Engineers, Life and Physical Scientists, and Related Occupations

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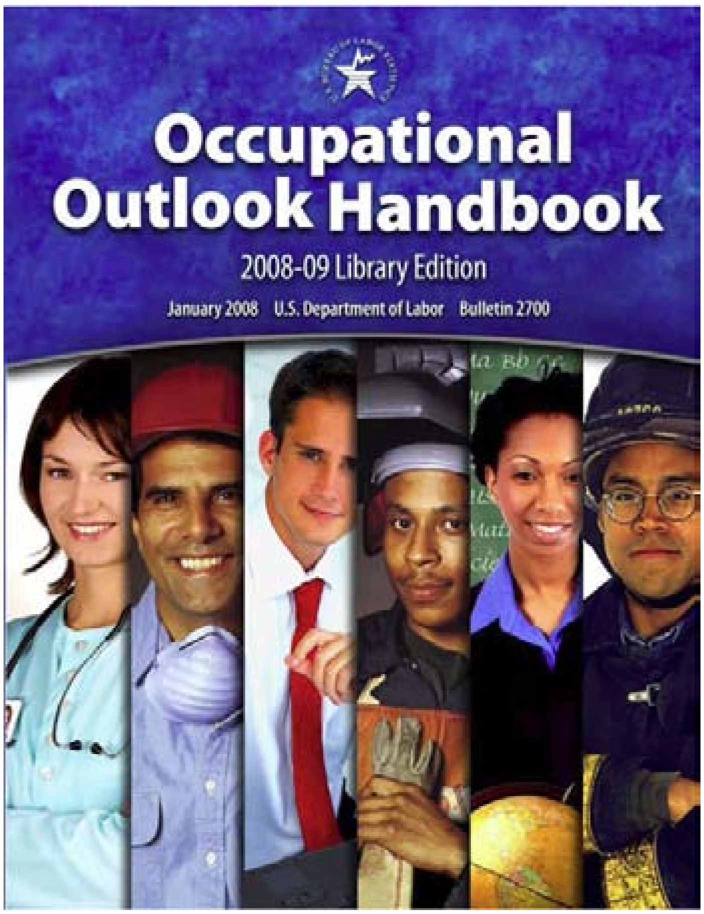

Occupations Included in this Reprint

Agricultural and food scientists
Architects, except landscape and naval
Atmospheric scientists
Biological scientists
Chemists and materials scientists
Conservation scientists and foresters
Drafters
Engineering and natural sciences managers
Engineering technicians
Engineers
Environmental scientists and hydrologists
Geoscientists
Landscape architects
Medical scientists
Physicists and astronomers
Science technicians
Surveyors, cartographers, photogrammerists, and surveying and mapping technicians

Agricultural and Food Scientists

(O*NET 19–1011.00, 19–1012.00, 19–1013.00)

Significant Points

- About 14 percent of agricultural and food scientists work for Federal, State, or local governments.
- A bachelor's degree in agricultural science is sufficient for some jobs in product development; a master's or Ph.D. degree is required for research or teaching.
- Opportunities for agricultural and food scientists are expected to be good over the next decade, particularly for those holding a master's or Ph.D. degree.

Nature of the Work

The work of agricultural and food scientists plays an important part in maintaining the Nation's food supply by ensuring agricultural productivity and food safety. Agricultural scientists study farm crops and animals and develop ways of improving their quantity and quality. They look for ways to improve crop yield with less labor, control pests and weeds more safely and effectively, and conserve soil and water. They research methods of converting raw agricultural commodities into attractive and healthy food products for consumers. Some agricultural scientists look for ways to use agricultural products for fuels.

In the past two decades, rapid advances in the study of genetics have spurred the growth of biotechnology. Some agricultural and food scientists use biotechnology to manipulate the genetic material of plants and crops, attempting to make these organisms more productive or resistant to disease. Advances in biotechnology have opened up research opportunities in many areas of agricultural and food science, including commercial applications in agriculture, environmental remediation, and the food industry. Interest in the production of biofuels, or fuels manufactured from agricultural derivatives, has also increased. Some agricultural scientists work with biologists and chemists to develop processes for turning crops into energy sources, such as ethanol produced from corn.

Another emerging technology expected to affect agriculture is nanotechnology—a molecular manufacturing technology which promises to revolutionize methods of testing agricultural and food products for contamination or spoilage. Some food scientists are using nanotechnology to develop sensors that can quickly and accurately detect contaminant molecules in food.

Many agricultural scientists work in basic or applied research and development. Basic research seeks to understand the biological and chemical processes by which crops and livestock grow, such as determining the role of a particular gene in plant growth. Applied research uses this knowledge to discover mechanisms to improve the quality, quantity, or safety of agricultural products. Other agricultural scientists manage or administer research and development programs, or manage marketing or production operations in companies that produce food products or agricultural chemicals, supplies, and machinery. Some agricultural scientists are consultants to business firms, private clients, or government.

Depending on the agricultural or food scientist's area of specialization, the nature of the work performed varies.

Food scientists and technologists usually work in the food processing industry, universities, or the Federal Government to create and improve food products. They use their knowledge of chemistry, physics, engineering, microbiology, biotechnology, and other sciences to develop new or better ways of preserving, processing, packaging, storing, and delivering foods. Some food scientists engage in basic research, discovering new food sources; analyzing food content to determine levels of vitamins, fat, sugar, or protein; or searching for substitutes for harmful or undesirable additives, such as nitrites. Others engage in applied research, finding ways to improve the content of food or to remove harmful additives. They also develop ways to process, preserve, package, or store food according to industry and government regulations. Traditional food processing research into baking, blanching, canning, drying, evaporation, and pasteurization also continues. Other food scientists enforce government regulations, inspecting food processing areas and ensuring that sanitation, safety, quality, and waste management standards are met.

Agricultural and food scientists often work in offices or labratories.

Food technologists generally work in product development, applying the findings from food science research to improve the selection, preservation, processing, packaging, and distribution of food.

Plant scientists study plants, helping producers of food, feed, and fiber crops to feed a growing population and conserve natural resources. *Agronomists* and *crop scientists* not only help increase productivity, but also study ways to improve the nutritional value of crops and the quality of seed, often through biotechnology. Some crop scientists study the breeding, physiology, and management of crops and use genetic engineering to develop crops resistant to pests and drought. Some plant scientists develop new technologies to control or eliminate pests and prevent their spread in ways appropriate to the specific environment. They also conduct research or oversee activities to halt the spread of insect-borne disease.

Soil scientists study the chemical, physical, biological, and mineralogical composition of soils as it relates to plant growth. They also study the responses of various soil types to fertilizers, tillage practices, and crop rotation. Many soil scientists who work for the Federal Government conduct soil surveys, classifying and mapping soils. They provide information and recommendations to farmers and other landowners regarding the best use of land and plants to avoid or correct problems, such as erosion. They may also consult with engineers and other technical personnel working on construction projects about the effects of, and solutions to, soil problems. Because soil science is closely related to environmental science, persons trained in soil science also work to ensure environmental quality and effective land use.

