Chronicle Guidance Publications

Astronomers

Occupational Brief Title Codes:
- D.O.T.: 021.067-010
- G.O.E.: 02.01.01
- S.O.C.: 19-2011
- O*NET™: 19-2011.00
- N.A.I.C.S.: 541710
- H.O.C.: IRE

Occupational Subtitles:
- Astrophysicists

Work Classification Based Related D.O.T. Occupations:
- Geographers
- Geologists
- Geophysicists
- Mathematicians
- Meteorologists

Interests Based Related G.O.E. Occupations:
- Hydrologists
- Mineralogists
- Paleontologists
- Petrologists
- Seismologists

Skills Based Related O*NET Occupations:
- Civil Drafters
- Electrical Engineering Technicians
- Geologists
- Mechanical Engineers
- Surveyors

Noteworthy Quote:

"The study of astronomy provides the opportunity to consider an extremely diverse group of topics from the happenings in our solar system to how matter and galaxies formed on the scale of the universe itself. The rewards of being in astronomy are many and can range from working on the leading edge of instrumentation and telescope development to the discovery of new objects and providing new insights into how the universe operates."

–Professor Scott W. Teare, Astronomy Department, San Diego State University.

Astronomers (as`tron-o-mers) use the principles of physics and mathematics to learn about the fundamental nature of the universe, including the sun, moon, planets, stars, and galaxies. They also apply their knowledge to solve problems in navigation, space flight, and satellite communications. They develop the instrumentation and techniques used to observe and collect astronomical data.

Astronomy, considered by many to be a sub-field of physics, is the oldest science. The history of astronomy dates back thousands of years to when primitive people noticed objects in the sky overhead and watched the way the objects moved. In ancient Egypt, the visibility of certain stars for the first time each year marked the onset of the seasonal flood, an important event for agriculture. In 17th-century England, astronomy provided methods of keeping track of time that were especially useful for accurate navigation. Astronomy has a long tradition of practical results, such as our current understanding of the stars, day and night, the seasons, and the phases of the Moon.

Astronomy differs from most other sciences, because astronomers cannot touch, handle, or control the objects they study. There are a few exceptions such as moon rocks and meteorites. But most of the information astronomers have about the universe comes from the study and measurement of electromagnetic radiation, radio waves, infrared light, ultraviolet rays, x-rays, and gamma rays.

To measure this radiation, astronomers use electronic equipment, which is controlled by computers. Optical and infrared telescopes, radio telescopes, ultraviolet ray, x-ray, and gamma ray telescopes detect and measure the light and movement of the stars and planets much more efficiently than the human eye or photographs.

Astronomers now have more than a few spacecraft images of the major planets, their moons, and some comets and minor planets. Many of these images are available on the Internet at a number of Web sites.

Work Performed

There are many powerful telescopes throughout the world that astronomers use to observe space and the objects within it. To do this work, astronomers may travel to observatories such as the National Optical Astronomy Observatories with sites in Arizona, New Mexico, and Chile in South America. The National Radio Astronomy Observatory also has stations in West Virginia, New Mexico and Arizona. However, astronomers seldom spend more than a few weeks a year making observations with telescopes or other instruments.

Astronomers spend most of their time at workstations, analyzing data gathered by observatories and satellites. They devise theories and write scientific papers. They study new developments in their field, attend scientific meetings, and design new observational instruments.

Astronomers usually concentrate their studies on one branch of astronomy. ***Solar astronomers*** study the sun. They collect data on its radiations, its magnetic fields, and its eruptions of plasma. Some solar astronomers use special underground installations for detecting neutrinos in order to study the processes of

Printed in United States of America, December 2004
Visit our Web Site www.ChronicleGuidance.com

CGP

thermonuclear fusion that fuel the sun. With spacecraft they sample and plot solar winds, and the subatomic particles shooting outward from the sun. They use a worldwide network of observation stations to probe the interior of the sun by detecting global oscillations (sound waves) that penetrate deeply into the sun. They chart and photograph sunspots. In aircraft they follow eclipses to get a glimpse of the corona of the sun.

Astrophysicists work to understand how stars and galaxies function and change as they age. They try to analyze why stars degenerate into white dwarfs, neutron stars, and black holes. Astrophysicists develop theories about evidence pointing to phenomena not yet known or understood. They study the formation of dust and gas clouds that may eventually produce stars. They make observations about the nature and characteristics of black holes and quasars.

