BEYOND ASTRONOMY

by Eric J. Chaisson and George B. Field

> You see then, studious reader, how the subtle mind of Galileo, in my opinion the first philosopher of the day, uses this telescope of ours like a sort of ladder, scales the furthest and loftiest walls of the visible world, surveys all things with his own eyes, and, from the position he has gained, darts the glances of his most acute intellect upon these petty abodes of ours—the planetary spheres I mean,—and compares with keenest reasoning the distant with the near, the lofty with the deep.
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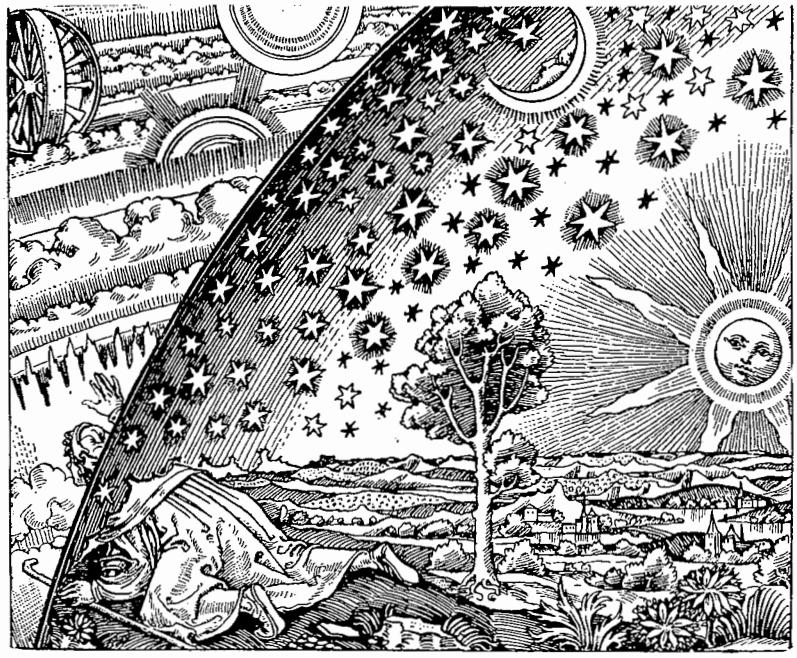
> *From* Dioptrics *by Johannes Kepler, Augsburg, 1611.*

Nature offers no greater splendor than the starry sky on a clear, dark night. Silent, timeless, jeweled with the constellations of ancient myth and legend, the night sky has inspired wonder throughout the ages—a wonder that leads our imaginations far from the confines of Earth and the pace of present day, out into boundless space and cosmic time itself.

Astronomy, born in response to that wonder, is sustained by two of the most fundamental traits of human nature: the need to explore and the need to understand. Through the interplay of curiosity, discovery, and analysis—the keys to exploration and understanding—answers to questions about the universe have been sought since the earliest times, for astronomy is the oldest of the sciences. Yet, not since its beginnings has astronomy been more vigorous or exciting than it is today.

Indeed, we are at the dawn of a new age in space science. Astronomy no longer evokes visions of plodding intellectuals peering through long telescope tubes. Nor does the cosmos any longer refer to that seemingly inactive, immutable regime captured visually by occasionally gazing at the nighttime sky. Modern astrophysics now deciphers a more vibrant, evolving universe—one in which stars emerge and perish like living things, galaxies spew forth vast quantities of energy, and life itself is understood as a natural consequence of the evolution of matter. Yet, amid the cosmic symphony of visible and invisible matter strewn across the universe, we humans seemingly play no special role. The rock called Earth is merely a platform on which to develop new technologies and sciences, all of which tend to reinforce the magnificent mediocrity of human life in the universe.

New discoveries always not only advance knowledge, but also raise new questions. Astrophysicists will encounter many new prob-



Man attempts to peer beyond the confines of Earth's skies—a classic theme here depicted by artist Camille Flammarion in a 19th-century woodcut.

lems in the decades ahead, but this should neither dismay nor frustrate us, for this is precisely how science operates. Each discovery adds to our storehouse of information, generating a host of questions that lead in turn to more discoveries, and so on, resulting in a rich acceleration of basic knowledge.