Animal scientists work to develop better, more efficient ways of producing and processing meat, poultry, eggs, and milk. Dairy scientists, poultry scientists, animal breeders, and other scientists in related fields study the genetics, nutrition, reproduction, and growth of domestic farm animals. Some animal scientists inspect and grade livestock food products, purchase livestock, or work in technical sales or marketing. As extension agents or consultants, animal scientists advise agricultural producers on how to upgrade animal housing facilities properly, lower mortality rates, handle waste matter, or increase production of animal products, such as milk or eggs.

Work environment. Agricultural scientists involved in management or basic research tend to work regular hours in offices and laboratories. The work environment for those engaged in applied research or product development varies, depending on specialty and on type of employer. For example, food scientists in private industry may work in test kitchens while investigating new processing techniques. Animal scientists working for Federal, State, or university research stations may spend part of their time at dairies, farrowing houses, feedlots, farm animal facilities, or outdoors conducting research. Soil and crop scientists also spend time outdoors conducting research on farms and agricultural research stations.

Training, Other Qualifications, and Advancement

Most agricultural and food scientists need at least a master's degree to work in basic or applied research, whereas a bachelor's degree is sufficient for some jobs in applied research or product development, or jobs in other occupations related to agricultural science.

Education and training. Training requirements for agricultural scientists depend on the type of work they perform. A bachelor's degree in agricultural science is sufficient for some jobs in product development or assisting in applied research, but a master's or doctoral degree is generally required for basic research or for jobs directing applied research. A Ph.D. in agricultural science usually is needed for college teaching and for advancement to senior research positions. Degrees in related sciences such as biology, chemistry, or physics or in related engineering specialties also may qualify people for many agricultural science jobs.

All States have a land-grant college that offers agricultural science degrees. Many other colleges and universities also offer agricultural science degrees or agricultural science courses. However, not every school offers all specialties. A typical undergraduate agricultural science curriculum includes communications, mathematics, economics, business, and physical and life sciences courses, in addition to a wide variety of technical agricultural science courses. For prospective animal scientists, these technical agricultural science courses might include animal breeding, reproductive physiology, nutrition, and meats and muscle biology. Graduate students usually specialize in a subfield of agricultural science, such as animal breeding and genetics, crop science, or horticulture science, depending on their interests. For example, those interested in doing genetic and biotechnological research in the food industry need a strong background in life and physical sciences, such as cell and molecular biology, microbiology, and inorganic and organic chemistry. Undergraduate students, however, need not specialize. In fact, undergraduates who are broadly trained often have greater career flexibility.

Students preparing to be food scientists take courses such as food chemistry, food analysis, food microbiology, food engineering, and food processing operations. Those preparing as soil and plant scientists take courses in plant pathology, soil chemistry, entomology, plant physiology, and biochemistry, among others. Advanced degree programs include classroom and fieldwork, laboratory research, and a thesis or dissertation based on independent research.

Other qualifications. Agricultural and food scientists should be able to work independently or as part of a team and be able to communicate clearly and concisely, both orally and in writing. Most of these scientists also need an understanding of basic business principles, the ability to apply statistical techniques, and the ability to use computers to analyze data and to control biological and chemical processing.

Certification and advancement. Agricultural scientists who have advanced degrees usually begin in research or teaching. With experience, they may advance to jobs as supervisors of research programs or managers of other agriculture-related activities.

The American Society of Agronomy certifies agronomists and crop advisors, and the Soil Science Society of America certifies soil scientists and soil classifiers. To become certified in soil science or soil classification, applicants must have

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Agricultural and food scientists	19-1010	33,000	36,000	3,100	9
Animal scientists	19-1011	5,400	5,900	500	10
Food scientists and technologists	19-1012	12,000	13,000	1,200	10
Soil and plant Scientists	19-1013	16,000	17,000	1,300	8

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

a bachelor's degree in soil science and 5 years of experience or a graduate degree and 3 years experience. Certification in agronomy requires a bachelor's degree in agronomy or a related field and 5 years experience or a graduate degree and 3 years. Crop advising certification requires either 4 years of experience or a bachelor's degree in agriculture and 2 years of experience. To receive any of these certifications, applicants must also pass designated examinations and agree to adhere to a code of ethics. Each certification is maintained through continuing education.

Employment

Agricultural and food scientists held about 33,000 jobs in 2006. In addition, many people trained in these sciences held faculty positions in colleges and universities. (See the statement on postsecondary teachers elsewhere in the *Handbook*.)

About 14 percent of agricultural and food scientists work for Federal, State, or local governments. State and local governments employed about 5 percent, while the Federal Government employed another 9 percent in 2006, mostly in the U.S. Department of Agriculture. Educational services accounted for another 18 percent of jobs. Other agricultural and food scientists worked for agricultural service companies, commercial research and development laboratories, seed companies, wholesale distributors, and food products companies. About 5,500 agricultural scientists were self-employed in 2006, mainly as consultants.

Job Outlook

Job growth among agricultural and food scientists should be about as fast as the average for all occupations. Opportunities are expected to be good over the next decade, particularly for those holding a master's or Ph.D. degree.

Employment change. Employment of agricultural and food scientists is expected to grow 9 percent between 2006 and 2016, about as fast as the average for all occupations. Past agricultural research has created higher yielding crops, crops with better resistance to pests and plant pathogens, and more effective fertilizers and pesticides. Research is still necessary, however, particularly as insects and diseases continue to adapt to pesticides and as soil fertility and water quality continue to need improvement. This creates more jobs for agricultural scientists.

Emerging biotechnologies will play an ever larger role in agricultural research. Scientists will be needed to apply these technologies to the creation of new food products and other advances. Moreover, increasing demand is expected for biofuels and other agricultural products used in industrial processes. Agricultural scientists will be needed to find ways to increase the output of crops used in these products.

Agricultural scientists will also be needed to balance increased agricultural output with protection and preservation of soil, water, and ecosystems. They increasingly encourage the practice of sustainable agriculture by developing and implementing plans to manage pests, crops, soil fertility and erosion, and animal waste in ways that reduce the use of harmful chemicals and do little damage to farms and the natural environment.

Job growth for food scientists and technologists will be driven by the demand for new food products and food safety measures. Food research is expected to increase because of heightened public awareness of diet, health, food safety, and biosecurity—preventing the introduction of infectious agents into herds of animals. Advances in biotechnology and nanotechnology should also spur demand, as food scientists and technologists apply these technologies to testing and monitoring food safety.

Fewer new jobs for agricultural and food scientists are expected in the Federal Government, mostly because of budgetary constraints at the U.S. Department of Agriculture.

