in propulsion. The second is the physiology of anaesthesia, where the anaesthetic agents, in humans or animals, are quite diverse in their chemical compositions, but attain the same objective. So the process is not chemical in nature but physical. The movement of electrons between the brain and the environment has been observed during induction and recovery from anaesthesia.

Direct evidence is through valid theoretical constructs of quantum-coherent phenomena in biological systems. So long as the energy of metabolic drive is large enough, and the dielectric properties of the materials concerned are sufficiently extreme, then there is the possibility of large-scale quantum coherence similar to that which occurs in the phenomena of superconductivity and superfluidity—sometimes referred to as Bose-Einstein condensation—even at the relatively high temperatures that are present in biological systems. ... With a Bose-Einstein condensate, it is as though the entire system containing a large number of particles behave as a whole very much as the quantum state of a single particle would, except that everything is scaled up appropriately.4

Without going any further, this construct would make one think that the process would involve bosons in Bose-Einstein condensate in a similar way as in superconductivity, which is present in the cosmos, though it is not spelt out specifically. Nature seems to prefer her accustomed tools and systems in diverse ways.

To a neurobiologist this is precisely the objection against quantum mechanics, because firstly, they think there is no possibility for such largescale quantum coherence or entanglement in a hot 300 degrees Kelvin wet brain. Secondly, how would this quantum process influence the perfectly classical function of firing or non-firing of one or a group of neurons that can be beautifully explained through classical physics in neurobiological research? The quantum scientists think that it is possible with microtubules, as they can switch to at least two different states, or conformations, and different messages can be sent through them.

According to Dr Stuart Hameroff, well-known for his studies on consciousness, the microtubules may behave like cellular automatons and complicated signals could be sent along them. Being tubes, there is a plausible possibility they might isolate what is going on in their interiors from the random activity in the environment, especially if the vicinal water wraps their exterior as in their interior. They would of course concede the knowledge deficit of contemporary physics at the quantum-classical interface in the biological systems. There would be a similar problem elsewhere in physics, until further development, of what is today called the new physics.

Neurobiological research on consciousness has been done by studies on visual perceptual phenomena in higher mammals, like macaque monkey, and in human brain injuries or comatose conditions as well as on normal brains in recent years. In monkey experiments and human examinations the basic phenomenon is the same. But a feature that distinguishes humans from most animals is that we are not born with an extensive repertoire of behavioural programs that would enable us to survive on our own—‘physiological prematurity’. A calf can stand as soon as it is born, but a human baby takes one year. To compensate for this we have an unmatched ability to learn, that is, to consciously acquire such programs by imitation or exploration. Once consciously acquired and sufficiently exercised, these programs can become automated to the extent that their execution happens beyond the realms of our awareness. To give two examples, the incredible fine motor skills exerted in playing Beethoven or the
sensorimotor coordination required to ride a motorcycle along a curved mountain road. Such complex behaviours are possible only because a sufficient number of the subprograms involved can be executed with minimal or even suspended conscious control. In fact, the conscious system may actually interfere somewhat with these automated programs.

From an evolutionary standpoint it makes sense to have both automated behavioural programs, which can be executed rapidly in a stereotyped and automated manner, and a slightly slower system that allows time for thinking and planning more complex behaviour. This latter aspect may be one of the principal functions of consciousness.

**Higher Brain Function**

The basic cognitive functions of the brain and modulation of those functions have been discussed so far. But beyond that a great area of consciousness, seen only in humans, has not yet been touched.

A science of consciousness must explain the exact relationship between subjective mental states and brain states, as well as the nature of the relationship between the conscious mind and the electro-chemical interactions in the body. Progress in neurophysiology has come by focusing on the body rather than the mind. In this context the neuronal correlates of consciousness (NCC) may be viewed as its causes, and consciousness may be thought of as a state-dependent property of some undefined complex, adaptive, and highly interconnected biological system.

Discovering and characterizing neural correlates does not offer a theory of consciousness that can explain how particular systems experience anything at all, or how they are associated with consciousness, the so-called hard problem of consciousness, but understanding the NCC may be a step towards such a theory. Most neurobiologists assume that the variables giving rise to consciousness are to be found at the neuronal level, governed by classical physics, but others have proposed theories based on quantum mechanics. However, Koch and Hepp at the end of their paper have concluded: 'Although we have, hopefully, convinced our physics colleagues that classical physics is superior framework for explaining HBF [higher brain function], we hurry to stress that on molecular and membrane level there are beautiful biophysical problems where the border between quantum and classical physics has to be drawn.' In common sense judgement integration seems to be desirable.

Foremost among the quantum physicists in this field today is Sir Roger Penrose. As a mathematical physicist he sees the world as a structure precisely governed according to timeless mathematical laws whose concepts are essential to describe the physical world. He also writes that this mathematics is not arrived at just by calculations but that something mysterious is profoundly involved in it, something like the higher mental awareness of the platonic world—though he concedes that there is far more to higher consciousness than the perception of mathematics.

**Mind and Consciousness**

Penrose is not the first mathematician to be aware of the inexplicable role that the mind plays in what may be called mathematical intuition. Henri Poincaré, a late nineteenth-century French mathematician, wrote a book named *Foundations of Science*. In it he described how solutions to mathematical problems suddenly came to him when he was not thinking about them. Once he was on a geological expedition and a solution occurred to him while looking intently at a rock face. Another time he solved a problem when he had taken coffee at night and was tossing in bed. He described this as the subliminal self, from where hidden ideas float up to the conscious mind.

