

EXPLORATION & EDUCATION

Robert A. Brown, STScI

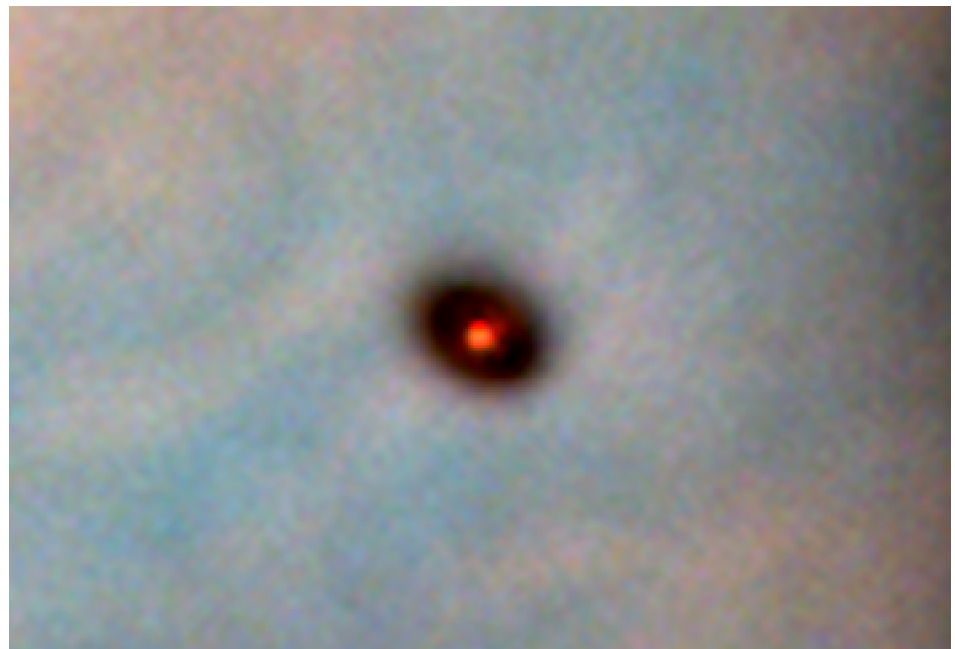
America is now debating the value and priority of federally funded exploration exemplified by Hubble Space Telescope and missions to Mars. The space program's advocates see a grand design. They call exploration a strong tonic for America's young people, an idealistic adventure that will cultivate intellectual excitement at its roots. This vision, critics say, is impractical and romantic. Advocates acknowledge the romance but assert it can have real, positive consequences. The average citizen supports the space program but usually assigns it a priority below social programs and ending deficit spending. Advocates maintain the space program *is* a social program, the purpose of which is to 'educate' America in the broadest sense of that word. Decision makers question where the money will come from. Advocates respond that space is an investment that will pay for itself in productivity gains years from now. Critics say the educational benefits of the space program could be achieved more directly at lower cost. And so the debate continues.

Advocates call for exploration while making assertions about our national personality, which, like that of any individual, colors our entire existence. Consequently, it is awkward to assess and accommodate exploration as public policy, especially at a time when the social responsibilities of the federal government are devolving to state and local authority across the board. Furthermore, the space program up to now has been designed to accomplish tasks in space, not back on the ground.

America is configured as an experiment, always in

the process of change, and our space program is part of that experimentation. New ideas about NASA's educational role are arising, due largely to the leadership of Administrator Dan Goldin. Whereas in the past, education at NASA has meant the graduate education of scientists, the training engineers, and general inspiration of all, a future NASA program proposes to engage the most widely understood scientific questions—who are we, where did we come from, and where are we going? And if this new endeavor is allowed to proceed, education based on scientific exploration will take on new meaning.