Job prospects. Opportunities should be good for agricultural and food scientists with a master's degree, particularly those seeking applied research positions in a laboratory. Master's degree candidates also can seek to become certified crop advisors, helping farmers better manage their crops. Those with a Ph.D. in agricultural and food science will experience the best opportunities, especially in basic research and teaching positions at colleges and universities.

Graduates with a bachelor's degree in agricultural or food science can sometimes work in applied research and product development positions under the guidance of a Ph.D. scientist, but usually only in certain subfields, such as food science and technology. The Federal Government also hires bachelor's degree holders to work as soil scientists.

Most people with bachelor's degrees find work in positions related to agricultural or food science rather than in jobs as agricultural or food scientists. A bachelor's degree in agricultural science is useful for managerial jobs in farm-related or ranch-related businesses, such as farm credit institutions or companies that manufacture or sell feed, fertilizer, seed, and farm equipment. In some cases, people with a bachelor's degree can provide consulting services or work in sales and marketing—promoting high-demand products such as organic foods. Bachelor's degrees also may help people become farmers, ranchers, and agricultural managers; agricultural inspectors; or purchasing agents for agricultural commodity or farm supply companies.

Employment of agricultural and food scientists is relatively stable during periods of economic recession. Layoffs are less likely among agricultural and food scientists than in some other occupations because food is a staple item and its demand fluctuates very little with economic activity.

Earnings

Median annual earnings of food scientists and technologists were $53,810 in May 2006. The middle 50 percent earned between $37,740 and $76,960. The lowest 10 percent earned less than $29,620, and the highest 10 percent earned more than $97,350. Median annual earnings of soil and plant scientists were $56,080 in May 2006. The middle 50 percent earned between $42,410 and $72,020. The lowest 10 percent earned less than $33,650, and the highest 10 percent earned more than $93,460. In May 2006, median annual earnings of animal scientists were $47,800.

The average Federal salary in 2007 was $91,491 in animal science and $79,051 in agronomy.

According to the National Association of Colleges and Employers, beginning salary offers in 2007 for graduates with a bachelor's degree in animal sciences averaged $35,035 a year; plant sciences, $31,291 a year; and in other agricultural sciences, $37,908 a year.

Related Occupations

The work of agricultural scientists is closely related to that of other scientists, including biological scientists, chemists, and conservation scientists and foresters. It also is related to the work of managers of agricultural production, such as farmers, ranchers, and agricultural managers. Certain specialties of agricultural science also are related to other occupations. For example, the work of animal scientists is related to the work of veterinarians.

Sources of Additional Information

Information on careers in agricultural science is available from:

➤ American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, 677 S. Segoe Rd., Madison, WI 53711-1086.
Internet: **http://www.agronomy.org**

➤ Living Science, Purdue University, 1140 Agricultural Administration Bldg., West Lafayette, IN 47907-1140.
Internet: **http://www.agriculture.purdue.edu/USDA/careers**

Information on careers in food science and technology is available from:

➤ Institute of Food Technologists, 525 W. Van Buren, Suite 1000, Chicago, IL 60607. Internet: **http://www.ift.org**

Information on getting a job as an agricultural scientist with the Federal Government is available from the Office of Personnel Management through USAJOBS, the Federal Government's official employment information system. This resource for locating and applying for job opportunities can be accessed through the Internet at **http://www.usajobs.opm.gov** or through an interactive voice response telephone system at (703) 724-1850 or TDD (978) 461-8404. These numbers are not tollfree, and charges may result.

Architects, Except Landscape and Naval

(O*NET 17-1011.00)

Significant Points

- About 1 in 5 architects are self-employed—more than 2 times the proportion for all occupations.
- Licensing requirements include a professional degree in architecture, at least 3 years of practical work training, and passing all divisions of the Architect Registration Examination.
- Architecture graduates may face competition, especially for jobs in the most prestigious firms.

Nature of the Work

People need places in which to live, work, play, learn, worship, meet, govern, shop, and eat. These places may be private or public; indoors or out; rooms, buildings, or complexes, and architects design them. Architects are licensed professionals trained in the art and science of building design who develop the concepts for structures and turn those concepts into images and plans.

Architects create the overall aesthetic and look of buildings and other structures, but the design of a building involves far more than its appearance. Buildings also must be functional, safe, and economical and must suit the needs of the people who use them. Architects consider all these factors when they design buildings and other structures.

Architects may be involved in all phases of a construction project, from the initial discussion with the client through the entire construction process. Their duties require specific skills—designing, engineering, managing, supervising, and communicating with clients and builders. Architects spend a great deal of time explaining their ideas to clients, construction contractors, and others. Successful architects must be able to communicate their unique vision persuasively.

The architect and client discuss the objectives, requirements, and budget of a project. In some cases, architects provide various predesign services: conducting feasibility and environmental impact studies, selecting a site, preparing cost analysis and land-use studies, or specifying the requirements the design must meet. For example, they may determine space requirements by researching the numbers and types of potential users of a building. The architect then prepares drawings and a report presenting ideas for the client to review.

After discussing and agreeing on the initial proposal, architects develop final construction plans that show the building's appearance and details for its construction. Accompanying these plans are drawings of the structural system; air-conditioning, heating, and ventilating systems; electrical systems; communications systems; plumbing; and, possibly, site and landscape plans. The plans also specify the building materials and, in some cases, the interior furnishings. In developing designs, architects follow building codes, zoning laws, fire regulations, and other ordinances, such as those requiring easy access by people who are disabled. Computer-aided design and drafting (CADD) and Building Information Modeling (BIM) technology has replaced traditional paper and pencil as the most common method for creating design and construction drawings. Continual revision of plans on the basis of client needs and budget constraints is often necessary.

Architects may also assist clients in obtaining construction bids, selecting contractors, and negotiating construction contracts. As construction proceeds, they may visit building sites to make sure that contractors follow the design, adhere to the schedule, use the specified materials, and meet work quality standards. The job is not complete until all construction is finished, required tests are conducted, and construction costs are paid. Sometimes, architects also provide postconstruction services, such as facilities management. They advise on energy efficiency measures, evaluate how well the building design adapts to the needs of occupants, and make necessary improvements.

Often working with engineers, urban planners, interior designers, landscape architects, and other professionals, architects in fact spend a great deal of their time coordinating information from, and the work of, other professionals engaged in the same project.

They design a wide variety of buildings, such as office and apartment buildings, schools, churches, factories, hospitals, houses, and airport terminals. They also design complexes such as urban centers, college campuses, industrial parks, and entire communities.

Architects sometimes specialize in one phase of work. Some specialize in the design of one type of building—for example, hospitals, schools, or housing. Others focus on planning and predesign services or construction management and do minimal design work.

Work environment. Usually working in a comfortable environment, architects.spend most of their time in offices consulting with clients, developing reports and drawings, and working with other architects and engineers. However, they often visit construction sites to review the progress of projects. Although most architects work approximately 40 hours per week, they often have to work nights and weekends to meet deadlines.

