sults. But Green and Wikler argue that the lower brain is just "one among many organs, and, like other organs, could conceivably be replaced by an artificial aid which performed its function."

Most "moralist" philosophers who support a brain-death definition do so on a different basis. Human beings, they contend, distinguish the dead from the living not only by analyzing vital signs but by reassessing their obligations toward them. Upper-brain "death"—when a person "has no capacity for happiness, has no interests"—justifies such a reassessment. The flaw in this argument, note Green and Wikler, is that it maintains "not that the brain dead are dead, but that [they] need not be cared for."

By contrast, the authors advance a brain-death argument derived from ontology, the philosophy of "being." The key criterion of human life, they say, is identity, defined as the capacity for mental activity. When that capacity is lost, personhood is lost as well, and the individual ceases to be. This new argument does not end the moral debate between brain-death and heart-lung-death adherents, the authors admit. The body can still function after the upper brain has died. But clearly, they contend, when the body is stripped of the psychological traits comprising identity, "the person who entered the hospital has literally ceased to exist."

SCIENCE & TECHNOLOGY

Man's Purple Ancestors

"Cytochrome c and the Evolution of Energy Metabolism" by Richard E. Dickerson, in *Scientific American* (Mar. 1980), 415 Madison Ave., New York, N.Y. 10017.

The faintness of the fossil traces left by 3-billion-year-old bacteria (the oldest known forms of life) long hampered the study of early metabolic evolution. But new processes such as x-ray crystallography now make it possible for scientists to examine an important chapter of this story—the development of respiration—by analyzing the building blocks of modern bacteria.

According to Dickerson, a chemist at the California Institute of Technology, learning the genetic make-up of a protein family called "Cytochrome c" opened the door.

All known life forms obtain and consume energy through fermentation (the chemical breakdown of high energy molecules), photosynthesis (the trapping of solar energy to make high-energy compounds), or respiration (the extraction of energy from molecules by combining them with free oxygen).

Different forms of Cytochrome c play a key role in the last two processes. They serve as shuttles that channel free electrons from broken down or oxidized high-energy compounds into storable forms. Certain species of bacteria that photosynthesize and/or respire possess their own forms of Cytochrome c.

Comparing the distinctive genetic structures of these proteins strongly suggests that their differences have resulted from the same kinds of mutations that spurred evolution in higher life forms. From this, scientists reason that the processes of photosynthesis and respiration have a common origin.

All three processes evolved in response to changes in ancient Earth's environment. The common ancestors were the fermenting bacteria, capable of directly breaking down the high-energy compounds present in the primeval soils and seas they inhabited. They were followed by the first photosynthesizers—the earliest ancestors of modern plants. For hundreds of millions of years these proto-plants released enough oxygen to transform Earth's atmosphere. Some bacteria "learned" how to both photosynthesize and respire.

But some microbes known as purple bacteria only developed respiratory systems. In a low-oxygen environment they might have died out. Atmospheric changes eventually made the dual system redundant. The respirers thrived and probably evolved into mitochondria—the respiratory centers of modern cells. If so, writes Dickerson, a sobering thought occurs: "Human beings are [ultimately] the metabolic offspring of defective purple photosynthetic bacteria."

Early Views of Life in Space

"The Origins of the Extraterrestrial Life Debate and its Relation to the Scientific Revolution" by Steven J. Dick, in *Journal of the History of Ideas* (Jan.–Mar. 1980), Humanities Bldg., Temple University, Philadelphia, Pa. 19122.

The roots of modern speculation about life on other worlds go back to the revolutionary theory of Nicolaus Copernicus (1473–1543) that the Earth moves around the sun. If Earth was not the center of the universe, scientists and philosophers mused, then this planet—and the life it supports—were not necessarily unique.

As early as the 17th century, Copernican ideas locked astronomers and churchmen in battle over the possibility that "we are not alone," writes Dick, an astronomer at the U.S. Naval Observatory. Indeed, Johannes Kepler (1571–1630), imperial mathematician to the Holy Roman Empire, believed Copernican theory positively implied the existence of other inhabited planets. Dutch philosopher Christiaan Huygens (1629–95) agreed, arguing that it was "not improbable that the rest of the planets have their inhabitants too."

Armed with a faith in direct observation, these Copernicans trained their crude telescopes on Earth's neighbors. But observation turned up contradictory evidence. English astronomer John Wilkins (1614–72)