The new "origins" program will address ancient questions about the uniqueness of our world, our place in cosmic space and time, and whether life has occurred other than on Earth. What is remarkable in an educational sense about this program is that its questions will attract everyone's interest and inform *everyone's* mind, not just the most educated. The program's distinctive quality is perhaps best appreciated by reflecting on the changes Nicolaus



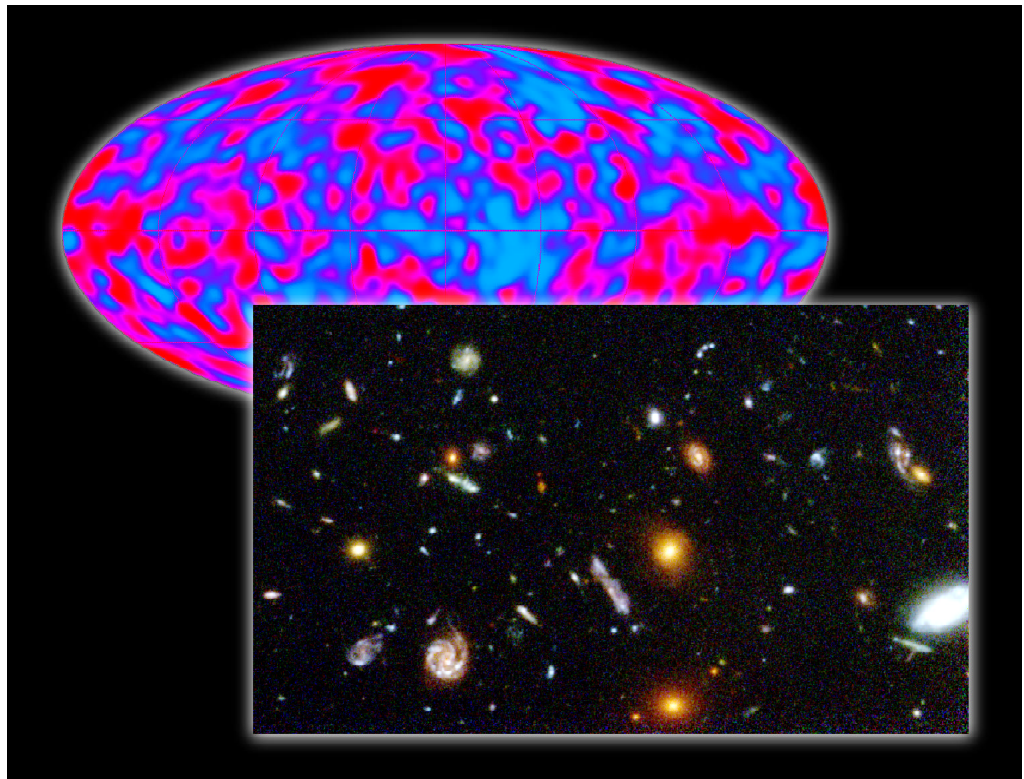
There is mounting evidence that planets may be a common occurrence around other stars. This close up of the Orion Nebula observed with the Hubble Space Telescope shows a young star surrounded by clouds of gas and dust where planets may be forming at the current time. The disk appears dark, in silhouette against the bright nebula. (Credit: C.R. O'Dell / Rice University, and NASA)

Copernicus inspired in the human mind almost 500 years ago.

The Copernican revolution was not one but two revolutions. The first, the one with which we are most familiar, placed the Earth in its proper place in the skies, orbiting the Sun, rather than the other way around. This master-stroke engendered science as we know it, for the scientific method was developed in the process of sorting out where the planets are in three dimensional space. Important tools of science, such as the calculus, were devised to assist the inquiry.

The second Copernican revolution, however, affected vastly more people than the first, as it altered their worldview. If the Earth was just another planet, then the human experience of Earth might or might not make it different from other planets: life, even civilization, might have arisen elsewhere. This *ramification* of science has played itself out in a half millenium of robust philosophical dispute about the uniqueness of Earth and the place of the human story in the history of the universe. That dispute is culminating at the current time, as part of its origins program, for NASA is designing a telescope to discover and study other worlds orbiting nearby stars. It will be able to measure the properties of these other planets, including whether they are Earth-like and conducive to life.