Training, Other Qualifications, and Advancement

There are three main steps in becoming an architect. First is the attainment of a professional degree in architecture. Second is work experience through an internship, and third is licensure through the passing of the Architect Registration Exam.

Education and training. In most States, the professional degree in architecture must be from one of the 114 schools of architecture that have degree programs accredited by the National Architectural Accrediting Board. However, State architectural registration boards set their own standards, so graduation from a non-accredited program may meet the educational requirement for licensing in a few States.

Three types of professional degrees in architecture are available: a 5-year bachelor's degree, which is most common and is intended for students with no previous architectural training; a 2-year master's degree for students with an undergraduate degree in architecture or a related area; and a 3- or 4-year master's degree for students with a degree in another discipline.

The choice of degree depends on preference and educational background. Prospective architecture students should consider the options before committing to a program. For example, although the 5-year bachelor of architecture offers the fastest route to the professional degree, courses are specialized, and if the student does not complete the program, transferring to a program in another discipline may be difficult. A typical program includes courses in architectural history and theory, building design with an emphasis on CADD, structures, technology, construction methods, professional practice, math, physical sciences, and liberal arts. Central to most architectural programs is the design studio, where students apply the skills and concepts learned in the classroom, creating drawings and three-dimensional models of their designs.

Many schools of architecture also offer postprofessional degrees for those who already have a bachelor's or master's degree in architecture or other areas. Although graduate education beyond the professional degree is not required for practicing architects, it may be required for research, teaching, and certain specialties.

All State architectural registration boards require architecture graduates to complete a training period—usually at least 3 years—before they may sit for the licensing exam. Every State, with the exception of Arizona, has adopted the training standards established by the Intern Development Program, a branch of the American Institute of Architects and the National Council of Architectural Registration Boards (NCARB). These standards stipulate broad training under the supervision of a licensed architect. Most new graduates complete their training period by working as interns at architectural firms. Some States allow a portion of the training to occur in the offices of related professionals, such as engineers or general contractors. Architecture students who complete internships while still in school can count some of that time toward the 3-year training period.

Interns in architectural firms may assist in the design of one part of a project, help prepare architectural documents or drawings, build models, or prepare construction drawings on CADD. Interns also may research building codes and materials or write

Architects design buidings.

specifications for building materials, installation criteria, the quality of finishes, and other, related details.

Licensure. All States and the District of Columbia require individuals to be licensed (registered) before they may call themselves architects and contract to provide architectural services. During the time between graduation and becoming licensed, architecture school graduates generally work in the field under the supervision of a licensed architect who takes legal responsibility for all work. Licensing requirements include a professional degree in architecture, a period of practical training or internship, and a passing score on all divisions of the Architect Registration Examination. The examination is broken into nine divisions consisting of either multiple choice or graphical questions. The eligibility period for completion of all divisions of the exam varies by State.

Most States also require some form of continuing education to maintain a license, and many others are expected to adopt mandatory continuing education. Requirements vary by State but usually involve the completion of a certain number of credits annually or biennially through workshops, formal university classes, conferences, self-study courses, or other sources.

Other qualifications. Architects must be able to communicate their ideas visually to their clients. Artistic and drawing ability is helpful, but not essential, to such communication. More important are a visual orientation and the ability to understand spatial relationships. Other important qualities for anyone interested in becoming an architect are creativity and the ability to work independently and as part of a team. Computer skills are also required for writing specifications, for 2- and 3-dimensional drafting using CADD programs, and for financial management.

Certification and advancement. A growing number of architects voluntarily seek certification by the National Council of Architectural Registration Boards. Certification is awarded after independent verification of the candidate's educational transcripts, employment record, and professional references. Certification can make it easier to become licensed across States. In fact, it is the primary requirement for reciprocity of licensing among State Boards that are NCARB members. In 2007, approximately one-third of all licensed architects had this certification.

After becoming licensed and gaining experience, architects take on increasingly responsible duties, eventually managing entire projects. In large firms, architects may advance to supervisory or managerial positions. Some architects become partners in established firms, while others set up their own practices. Some graduates with degrees in architecture also enter related fields, such as graphic, interior, or industrial design; urban planning; real estate development; civil engineering; and construction management.

Employment

Architects held about 132,000 jobs in 2006. Approximately 7 out of 10 jobs were in the architectural, engineering, and related services industry—mostly in architectural firms with fewer than five workers. A small number worked for residential and nonresidential building construction firms and for government agencies responsible for housing, community planning, or construction of government buildings, such as the U.S. Departments of Defense and Interior, and the General Services Administration. About 1in 5 architects are self-employed.

Job Outlook

Employment of architects is expected to grow faster than the average for all occupations through 2016. Keen competition is expected for positions at the most prestigious firms, and opportunities will be best for those architects who are able to distinguish themselves with their creativity.

Employment change. Employment of architects is expected to grow by 18 percent between 2006 and 2016, which is faster than the average for all occupations. Employment of architects is strongly tied to the activity of the construction industry. Strong growth is expected to come from nonresidential construction as demand for commercial space increases. Residential construction, buoyed by low interest rates, is also expected to grow as more people become homeowners. If interest rates rise significantly, home building may fall off, but residential construction makes up only a small part of architects' work.

Current demographic trends also support an increase in demand for architects. As the population of Sunbelt States continues to grow, the people living there will need new places to live and work. As the population continues to live longer and baby-boomers begin to retire, there will be a need for more healthcare facilities, nursing homes, and retirement communities. In education, buildings at all levels are getting older and class sizes are getting larger. This will require many school districts and universities to build new facilities and renovate existing ones.

In recent years, some architecture firms have outsourced the drafting of construction documents and basic design for large-scale commercial and residential projects to architecture firms overseas. This trend is expected to continue and may have a negative impact on employment growth for lower level architects and interns who would normally gain experience by producing these drawings.

Job prospects. Besides employment growth, additional job openings will arise from the need to replace the many architects who are nearing retirement, and others who transfer to other occupations or stop working for other reasons. Internship opportunities for new architectural students are expected to be good over the next decade, but more students are graduating with architectural degrees and some competition for entry-level jobs can be anticipated. Competition will be especially keen for jobs

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016 Number	Change, 2006-2016 Percent
Architects, except landscape and naval	17-1011	132,000	155,000	23,000	18

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

at the most prestigious architectural firms as prospective architects try to build their reputation. Prospective architects who have had internships while in school will have an advantage in obtaining intern positions after graduation. Opportunities will be best for those architects that are able to distinguish themselves from others with their creativity.

Prospects will also be favorable for architects with knowledge of "green" design. Green design, also known as sustainable design, emphasizes energy efficiency, renewable resources such as energy and water, waste reduction, and environmentally friendly design, specifications, and materials. Rising energy costs and increased concern about the environment has led to many new buildings being built green.