Through modern astronomical research, we now realize that we are connected to distant space and time not only by our imaginations but also through a common cosmic heritage: Most of the chemical elements comprising our bodies were created billions of years ago in the hot interiors of remote and long-vanished stars. Their hydrogen and helium fuel finally spent, these giant stars met death in cataclysmic supernova explosions, scattering afar the atoms of heavy elements synthesized deep within their cores. Eventually this matter collected into clouds of gas in interstellar space; these, in turn, slowly collapsed to give birth to a new generation of stars. In this way, the Sun and its complement of planets were formed nearly five billion years ago. Drawing upon the matter gathered from the debris of its stellar ancestors, the planet Earth provided the conditions that ultimately gave rise to life. Thus, like every object in our solar system,

EXTRATERRESTRIAL LIFE?

In 1894, Boston astronomer Percival Lowell titillated America with his "proof" that life exists on Mars. Telescope images of channels on Mars's surface, he argued, were evidence of a Martian civilization.

There is no life on Mars. But there might be life elsewhere.

Though often regarded as the province of dreamers (or Hollywood producers), the Search for Extraterrestrial Intelligence (SETI) is a serious scientific enterprise. In 1982, Congress authorized the National Aeronautics and Space Administration (NASA) to spend $1.5 million on SETI—a big turnaround, since Congress had previously scuttled SETI.

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Why the reversal? One factor was *Astronomy and Astrophysics for the 1980s*, a report issued in April 1982 by the National Academy of Sciences recommending a SETI program. Then, in August 1982, the International Astronomical Union created a SETI commission. In addition, 68 scientists from 12 nations published a SETI Manifesto, calling for "a coordinated, worldwide, and systematic search for extraterrestrial life." As a result, for fiscal 1987, NASA will spend roughly $2.2 million on SETI.

Proponents of SETI argue that, since life *did* evolve on Earth, it probably has done so elsewhere. The best estimates indicate that roughly 10 million stars in the visible universe have planets that potentially could support life.

To find out if anyone is out there, in 1959 astronomers Giuseppe Cocconi and Philip Morrison proposed listening for extraterrestrial radio signals. Then, in 1960, Cornell astronomer Frank Drake first eavesdropped on two nearby stars, Tau Ceti and Epsilon Eridani—but to no avail. By 1973, Ohio State University had begun round-the-clock monitoring of extraterrestrial radio signals, on 50 channels. Today, the Harvard-Smithsonian Project Meta uses an 84-foot radio telescope at Massachusetts's Oak Ridge Observatory to scan eight million radio channels. And, at the University of California, Berkeley, astronomers are searching 128,000 radio channels "piggybacked" from other experiments at the National Radio Astronomy Observatory in West Virginia.

On the SETI drawing board: NASA's "multi-channel spectrum analyzer." If built, it will monitor 10 million radio channels as part of the Microwave Observing Project. The total cost: $70 million over 10 years.

A few astronomers are even sending out messages to distant galaxies. In 1974, astronomers at Arecibo, Puerto Rico, transmitted signals to the Great Cluster of Hercules, 21,000 light years away. (A reply is expected in 42,000 years.) Even the Pioneer 10 and 11 and Voyager I and II space probes, launched during the 1970s, carried "greeting" plaques, solar system maps, and video disks. But such "shots in the dark" are not popular. Why? Most astronomers, says Berkeley's Stuart Bowyer, prefer projects that "bear fruit during their lifetimes."

each living creature on Earth embodies atoms from distant realms of our galaxy and from a past far more remote than the beginnings of human evolution.

Although ours is the only planetary system we know for sure, others may surround many of the hundreds of billions of stars in our galaxy. Elsewhere in the universe, beings with an intelligence surpassing our own may also at this moment gaze in wonder at the nighttime sky, impelled by even more powerful imaginations. If such beings exist—possibly even communicating across the vast expanses of interstellar space—they, too, must share our cosmic heritage.

Emerging largely from our studies of the invisible universe, this recognition of our cosmic heritage is a relatively recent achievement in astronomy. However, it is but one of many such insights that our generation alone has been privileged to attain. Indeed, our descendants will likely regard our generation as the one that broached the electromagnetic spectrum beyond visible light, thus not only providing a whole new glimpse of our richly endowed universe, but perhaps more significantly recognizing life's integral role in the cosmos.

In all of history, there have been only two periods in which our perception of the universe has been so revolutionized within a single human lifetime. The first occurred nearly four centuries ago at the time of Galileo; the second is now under way.

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