

## **Why Do Astronomy? Or, What do we get for our tax money?**

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The purpose of the VLA, the VLBA and of NRAO is to do fundamental research on the nature of the universe in which we live. This research seeks to answer some of the biggest questions we can ask, such as how did the universe begin (or did it begin), how big is it, how old is it, and how will it end (or will it end)? As the science that provides the framework knowledge of where we, and the planet on which we live, fit into the environment of the universe, astronomy is a vital part of the culture of all mankind. A person deprived of the broad outlines of astronomical knowledge is as culturally handicapped as one never exposed to history, literature, music or art. As astronomers communicate new discoveries about the universe, they enrich the intellectual lives of millions.

From the dawn of civilization, astronomy has provided important stepping stones for human progress. Our calendar and system of timekeeping came from astronomy. Much of today's mathematics is the result of astronomical research. Trigonometry was invented by Hipparchus, a Greek astronomer. The adoption of logarithms was driven by the needs of astronomical calculations. The calculus, the basis of all modern science and engineering, was invented by Sir Issac Newton for astronomical calculations. Astronomy provided the navigational techniques that allowed sailors and aviators to explore our planet (and today allow spacecraft to explore our solar system). Astronomy's appetite for computational power drove the development of many of the earliest electronic computers. The space age, which brought us the communication and weather satellites upon which we depend each day, would have been impossible without the fundamental knowledge of gravity and orbits discovered by astronomers. Radio astronomers led the development of low-noise radio receivers that made possible the satellite communications industry. Image-processing techniques developed by astronomers now are part of the medical imaging systems that allow non-invasive examination of patients' internal organs. At today's observatories, the needs of astronomers for better instruments continue to drive developments in such diverse fields as electronics, mechanical engineering, and computer science.

Astronomy has much yet to contribute to human knowledge and progress. From the airplane to the transistor, from radio to lasers, the developments of the Twentieth Century were based on fundamental knowledge of the physics of matter and energy. Astronomy offers scientists from a wide range of backgrounds with a nearly infinite variety of cosmic "laboratories" for observing physical phenomena. It is unlikely that any laboratory on Earth will ever produce matter as dense as that of a neutron star, temperatures as hot as those inside a supernova, or gravity as strong as that of a black hole. Yet, astronomers can study the physics of such extreme conditions routinely with instruments such as the VLA and VLBA. Closer to home, the VLBA is a primary instrument providing valuable data on the drift of Earth's continents and the mechanisms of global climate.

What will this yield? It is the nature of basic research that we can't predict what will come of this work, except that we probably will be surprised. When Kepler and Newton labored to develop the science of orbital mechanics, they weren't thinking of weather satellites or CNN.

Finally, astronomy performs an important educational service for our nation. As an exciting, visual science easily accessible to amateur observers, astronomy stirs scientific curiosity in thousands of young people every year. These young people soon learn that astronomy involves nearly the whole range of the physical sciences, including mathematics, physics, chemistry, geology,

engineering and computer science. Many professional scientists in these and other fields first became interested in their profession through astronomy. In today's world marketplace, a competitive nation needs for its entire population, not just its scientists, to have a basic level of scientific literacy. Astronomy, by providing the excitement of new knowledge about the fascinating variety of strange objects in the universe, can help communicate much basic science to all our people.

In sum, astronomy has been a cornerstone of technological progress throughout history, has much to contribute in the future, and offers all humans a fundamental sense of our place in an unimaginably vast and exciting universe.

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