Some types of construction are sensitive to cyclical changes in the economy. Architects seeking design projects for office and retail construction will face especially strong competition for jobs or clients during recessions, and layoffs may ensue in less successful firms. Those involved in the design of institutional buildings, such as schools, hospitals, nursing homes, and correctional facilities, will be less affected by fluctuations in the economy. Residential construction makes up a small portion of work for architects, so major changes in the housing market would not be as significant as fluctuations in the nonresidential market.

Despite good overall job opportunities some architects may not fare as well as others. The profession is geographically sensitive, and some parts of the Nation may have fewer new building projects. Also, many firms specialize in specific buildings, such as hospitals or office towers, and demand for these buildings may vary by region. Architects may find it increasingly necessary to gain reciprocity in order to compete for the best jobs and projects in other States.

Earnings

Median annual earnings of wage-and-salary architects were $64,150 in May 2006. The middle 50 percent earned between $49,780 and $83,450. The lowest 10 percent earned less than $39,420, and the highest 10 percent earned more than $104,970. Those just starting their internships can expect to earn considerably less.

Earnings of partners in established architectural firms may fluctuate because of changing business conditions. Some architects may have difficulty establishing their own practices and may go through a period when their expenses are greater than their income, requiring substantial financial resources.

Many firms pay tuition and fees toward continuing education requirements for their employees.

Related Occupations

Architects design buildings and related structures. Construction managers, like architects, also plan and coordinate activities concerned with the construction and maintenance of buildings and facilities. Others who engage in similar work are landscape architects, civil engineers, urban and regional planners, and designers, including interior designers, commercial and industrial designers, and graphic designers.

Sources of Additional Information

Information about education and careers in architecture can be obtained from:

➤ The American Institute of Architects, 1735 New York Ave. NW., Washington, DC 20006. Internet: **http://www.aia.org**

➤ Intern Development Program, National Council of Architectural Registration Boards, Suite 1100K, 1801 K St. NW., Washington, D.C. 20006.
Internet: **http://www.ncarb.org**

Atmospheric Scientists

(O*NET 19-2021.00)

Significant Points

- About 37 percent of atmospheric scientists are employed by the Federal Government; most of these work in the National Weather Service.
- A bachelor's degree in meteorology, or in a closely related field with courses in meteorology, is the minimum educational requirement; a master's degree is necessary for some positions, and a Ph.D. degree is required for most basic research positions.
- Atmospheric scientists should have favorable job prospects, but opportunities as weather broadcasters are rare and highly competitive.

Nature of the Work

Atmospheric science is the study of the atmosphere—the blanket of air covering the Earth. Atmospheric scientists, commonly called *meteorologists*, study the atmosphere's physical characteristics, motions, and processes, and the way in which these factors affect the rest of our environment. The best known application of this knowledge is forecasting the weather. In addition to predicting the weather, atmospheric scientists attempt to identify and interpret climate trends, understand past weather, and analyze today's weather. Weather information and meteorological research are also applied in air-pollution control, agriculture, forestry, air and sea transportation, defense, and the study of possible trends in the Earth's climate, such as global warming, droughts, and ozone depletion.

Atmospheric scientists who forecast the weather are known as *operational meteorologists*; they are the largest group of specialists. These scientists study the Earth's air pressure, temperature, humidity, and wind velocity, and they apply physical and mathematical relationships to make short-range and long-range weather forecasts. Their data come from weather satellites, radars, sensors, and stations in many parts of the world. Meteorologists use sophisticated computer models of the world's atmosphere to make long-term, short-term, and local-area forecasts. More accurate instruments for measuring and observing weather conditions, as well as high-speed computers to process and analyze weather data, have revolutionized weather forecasting. Using satellite data, climate theory, and sophisticated computer models of the world's atmosphere, meteorologists can more effectively interpret the results of these models to make local-area weather predictions. These forecasts inform not only the general public, but also those who need accurate weather information for both economic and safety reasons, such as the shipping, air transportation, agriculture, fishing, forestry, and utilities industries.

The use of weather balloons, launched a few times a day to measure wind, temperature, and humidity in the upper atmosphere, is currently supplemented by sophisticated atmospheric satellite monitoring equipment that transmits data as frequently as every few minutes. Doppler radar, for example, can detect airflow patterns in violent storm systems, allowing forecasters to better predict thunderstorms, flash floods, tornadoes, and other hazardous winds, and to monitor the direction and intensity of storms.

Some atmospheric scientists work in research. *Physical meteorologists*, for example, study the atmosphere's chemical and physical properties; the transmission of light, sound, and radio waves; and the transfer of energy in the atmosphere. They also study factors affecting the formation of clouds, rain, and snow; the dispersal of air pollutants over urban areas; and other weather phenomena, such as the mechanics of severe storms. *Synoptic meteorologists* develop new tools for weather forecasting using computers and sophisticated mathematical models of atmospheric activity. *Climatologists* study climactic variations spanning hundreds or even millions of years. They also may collect, analyze, and interpret past records of wind, rainfall, sunshine, and temperature in specific areas or regions. Their studies are used to design buildings, plan heating and cooling systems, and aid in effective land use and agricultural production. Environmental problems, such as pollution and shortages of fresh water, have widened the scope of the meteorological profession. *Environmental meteorologists* study these problems and may evaluate and report on air quality for environmental impact statements. Other research meteorologists examine the most effective ways to control or diminish air pollution.

Work environment. Weather stations are found everywhere—at airports, in or near cities, and in isolated and remote areas. Some atmospheric scientists also spend time observing weather conditions and collecting data from aircraft. Weather forecasters who work for radio or television stations broadcast their reports from station studios, and may work evenings and weekends. Meteorologists in smaller weather offices often work alone; in larger ones, they work as part of a team. Those who work for private consulting firms or for companies analyzing and monitoring emissions to improve air quality usually work with other scientists or engineers; fieldwork and travel may be common for these workers.

Atmospheric scientists in smaller weather offices often work alone.

Most weather stations operate around the clock, 7 days a week. Jobs in such facilities usually involve night, weekend, and holiday work, often with rotating shifts. During weather emergencies, such as hurricanes, meteorologists may work overtime. Operational meteorologists also are often under pressure to meet forecast deadlines. Meteorologists who are not involved in forecasting tasks work regular hours, usually in offices.

Training, Other Qualifications, and Advancement

A bachelor's degree in meteorology or atmospheric science, or in a closely related field with courses in meteorology, usually is the minimum educational requirement for an entry-level position as an atmospheric scientist. A master's degree is necessary for some positions, and a Ph.D. degree is required for most basic research positions.