Cosmologists examine the properties and evolution of the observable universe, which extends to more than ten billion light years away from Earth. They develop theories such as the one that explains how, ten or fifteen billion years ago, the universe exploded from a single point. Most of these scientists are theorists, but some perform difficult observations of very distant objects, such as primordial radiation and elemental abundances.

Radio astronomers study the source and nature of celestial radio waves with very sensitive telescopes. The largest steerable radio telescopes range in size from 165 feet to 310 feet in diameter. The largest immovable radio telescope is located at the Arecibo Observatory in Puerto Rico.

About 60 percent of the astronomers teach in colleges and universities. They divide their time between teaching and research. Many teach physics or mathematics along with astronomy.

Astronomy is an international endeavor. Astronomers from around the world attend meetings and use telescopes in many countries. They also cooperate in the building of international observatories like the Gemini telescopes in Hawaii and Chile. They are a community of scientists who exchange ideas freely. Astronomers worldwide communicate through global computer networks such as the Internet.

Working Conditions

Astronomers do most of their work in offices, laboratories, or classrooms. They work with the most modern computational and information transmission technologies. Astronomers may work on an assignment with high-altitude aircraft or in a remote site such as the observatory at Cerro Tololo high in the Chilean Andes. When in an observatory, they center their work on the console near a telescope and its instruments, which are served by computers. They usually have one or more assistants, some of whom may be graduate students.

Radio astronomers and those who work with spacecraft or rocket-borne instruments may work at a console or a workstation. They may work either days or nights.

Hours and Earnings

Astronomers work at least forty hours a week, more if a project requires it. They work whatever hours the assignment dictates. When at an observatory, astronomers work at night. College teachers plan and conduct classes according to a schedule. They carry out their research and write their conclusions or theories for publication at other times.

According to the Bureau of Labor Statistics, in 2003, astronomers earned an average of $88,310 a year. Salaries ranged from a high of more than $130,740 a year to a low of less than $42,120 a year. Earnings vary depending on geographic location, employer, and years of experience. Typically, astronomers working in academic settings tend to earn less than those working for government or private industry.

Education and Training

High school students considering a career in astronomy should take as much physics, mathematics, and computer science as possible. As a minimum for mathematics, they should take algebra, geometry, and trigonometry. Chemistry, in particular, and earth science are recommended as well.

Astronomers usually have a Ph.D. degree in astronomy or physics. A bachelor's degree may qualify individuals for work as assistants, instrument operators, or data processors. Those with a master's degree may teach at a community college or a planetarium.

Students preparing for a doctorate should earn a bachelor's degree in astronomy, chemistry, or physics. The study of physics should range from classical mechanics and thermodynamics through electromagnetic theory and atomic and nuclear physics. Courses in mathematics should range from calculus and linear algebra through differential equations. Chemistry and computer programming are useful. Other undergraduate studies are astronomy, astrophysics, meteorology, and English. A good knowledge of English is essential because astronomers must be able to describe the results of their research both orally and in writing.

Entrance requirements for graduate school usually include a bachelor's degree with a major in physics, chemistry, or astronomy, a B average or higher, and satisfactory performance on the Graduate Record Examination.

Graduate work for the Ph.D. generally requires at least three years, normally five years, and often longer. In the first two years, students take mathematics, advanced astronomy, and advanced physics. Other typical graduate

courses are cosmology, celestial mechanics, galactic structure, radio astronomy, stellar atmospheres and interiors, theoretical astrophysics, interstellar medium, extragalactic objects, and binary and variable stars.

To earn a Ph.D., graduate students usually must pass written and oral examinations on astronomical and scientific knowledge. The final step is the dissertation. Students conduct research on a chosen topic and write a publishable account of the results. This dissertation serves to demonstrate their knowledge and skills in astronomy and physics. Students do their dissertation research with guidance from an advisor. Some graduate schools require that applicants for a doctorate spend several months in residence at an observatory. Most graduate schools allow the students to take the courses most applicable to their specialty or field of interest.

Licensing, Certification, Unions and Professional Societies

There are many organizations to which professional astronomers may belong. The American Astronomical Society publishes several journals and a quarterly newsletter. It also runs a job service consisting of a monthly job listing, a list of candidates' resumes, and a job center.

