Letters

Space Program and Earth-Based Astronomy

I was very interested, and somewhat puzzled, by the results of the AAAS poll on the space program. Of course, every specialist tends to think of his own field as the pinnacle of scientific endeavor. But I was very surprised to see earth-based astronomy rated below manned lunar research in every column of responses to question 4. The question is worded quite vaguely; but if we take "manned lunar research" to mean what it literally says —direct exploration of the moon by men—it is hard to see how anyone could expect this to produce more new scientific knowledge than astronomy, even ground-based astronomy. I myself would have rated astronomy and oceanography about equally, with manned lunar research far below either.

Perhaps the overwhelming number of votes for biomedical research provides a clue to this puzzle. It is evident from the "Reports" section of *Science* that most of the readership is in this field. If the majority of poll respondents are not physical scientists, they may be unaware of the power of ground-based astronomical techniques. It would be interesting to have a separate tabulation of the responses of only physical scientists.

Since the principal justification of the space program is supposed to be "scientific," I would like to compare recent scientific accomplishments of earth-based astronomy with those of the space program. I remark at the outset that the number of people and dollars devoted to the space program in this country is at least an order of magnitude greater than that devoted to astronomy in the entire world. Furthermore, most astronomers are still working with 19th-century instruments and techniques; technologically, astronomy remains a rather backward and "underdeveloped" field.

The most exciting *new* development in purely earth-based astronomy is the discovery of objects which appear to involve energies comparable to the energy that would be released by the total annihilation of a million stars the size of the sun (about a billion times the energy radiated by the sun during its entire lifetime). If we can go back a few years, I would cite the discovery that the chemical elements which make up the solar system were produced within older stars, rather than being primordial. This has also been learned entirely from ground-based observations, such as the spectroscopic detection of the element Technetium (which has no stable isotopes) in some stars. I believe this is a fundamental scientific accomplishment that the space program will be hard pressed to equal.

The most recent triumph of the space program is the success of Ranger 7, which produced some beautiful pictures of the Moon. This is certainly a dazzling technical accomplishment. But, aside from their esthetic value, one cannot say that these pictures provide great *scientific* knowledge. They may be adequate for certain statistical studies of small craters. They *may* indicate that the "dust" layer is thin, or that it is solid enough to support crater formation; in any event, we expect to learn the actual thickness of the insulating layer from ground-based infrared and microwave studies in the next few years. On the whole, the pictures show nothing very surprising.

The previous major scientific effort of the space program was the Mariner II probe to Venus. But every conclusion about the planet derived from Mariner, with the exception of the magnetic field measurement, had already been derived from ground-based astronomical observations made before Mariner reached Venus. Furthermore, ground-based observations provided the basic determination of the accurate linear scale of the solar system that was needed to get Mariner to Venus in the first place. One must not, however, underestimate the importance of Mariner as an interplanetary probe which samples the solar corona along the way.

It is clear that there are some things that can only be learned from above the atmosphere, and it is important that we have a program directed to learning them. Astronomers expect to be the chief beneficiaries of this new knowledge, for the extra-atmospheric telescope should open up new vistas in astronomy comparable to those opened up in biology by the electron microscope. But, just as the electron microscope has not made optical microscopes obsolete, space technology is not going to put earth-based astronomy out of business. The earth-bound telescope will always be more convenient, cheaper, and even better for some purposes. We should realize that many things that can be learned from above the atmosphere can also be learned, much more cheaply, by ground-based techniques.

For example, some of the most convincing evidence for life on Mars is based on a few hours of twilight observations with the 200-inch telescope. The evidence would be greatly strengthened if these observations could be repeated often enough to establish a correlation with Martian seasonal changes. But the 200-inch telescope has been available for planetary research only a few times, generally during daylight or twilight, because the scientific merits of planetary observations are not judged sufficient to compete with normal astronomical work.

Many NASA programs would be aided greatly by extended observations with such an instrument. Rocket-borne research involves many costly failures, but a duplicate 200-inch telescope could easily be built and staffed for the $28 million that Ranger 7 alone cost. However, NASA has persistently refused proposals to build ground-based telescopes, even to support its own programs.

If NASA is really interested in learning something about the solar system, rather than in providing spectacles for the public, it could do a lot more by fully exploiting earth-based astronomical techniques at the expense of, say, one major rocket launch per year. But perhaps we cannot expect a broad sense of perspective from people who call anything beyond the moon "deep space"; they could see ten trillion times farther with less myopic eyesight.

ANDREW T. YOUNG
Harvard College Observatory,
Cambridge 38, Massachusetts