Education and training. The preferred educational requirement for entry-level meteorologists in the Federal Government is a bachelor's degree—not necessarily in meteorology—with at least 24 semester hours of meteorology/atmospheric science courses, including 6 hours in the analysis and prediction of weather systems, 6 hours of atmospheric dynamics and thermodynamics, 3 hours of physical meteorology, and 2 hours of remote sensing of the atmosphere or instrumentation. Other required courses include 3 semester hours of ordinary differential equations, 6 hours of college physics, and at least 9 hours of courses appropriate for a physical science major—such as statistics, chemistry, physical oceanography, physical climatology, physical hydrology, radiative transfer, aeronomy (the study of the upper atmosphere), advanced thermodynamics, advanced electricity and magnetism, light and optics, and computer science. Sometimes, a combination of education and appropriate experience may be substituted for a degree.

Although positions in operational meteorology are available for those with only a bachelor's degree, obtaining a second bachelor's degree or a master's degree enhances employment opportunities, pay, and advancement potential. A master's degree usually is necessary for conducting applied research and development, and a Ph.D. is required for most basic research positions. Students planning on a career in research and development do not necessarily need to major in atmospheric science or meteorology as an undergraduate. In fact, a bachelor's degree in mathematics, physics, or engineering provides excellent preparation for graduate study in atmospheric science.

Because atmospheric science is a small field, relatively few colleges and universities offer degrees in meteorology or atmospheric science, although many departments of physics, earth science, geography, and geophysics offer atmospheric science and related courses. In 2007, the American Meteorological Society listed approximately 100 undergraduate and graduate atmospheric science programs. Many of these programs combine the study of meteorology with another field, such as agriculture, hydrology, oceanography, engineering, or physics. For example, hydrometeorology is the blending of hydrology (the science of Earth's water) and meteorology, and is the field concerned with the effect of precipitation on the hydrologic cycle and the environment.

Prospective students should make certain that courses required by the National Weather Service and other employers are offered at the college they are considering. Computer science courses, additional meteorology courses, a strong background in mathematics and physics, and good communication skills are important to prospective employers.

Students should also take courses in subjects that are most relevant to their desired area of specialization. For example, those who wish to become broadcast meteorologists for radio or television stations should develop excellent communication skills through courses in speech, journalism, and related fields. Students interested in air quality work should take courses in chemistry and supplement their technical training with coursework in policy or government affairs. Prospective meteorologists seeking opportunities at weather consulting firms should possess knowledge of business, statistics, and economics, as an increasing emphasis is being placed on long-range seasonal forecasting to assist businesses.

Beginning atmospheric scientists often do routine data collection, computation, or analysis, and some basic forecasting. Entry-level operational meteorologists in the Federal Government usually are placed in intern positions for training and experience. During this period, they learn about the Weather Service's forecasting equipment and procedures, and rotate to different offices to learn about various weather systems. After completing the training period, they are assigned to a permanent duty station.

Certification and advancement. The American Meteorological Society (AMS) offers professional certification for consulting meteorologists, administered by a Board of Certified Consulting Meteorologists. Applicants must meet formal education requirements, pass an examination to demonstrate thorough meteorological knowledge, have a minimum of 5 years of experience or a combination of experience plus an advanced degree, and provide character references from fellow professionals. In addition, AMS also offers professional certification for broadcast meteorologists.

Experienced meteorologists may advance to supervisory or administrative jobs, or may handle more complex forecasting jobs. After several years of experience, some meteorologists establish their own weather consulting services.

Employment

Atmospheric scientists held about 8,800 jobs in 2006. Although several hundred people teach atmospheric science and related courses in college and university departments of meteorology or atmospheric science, physics, earth science, or geophysics, these individuals are classified as college or university faculty, rather than atmospheric scientists. (See the statement on postsecondary teachers elsewhere in the *Handbook*.)

The Federal Government was the largest single employer of civilian meteorologists, accounting for about 37 percent. The National Oceanic and Atmospheric Administration (NOAA) employed most Federal meteorologists in National Weather Service stations throughout the Nation; the remainder of NOAA's meteorologists worked mainly in research and development or management. The U.S. Department of Defense employed several hundred civilian meteorologists. In addition to civilian meteorologists, hundreds of Armed Forces members are involved in forecasting and other meteorological work. (See the statement on job opportunities in the Armed Forces elsewhere in the *Handbook*.) Others worked for professional, scientific, and technical services firms, including private weather consulting services; radio and television broadcasting; air carriers; and State government.

Job Outlook

Employment is expected to increase about as fast as the average. Atmospheric scientists should have favorable job prospects, but opportunities in broadcasting are rare and highly competitive.

Employment change. Employment of atmospheric scientists is projected to grow 11 percent over the 2006-16 decade, about as fast as the average for all occupations. The National Weather Service has completed an extensive modernization of its weather forecasting equipment and finished all hiring of meteorologists needed to staff the upgraded stations. The Service has no plans to increase the number of weather stations or the number of meteorologists in existing stations. Employment of meteorologists in other Federal agencies is expected to decline.

In private industry, on the other hand, job opportunities for atmospheric scientists are expected to be better than in the Federal Government. As research leads to continuing improvements in weather forecasting, demand should grow for private weather consulting firms to provide more detailed information than has formerly been available, especially to climate-sensitive industries. Farmers, commodity investors, radio and television stations, and utilities, transportation, and construction firms can greatly benefit from additional weather information more closely targeted to their needs than the general information provided by the National Weather Service. Additionally, research on seasonal and other long-range forecasting is yielding positive results, which should spur demand for more atmospheric scientists to interpret these forecasts and advise climate-sensitive industries. However, because many customers for private

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Atmospheric and space scientists..	19-2021	8,800	9,700	900	11

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

weather services are in industries sensitive to fluctuations in the economy, the sales and growth of private weather services depend on the health of the economy.

There will continue to be demand for atmospheric scientists to analyze and monitor the dispersion of pollutants into the air to ensure compliance with Federal environmental regulations, but related employment increases are expected to be small. Efforts toward making and improving global weather observations also could have a positive impact on employment.

Job prospects. Atmospheric scientists should have favorable job prospects, as the number of graduates is expected to be in rough balance with the number of openings. Opportunities in broadcasting are rare and there will be very few job openings in this industry. Openings for academic and government positions should result primarily from replacement needs as older workers retire or leave the occupation for other reasons.

Earnings

Median annual earnings of atmospheric scientists in May 2006 were $77,150. The middle 50 percent earned between $55,530 and $96,490. The lowest 10 percent earned less than $39,090, and the highest 10 percent earned more than $119,700.

The average salary for meteorologists employed by the Federal Government was $84,882 in 2007. Many meteorologists in the Federal Government with a bachelor's degree received a starting salary of $35,752, or slightly higher in areas of the country where the prevailing local pay level is higher.

Related Occupations

Workers in other occupations concerned with the physical environment include environmental scientists and hydrologists, geoscientists, physicists and astronomers, mathematicians, and engineers.