The Astronomical Society of the Pacific, which includes amateur and professional astronomers, works to increase public understanding and appreciation of astronomy. This organization publishes two journals on astronomy, one popular and one technical, and a catalog of educational material.

Many professional astronomers belong to the International Astronomical Union, a scientific union that admits lay individuals as members.

Personal Qualifications

Astronomers should have mathematical ability, imagination, and an inquiring mind. They should have orderly and logical thought processes in order to see the relationships among observable events, data, and theoretical models. They should be able to work independently. Astronomers must be motivated in order to complete the years of study and preparation for this work.

Occupations can be adapted for workers with disabilities. Persons should contact their school or employment counselors, their state office of vocational rehabilitation, or their state department of labor to explore fully their individual needs and requirements as well as the requirements of the occupation.

Where Employed

This is a small field. According to the Bureau of Labor Statistics, in 2003, there were about 770 astronomers at work throughout the United States. Most of these professionals work in colleges and universities, and in observatories at these schools. One in five astronomers in academia is a research associate. These are not faculty members but staff. They do not have tenure and are technically short-term employees.

Some astronomers work for nonprofit foundations. About one third of all astronomers work for the federal government in the National Aeronautics and Space Administration, the Smithsonian Astrophysical Observatory, the U.S. Naval Observatory, and the U.S. Naval Research Laboratory. A few astronomers work in museums and planetariums.

Other astronomers work for high technology companies in private industry. Some work for aerospace companies as spacecraft designers or for companies in other fields of technology, particularly computers or electronic imaging.

Employment Outlook

New astronomers will continue to face sharp competition for the few positions that will open in the future. One reason is the high cost of equipment necessary for observations. The need for replacements will be small because the number of openings created by retirements will be few. The chances for employment are best for those with a Ph.D. and a wide range of skills. The number of qualified people may continue to be greater than the number of jobs.

The demand for astronomers in universities, planetariums, and in government agencies and laboratories is low but steady. The number of jobs in industry will depend in part, on the extent of high-technology products, to which astronomers can contribute, and on whether the government gives contracts to industry. At present the government does not offer much promise of employment to these professionals. There is a distinct trend toward the downsizing of national installations and companies. The privatizing of some laboratories will create some jobs in the nonprofit sector and in industry.

Entry Methods

The method most used by astronomers is to register with their college placement office or with a professional service. Job seekers may apply to one of the government agencies that employs astronomers or request a job listing from the American Astronomical Society. Many instructors begin their career in one-year or two-year research positions, subsidized by grants from foundations or the government.

Top positions in astronomy go to those with a Ph.D. Those with a bachelor's or a master's degree may find jobs as technicians, programmers, and research assistants. Some working for a doctorate may help astronomers analyze data, interpret photographs, and do observational work. Graduates with a doctorate may find teaching or research jobs in universities, in government, and in industry.

Advancement

Since this field is small, advancement tends to be limited. A position as administrator in a large university, international or national observatory, or government agency is considered the highest post available for astronomers. A few astronomers have become astronauts and have participated in space shuttle flights.

Another form of advancement for astronomers is a fellowship or a grant to carry on a research project. Much work in this field consists of teamwork and the use of national and international equipment.

Astronomers with years of experience and proven skills may get an appointment to serve on an international research project, which may take years to complete. A few with outstanding communications skills, teaching experience, and talent may write books or appear in television documentaries.

For Further Research

American Astronomical Society, 2000 Florida Avenue, N.W., Suite 400, Washington, D.C. 20009-1231. Web site: www.aas.org

A New Universe to Explore: Careers in Astronomy. View the brochure on the Internet at: www.aas.org/education/career.html

Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 94112. Web site: www.astrosociety.org

The International Astronomical Union. Web site: www.iau.org

Acknowledgments

Chronicle Guidance Publications appreciates the cooperation of the individuals who reviewed the information in this brief.

Briefs Related to This Title

Aerospace Engineers. **Brief 159.**
Cartographers. **Brief 199.**
Geographers. **Brief 155.**
Geologists. **Brief 129.**
Geophysicists. **Brief 148.**
Hydrologists. **Brief 364.**
Mathematicians. **Brief 162.**
Mechanical Engineers. **Brief 326.**
Meteorologists. **Brief 143.**
Oceanographers. **Brief 200.**
Paleontologists. **Brief 600.**
Petrologists. **Brief 560.**
Physicists. **Brief 141.**
Surveyors. **Brief 221.**