An important extension of the Copernican revolutions is the question of our place in cosmic time and space. This question is now accessible to another

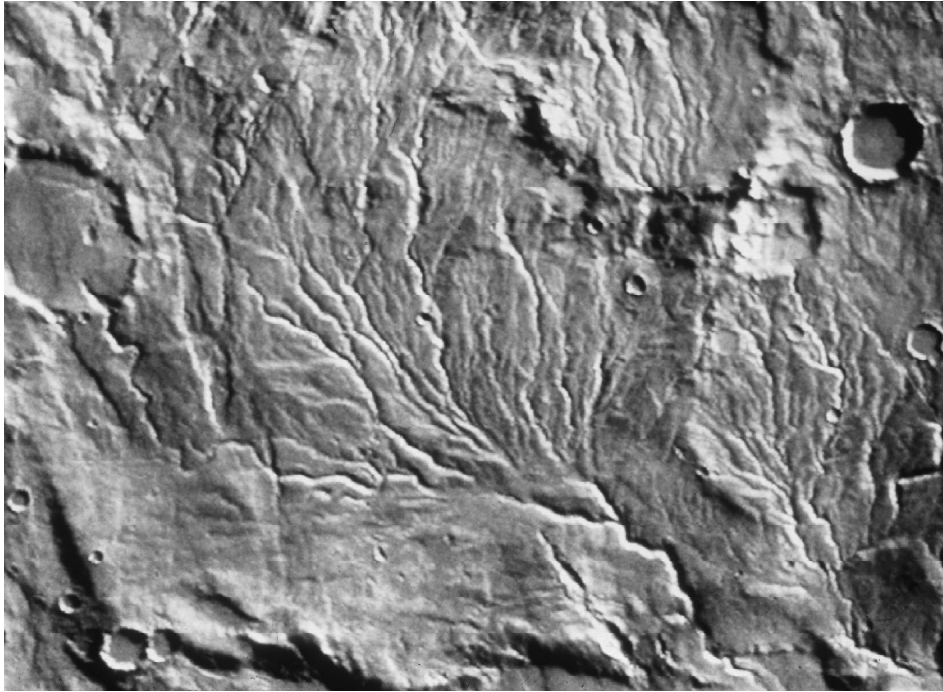


During the first few billion years after the Big Bang, the expanding universe developed gross structure that later divided into galaxies, in a series of steps that have not yet been observed. The upper panel shows the early structure at a lookback time about 99.9% the age of the universe, as seen by the Cosmic Background Explorer telescope. The lower panel shows the most remote galaxies yet observed by the Hubble Space Telescope, back to about 80-90% of the time since the Big Bang. The successor telescope to Hubble could explore the first 10% of time, when protogalaxies like our Milky Way were formed. (Credits: Robert Williams and the Hubble Deep Field Team (STScI) and NASA. DMR image courtesy of the COBE Science Working Group, and NASA.)

telescope being designed by NASA to look deep into space, back in time, to the earliest galaxies like our Milky Way. This research will enable us to follow the progression of events, starting with the first organization of matter after the Big Bang, giving rise to our galactic home.

The question of whether life arose elsewhere in the Solar System is to be addressed by missions to Mars to look for fossil life. The definitive search will probably involve human rock hounds exploring the surface of Mars. It is already widely accepted that Mars had a thicker atmosphere in an earlier era, and space probes have taken pictures of erosion by flowing water on the surface. These factors, combined with recent evidence that life appeared in the very early history of Earth, encourages the idea that life may have started on Mars only to be terminated when the environment changed to the dry and hostile conditions observed today.