Sources of Additional Information

Information about careers in meteorology and a listing of colleges and universities offering meteorology programs is provided by the American Meteorological Society on the Internet at: **http://www.ametsoc.org**

General information about meteorology and careers in atmospheric science can also be obtained from the National Oceanic and Atmospheric Administration on the Internet at: **http://www.noaa.gov**

Information on obtaining a position as a meteorologist with the Federal Government is available from the Office of Personnel Management through USAJOBS, the Federal Government's official employment information system. This resource for locating and applying for job opportunities can be accessed through the Internet at **http://www.usajobs.opm.gov** or through an interactive voice response telephone system at (703) 724-1850 or TDD (978) 461-8404. These numbers are not toll free, and charges may result.

Biological Scientists

(O*NET 19-1021.00, 19-1022.00, 19-1023.00, 19-1029.99)

Significant Points

- Biotechnological research and development should continue to drive employment growth.
- A Ph.D. degree usually is required for independent research, but a master's degree is sufficient for some jobs in applied research or product development; temporary postdoctoral research positions are common.
- Competition for jobs is expected.

Nature of the Work

Biological scientists study living organisms and their relationship to the environment. They perform research to gain a better understanding of fundamental life processes or apply that understanding to developing new products or processes. Most specialize in one area of biology, such as zoology (the study of animals) or microbiology (the study of microscopic organisms). (Medical scientists, whose work is closely related to that of biological scientists, are discussed elsewhere in the *Handbook*.)

Many biological scientists work in research and development. Some conduct basic research to advance our knowledge of living organisms, including bacteria and other infectious agents. Basic biological research enhances our understanding so that we can develop solutions to human health problems and improve the natural environment. These biological scientists mostly work in government, university, or private industry laboratories, often exploring new areas of research. Many expand on specialized research they started in graduate school.

Many research scientists must submit grant proposals to obtain funding for their projects. Colleges and universities, private industry, and Federal Government agencies such as the National Institutes of Health and the National Science Foundation contribute to the support of scientists whose research proposals are determined to be financially feasible and to have the potential to advance new ideas or processes.

Biological scientists who work in applied research or product development use knowledge gained by basic research to develop new drugs, treatments, and medical diagnostic tests; increase crop yields; and develop new biofuels. They usually have less freedom than basic researchers do to choose the emphasis of their research, and they spend more time working on marketable treatments to meet the business goals of their employers. Biological scientists doing applied research and product development in private industry may be required to describe their research plans or results to nonscientists who are in a position to veto or approve their ideas. These scientists must consider the business effects of their work. Scientists often work in teams, interacting with engineers, scientists of other disciplines, business managers, and technicians. Some biological scientists also work with customers or suppliers and manage budgets.

Scientists usually conduct research in laboratories using a wide variety of other equipment. Some conduct experiments involving animals or plants. This is particularly true of botanists, physiologists, and zoologists. Some biological research also takes place outside the laboratory. For example, a botanist might do field research in tropical rain forests to see which plants grow there, or an ecologist might study how a forest area recovers after a fire. Some marine biologists also work outdoors, often on research vessels from which they study fish, plankton, or other marine organisms.

Swift advances in knowledge of genetics and organic molecules spurred growth in the field of biotechnology, transforming the industries in which biological scientists work. Biological scientists can now manipulate the genetic material of animals and plants, attempting to make organisms more productive or resistant to disease. Basic and applied research on biotechnological processes, such as recombining DNA, has led to the production of important substances, including human insulin and growth hormone. Many other substances not previously available in large quantities are now produced by biotechnological means. Some of these substances are useful in treating diseases.

Today, many biological scientists are involved in biotechnology. Those working on various genome (chromosomes with their associated genes) projects isolate genes and determine their function. This work continues to lead to the discovery of genes associated with specific diseases and inherited health risks, such as sickle cell anemia. Advances in biotechnology have created research opportunities in almost all areas of biology, with commercial applications in areas such as medicine, agriculture, and environmental remediation.

Most biological scientists specialize in the study of a certain type of organism or in a specific activity, although recent advances have blurred some traditional classifications.

Aquatic biologists study micro-organisms, plants, and animals living in water. *Marine biologists* study salt water organisms, and *limnologists* study fresh water organisms. Much of the work of marine biology centers on molecular biology, the study of the biochemical processes that take place inside living cells. Marine biologists sometimes are mistakenly called oceanographers, but oceanography is the study of the physical characteristics of oceans and the ocean floor. (See the *Handbook* statements on environmental scientists and hydrologists and on geoscientists.)

Biochemists study the chemical composition of living things. They analyze the complex chemical combinations and reactions involved in metabolism, reproduction, and growth. Biochemists do most of their work in biotechnology, which involves understanding the complex chemistry of life.

Botanists study plants and their environments. Some study all aspects of plant life, including algae, fungi, lichens, mosses, ferns, conifers, and flowering plants; others specialize in areas such as identification and classification of plants, the structure and function of plant parts, the biochemistry of plant processes, the causes and cures of plant diseases, the interaction of plants with other organisms and the environment, and the geological record of plants.

Microbiologists investigate the growth and characteristics of microscopic organisms such as bacteria, algae, or fungi. Most microbiologists specialize in environmental, food, agricultural, or industrial microbiology; virology (the study of viruses); immunology (the study of mechanisms that fight infections); or bioinformatics (the use of computers to handle or characterize biological information, usually at the molecular level). Many microbiologists use biotechnology to advance knowledge of cell reproduction and human disease.

A Ph.D. usually is required for independent research.

Physiologists study life functions of plants and animals, both in the whole organism and at the cellular or molecular level, under normal and abnormal conditions. Physiologists often specialize in functions such as growth, reproduction, photosynthesis, respiration, or movement, or in the physiology of a certain area or system of the organism.

Biophysicists study how physics, such as electrical and mechanical energy and related phenomena, relates to living cells and organisms. They perform research in fields such as neuroscience or bioinformatics.

Zoologists and wildlife biologists study animals and wildlife—their origin, behavior, diseases, and life processes. Some experiment with live animals in controlled or natural surroundings, while others dissect dead animals to study their structure. Zoologists and wildlife biologists also may collect and analyze biological data to determine the environmental effects of current and potential uses of land and water areas. Zoologists usually are identified by the animal group they study—ornithologists study birds, for example, mammalogists study mammals, herpetologists study reptiles, and ichthyologists study fish.

Ecologists investigate the relationships among organisms and between organisms and their environments, examining the effects of population size, pollutants, rainfall, temperature, and altitude. Using knowledge of various scientific disciplines, ecologists may collect, study, and report data on the quality of air, food, soil, and water.

(Agricultural and food scientists, sometimes referred to as biological scientists, are discussed elsewhere in the *Handbook*, as are medical scientists, whose work is closely related to that of biological scientists.)

Work environment. Biological scientists usually are not exposed to unsafe or unhealthy conditions. Those who work with dangerous organisms or toxic substances in the laboratory must follow strict safety procedures to avoid contamination. Many biological scientists, such as botanists, ecologists, and zoologists, do field studies that involve strenuous physical activity and primitive living conditions. Biological scientists in the field may work in warm or cold climates, in all kinds of weather.