The mind is as much an attribute of the body as the brain, and it is multilayered—its highest levels are beyond ordinary consciousness. In the physical level the body stores probably as much memory as the brain. That is only to be expected because the body cells have the same basic structure of the nucleus and most of them have the centrosome—the former containing the genetic material and the latter guiding cell function. In addition there are nerve cells scattered in the body and not all of them are directly connected to the neural network. Modern science has brought us material knowledge and altered our lives to an unimaginable degree. But it has cut our world into small pieces. Only now the need for an inclusive view is becoming apparent, from sociology to economics, to environment and mind. Nature seems to create this world with only a few sticks and balls, and we are only beginning to understand that.

Abner Shimony, Professor Emeritus of philosophy and physics at Boston University, responded to Penrose’s seminar on mind and consciousness. Such professorial chairs, which were unthinkable only a few decades back, are coming into existence in some universities. I remember having read Werner Heisenberg’s *Physics and Philosophy* as a just-passed undergraduate in the sixties and was mesmerized. I think this trend is an invaluable contribution of quantum physics in addition to everything it has brought, especially its influencing minds in many spheres.
Prof. Shimony quotes from Whitehead: ‘The functionings of inorganic matter remain intact amid the functionings of living matter. It seems that, in bodies that are obviously living, a coordination has been achieved that raises into prominence some functions inherent in the ultimate occasions.’ He criticizes Penrose by saying: ‘What is missing in Roger’s theory of mind is the idea of mentality to be “ontologically fundamental in the Universe.”’ And he continues: ‘The modernized Whiteheadianism … incorporates the concept of potentiality and entanglement in essential ways. Potentiality is the instrument whereby the embarrassing bifurcation between dim prot mentality and high-level consciousness can be bridged’ (151). ‘Finally, it is worth remarking that from a Whiteheadian point of view the hypothesis that the actualization of potentialities is achieved by the psyche of the perceiver is not as ridiculous, anthropocentric, mystical and unscientific as it is commonly regarded to be’ (159). Not many scientists agree to such a construct, and Stephen Hawking is one of them, raising objections like quantum gravity causing objective reduction of wave function, or that consciousness is not measurable from outside. Penrose’s response was of possibilities of experimental work in this field and the exciting nature of the problem of consciousness. An association with psychology is a possible approach.

Penrose’s response to Professor Shimony was: ‘First, let me say I very much appreciate Abner’s comments, which I think are extremely helpful. However, he suggests that by concentrating on the computability issue, I may be attempting to climb the wrong mountain! If, by this, he is pointing out that there are many important manifestations of mentality, other than non-computability, then I fully agree with him’ (173). According to Shimony, prot mentality is pervasive throughout nature, but high-level mentality is contingent upon the evolution of special hospitable complexes of occasions. With macromolecules—tubulin dimer—quantum superposition may have a short lifespan, with breaking and non-breaking of coherence to account for a definite conscious state. The mechanism is conjectural but exciting, if it is in quantum level and pervasive through nature with manifestation of ‘coherence’, ‘decoherence’ or ‘superselection’ and actualization of potential. In that case the root could be at the basic level of creation. Would it be through quantum gravity? Is something else involved—a force, a mental field, a virtual particle like the menton?

Looking Back

From antiquity to contemporary times the development of our knowledge of the universe and of consciousness has been a fascinating journey that raises many questions and ideas.

The Brihadaranyaka Upanishad records a beautiful dialogue between Maitreyi and Yajnavalkya. This great sage decided to renounce the world and went to his wife Maitreyi to take leave of her. He asked her what she wanted, and she requested immortality—in this context immortality does not mean avoiding death but going beyond death. Yajnavalkya then taught Maitreyi: ‘As a lump of salt dropped into water dissolves in it and no one is able to pick the salt up, and from wherever one drinks the water, it tastes salty; in the same way, my dear, this great, endless, infinite Reality is but pure Intelligence. (The self ) comes out (as a separate entity) from these elements, and (this separateness) is destroyed with them [in their contact]. After attaining (this oneness) it (the self ) has no more [individual] consciousness. This is what I say, my dear.’ Yajnavalkya further says:

Because when there is a duality, as it were, then one smells something, one sees something, one hear something, one speaks something, one thinks something, one knows something. (But) when for the knower of Brahman everything has become the Self, then what should he smell and through what, what should he see and through what, what should he hear and through what, what should he speak and through
what, what should he think and through what, what should he know and through what? Through what should one know That owing to which all this is known—through what, O Maitreyi, should one know the Knower? (2.4.14).

This last question—‘through what, O Maitreyi, should one know the Knower’—has been posed many times by Swami Vivekananda in his lectures on Vedanta. These two verses settle that Brahman cannot be realized through the sense organs and the mind but only by stilling the sense organs and the mind so that pure Consciousness can be experienced.

Vedanta teaches that individual minds are tiny whirlpools in the immense ocean of the cosmic mind. In August 1890 Swami Vivekananda, as a wandering monk, sat in deep meditation under a peepul tree beside the Kosi River at a place called Kakrighat, near Almora. ‘Later, returning to normal consciousness, he said to Akhandananda: “Oh, Gangadhar! I have just passed through one of the greatest moments of my life. Here under this peepul tree one of the greatest problems of my life has been solved. I have found the oneness of the macrocosm with the microcosm. In this microcosm of the body everything that is there [in the macrocosm], exists. I have seen the whole universe within an atom.”’ 9

Though the idea of an all-inclusive conscious creation has always been present in human consciousness, we are now living in a glorious age when science, philosophy, and spirituality are converging to that idea. This convergence will deeply influence humanity in a not so distant future, beyond present-day turmoil.

References

1. See Roger Penrose, The Large, the Small and the Human Mind (Cambridge: Cambridge University), (1999), 97.
7. The Large, the Small and the Human Mind, 175–6.
8. Bṛhadāraṇyaka Upaniṣad, 2.4.12.