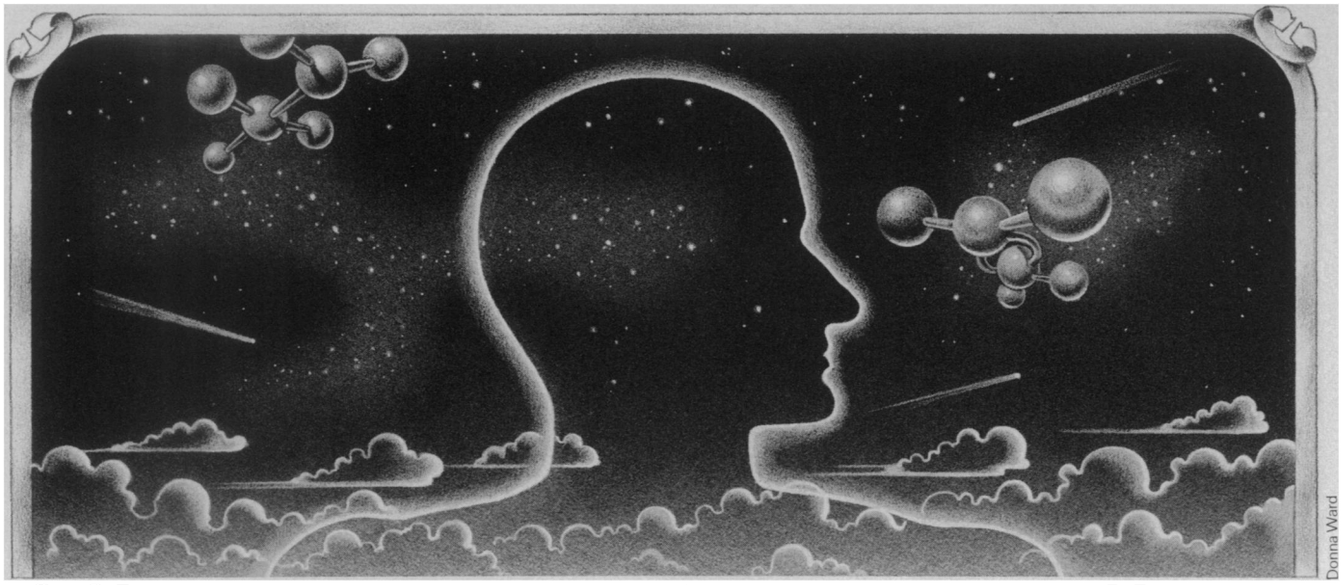

A Knowing Universe Seeking to be Known

"There are two major problems rooted in science but unassimilable as science, consciousness and cosmology." With that statement George Wald of Harvard University, winner of the 1967 Nobel Prize for Physiology or Medicine, began to tell his audience at the recent Orbis Scientiae meeting in Miami that we live in a very special universe indeed. It is a historical universe, he says: "Stars, galaxies are born, mature, grow and die." And it is permeated with life.

Yet life as we know it would become impossible here or anywhere if any one of a considerable number of natural properties was changed. For instance, protons are 1,080 times as heavy as electrons. This means that the location of the nucleus is the location of the atom, and so chemistry and physics of solids are possible. More equality between electron and proton, and that would not be so.

Another instance: of 92 chemical elements, 99 percent of living organisms is made of four of them, hydrogen, carbon, nitrogen and oxygen. Why? Because only carbon, nitrogen and oxygen can readily form multiple bonds and so make the long chains and complex rings that characterize organic compounds. "If you want to make rocks, silicon will do, but if you want to make life, it has to be carbon," Wald notes.

And again: Water ice floats. It is one of the very few solids that floats in its own liquid. Ammonia ice does not float in liquid ammonia. Only in rivers of water can life survive the winter, a crucial circumstance for evolution.

There are more physical examples of this kind. As Wald points out, their significance has been discussed by prominent physicists, primarily those he calls the "Princeton school," John Wheeler, Eugene Wigner and Robert F. Dicke, who were all together in the Princeton physics department for a long time.

Such occurrences require that some very precise information be fed into the evolution of the universe. "How did the universe find that out?" Wald asks, and the question leads him to consider consciousness.

Wald says his most recent piece of experimental work, which involved the visual systems of frogs, led him to contemplate the question: "I know that *I* see. Does a frog see?" A frog's visual system responds to light stimuli, but so does an electronically operated garage door. "Dogs, men and cattle see. As to a frog," Wald says, "I'm bewildered." And he cites even lower organisms, sea worms and scallops, that have organs like eyes but no response to light. "Seeing" is related to self-consciousness. Consciousness seems to be characteristic of higher organisms, and a particular self-awareness connected with the ability to plan future actions on the basis of past experience of human beings.

He concedes that nothing one can do as a scientist identifies the presence or absence of consciousness — does a computer feel elation when it wins at chess? Consciousness lies outside the parameters of space and time. Indeed, Wald cites at length the work of the late Wilder Penfield, a famous neurosurgeon of Montreal, who tried to find a physiological locus for consciousness — and failed.

These qualities of consciousness make biologists uncomfortable, Wald says, and they tend to dismiss consciousness as some kind of epiphenomenon. Wald disagrees.

Believing in the importance of consciousness, he now tries to put consciousness and cosmology together. Perhaps consciousness, rather than being a late evolutionary development, was there all the time. Consciousness formed the material universe and brought out life and overt forms of consciousness. "The universe wants to be known," Wald says. "Did the universe come about to play its role to empty benches?"

Wald suggests that matter and mind are a complementarity in the sense of Niels Bohr's theory — that is, two contradictory sides of the same reality. The original Bohrean complementarity was physical, the union of such opposites as wave and particle in the nature of an elementary piece of matter, an electron or a proton, say.

Objections will be raised by those who want to insist that the material universe is all the reality there is. Materialism of this kind is a doctrine that anyone may choose as a working hypothesis or as a religion, but I am unaware of a proof of it. On the contrary, the scientific method, which was designed on a basis of materialism in a deliberate attempt to exclude nonmaterial considerations, has led to other prominent scientists, from Newton and Galileo on down, to conclude that there were problems "rooted in science but unassimilable as science."

If such questions arose in the days of absolute, classical science, how much more likely are they today when reality is no longer something separate from us to be contemplated externally, but an experience in which the observer is always necessarily involved. In physics of yore the experimenter could stand apart from the system under observation. Today every measurement disturbs the thing that is measured. Wheeler has been particularly eloquent on this theme. Perhaps what is needed is a kind of Bohrean complementarity of method, in which all of the methods that humanity has historically used to approach reality — scientific, philosophical, theological, esthetic, even mystical — are used together in all of their vigor. Such a procedure would require minds willing to tolerate, or even enjoy, paradox, contradiction and antinomy, but such minds are already required by the Bohrean complementarity of contemporary physics. *Contraria sunt complementaria* was Bohr's motto. He intended to tell us something about reality. —*Dietrick E. Thomsen*