As it takes on the exciting origins research program, the space exploration community recognizes how important it is to explain its motivations, goals,



Liquid water is thought to be required for life to arise in a planetary environment, and it was present on Mars at an earlier time. This Viking orbiter image shows a network of interconnecting dry river beds in a pattern of branching channels characteristic of a network that drains precipitation. This is the strongest evidence that Mars' atmosphere must once have been warmer and of higher pressure than it is now. (Credit: From Mars Digital Image Map, image processing by Brian Fessler, Lunar and Planetary Institute)

and results to the society that supports its research. The necessity of doing so is especially acute because, as we draw nearer to answering some of humanity's ancient questions, the competition for resources will be stronger than at any time in the last half century. America's space scientists are also keenly aware they bear the national mantle of exploration, which so resonates with our frontiering history.

It is not often given to scientific exploration to inform directly a culture's beliefs, and an average person's self understanding. We know about the Copernican revolutions, but there are other historical examples as well. Darwin's voyage on the Beagle, which led to the theory of evolution, is one. The Apollo missions to the Moon are perhaps another, for the magnificent pictures of the Earth as an island of life in space produced the indelible impression that our common inheritance and destiny overarches all the divisions and distinctions between the people of the world.

Admittedly, such opportunities to influence any culture's worldview or ideology must not be taken on without circumspection, and it would certainly

be inappropriate for our government to attempt the task of informing people what they should or should not believe about their origins and place in the universe in a religious sense. Nevertheless, not to inquire of nature—not to look for Earth-like planets around other stars, not to look at the formation and evolution of galaxies, and not to seek fossil life on Mars—would be a perilous and sad choice for a society such as ours that is committed to truth, objective thinking, and technological progress. Indeed, the very design of American government is a monument to the benefit of increasing and applying

new knowledge. Soon, as budget battles over NASA's funding begin, the same democratic institutions that arose from that principle will choose whether to shed new light on the origins of human experience in its most universal context—or to avoid the challenging task.

Exploration and discovery are the pure expression and due consequence of freedom. This intellectual duet has been the heartbeat of our nation since its inception. Pioneers cultivated this principle in the wilderness, where it was reinforced by the abundance of a continent. The idea sprung roots in how Americans view learning: from George Washington onward national leaders have supported the gathering and dissemination of knowledge as essential to the conduct of democracy, and to elevating the thoughts of individual citizens. Today, innovation and experimentation are ideals and icons of our free enterprise system, affecting our approach to child-rearing and education, and our arts, literature,

and national mythology. Freedom in all guises is our national personality.

For 200 years, America has reaped the benefits of this premise that freedom—liberty to explore and discover in all parts of life, nature, and thought—is superior to any other principle. Our democracy has invested public funds to open frontiers that lie beyond the grasp of individual Americans. Presidents Jefferson, Madison, and Monroe approved the building of the National Road from Maryland to the Ohio River to open up the West for pioneers. Franklin D. Roosevelt—and all succeeding Presidents and Congresses—have believed science to be a metaphorical frontier that has a significance for modern America comparable to that of the West in the eighteenth and nineteenth centuries. Most recently, our government opened space to American pioneering. Since Eisenhower, each of the Presidents and Congresses has viewed space, like science, as a frontier ideally suited to America.

Exploration and discovery—these crown jewels of America—are epitomized today in the federal space and science programs. The debate is whether to hold them to the light or risk losing their magic and power. America might choose to leave these activities to other nations because it no longer has faith in the intrinsic value of new knowledge, or because it believes itself not sufficiently clever to exploit wildernesses of the intellect. But just as it does for individuals, personality distinguishes one nation from another, and in both cases it is a key to success and prosperity. I believe America will not neglect these investments because we value what makes Americans and American ideas different. I believe we will not neglect to pass these frontier opportunities on to our children.

NASA and the community of space science explorers are making an innovative contribution to the great debate on space exploration by coming forward with a unique program to educate and inform the entire public on the deepest and most widely understood questions of our existence: the questions of our origins. In doing so, they open the floor to whole communities of educators, philosophers, theologians, artists and authors, as well as private citizens, who will voice their opinions on the value of these learning opportunities. And how to take best advantage of them.

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