Marine biologists encounter a variety of working conditions. Some work in laboratories; others work on research ships, and those who work underwater must practice safe diving while working around sharp coral reefs and hazardous marine life. Although some marine biologists obtain their specimens from the sea, many still spend a good deal of their time in laboratories and offices, conducting tests, running experiments, recording results, and compiling data.

Many biological scientists depend on grant money to support their research. They may be under pressure to meet deadlines and to conform to rigid grant-writing specifications when preparing proposals to seek new or extended funding.

Biological scientists typically work regular hours. While the 40-hour workweek is common, longer hours are not uncommon. Researchers may be required to work odd hours in laboratories or other locations (especially while in the field), depending on the nature of their research.

Training, Other Qualifications, and Advancement

Most biological scientists need a Ph.D. degree in biology or one of its subfields to work in research or development positions. A period of postdoctoral work in the laboratory of a senior researcher has become common for biological scientists who intend to conduct research or teach at the university level.

Education and training. A Ph.D. degree usually is necessary for independent research, industrial research, and college teaching, as well as for advancement to administrative positions. A master's degree is sufficient for some jobs in applied research, product development, management, or inspection; it also may qualify one to work as a research technician or a teacher. The bachelor's degree is adequate for some nonresearch jobs. For example, graduates with a bachelor's degree may start as biological scientists in testing and inspection or may work in jobs related to biological science, such as technical sales or service representatives. Some work as research assistants, laboratory technicians, or high school biology teachers. (See the statements elsewhere in the *Handbook* on clinical laboratory technologists and technicians; science technicians; and teachers—preschool, kindergarten, elementary, middle, and secondary.) Many with a bachelor's degree in biology enter medical, dental, veterinary, or other health profession schools.

In addition to required courses in chemistry and biology, undergraduate biological science majors usually study allied disciplines such as mathematics, physics, engineering, and computer science. Computer courses are beneficial for modeling and simulating biological processes, operating some laboratory equipment, and performing research in the emerging field of bioinformatics. Those interested in studying the environment also should take courses in environmental studies and become familiar with applicable legislation and regulations. Prospective biological scientists who hope to work as marine biologists should have at least a bachelor's degree in a biological or marine science. However, students should not overspecialize in undergraduate study, as knowledge of marine biology often is acquired in graduate study.

Most colleges and universities offer bachelor's degrees in biological science, and many offer advanced degrees. Advanced degree programs often emphasize a subfield such as microbiology or botany, but not all universities offer curricula in all subfields. Larger universities frequently have separate departments specializing in different areas of biological science. For example, a program in botany might cover agronomy, horticulture, or plant pathology. Advanced degree programs typically include classroom and fieldwork, laboratory research, and a thesis or dissertation.

Biological scientists with a Ph.D. often take temporary postdoctoral research positions that provide specialized research experience. Postdoctoral positions may offer the opportunity to publish research findings. A solid record of published research is essential in obtaining a permanent position involving basic research, especially for those seeking a permanent college or university faculty position.

Other qualifications. Biological scientists should be able to work independently or as part of a team and be able to communicate clearly and concisely, both orally and in writing. Those in private industry, especially those who aspire to management or administrative positions, should possess strong business and communication skills and be familiar with regulatory issues and

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Biological scientists	19-1020	87,000	95,000	8,000	9
Biochemists and biophysicists	19-1021	20,000	23,000	3,200	16
Microbiologists	19-1022	17,000	19,000	1,900	11
Zoologists and wildlife biologists	19-1023	20,000	22,000	1,700	9
Biological scientists, all other	19-1029	29,000	30,000	1,100	4

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

marketing and management techniques. Those doing field research in remote areas must have physical stamina. Biological scientists also must have patience and self-discipline to conduct long and detailed research projects.

Advancement. As they gain experience, biological scientists typically gain greater control over their research and may advance to become lead researchers directing a team of scientists and technicians. Some work as consultants to businesses or to government agencies. However, those dependent on research grants are still constrained by funding agencies, and they may spend much of their time writing grant proposals. Others choose to move into managerial positions and become natural science managers (see engineering and natural science managers elsewhere in the *Handbook*). They may plan and administer programs for testing foods and drugs, for example, or direct activities at zoos or botanical gardens. Those who pursue management careers spend much of their time preparing budgets and schedules. Some leave biology for nontechnical managerial, administrative, or sales jobs.

Employment

Biological scientists held about 87,000 jobs in 2006. In addition, many biological scientists held biology faculty positions in colleges and universities but are not included in these numbers. Those whose primary work involves teaching and research are considered postsecondary teachers. (See the statement on teachers—postsecondary elsewhere in the *Handbook*.)

About 39 percent of all biological scientists were employed by Federal, State, and local governments. Federal biological scientists worked mainly for the U.S. Departments of Agriculture, Interior, and Defense and for the National Institutes of Health. Most of the rest worked in scientific research and testing laboratories, the pharmaceutical and medicine manufacturing industry, or colleges and universities.

Job Outlook

Biological scientists can expect to face competition for jobs. After a recent period of rapid expansion in research funding, moderate growth in research grants should drive average employment growth over the next decade.

Employment change. Employment of biological scientists is projected to grow 9 percent over the 2006-16 decade, about as fast as the average for all occupations, as biotechnological research and development continues to drive job growth. The Federal Government funds much basic research and development, including many areas of medical research that relate to biological science. Recent budget increases at the National Institutes of Health have led to large increases in Federal basic research and development expenditures, with research grants growing both in number and dollar amount. Nevertheless, the increase in expenditures has slowed substantially and is not expected to match its past growth over the 2006-16 projection period. This may result in a highly competitive environment for winning and renewing research grants.

Biological scientists enjoyed very rapid employment gains since the 1980s—reflecting, in part, the growth of biotechnology companies. Employment growth should slow somewhat, as fewer new biotechnology firms are founded and existing firms merge or are absorbed by larger biotechnology or pharmaceutical firms. Some companies may conduct a portion of their research and development in other lower-wage countries, further limiting employment growth. However, much of the basic biological research done in recent years has resulted in new knowledge, including the isolation and identification of genes. Biological scientists will be needed to take this knowledge to the next stage, which is the understanding how certain genes function within an entire organism, so that medical treatments can be developed to treat various diseases. Even pharmaceutical and other firms not solely engaged in biotechnology use biotechnology techniques extensively, spurring employment increases for biological scientists. For example, biological scientists are continuing to help farmers increase crop yields by pinpointing genes that can help crops such as wheat grow worldwide in areas that currently are hostile to the crop. Continued work on chronic diseases should also lead to growing demand for biological scientists.

In addition, efforts to discover new and improved ways to clean up and preserve the environment will continue to add to job growth. More biological scientists will be needed to determine the environmental impact of industry and government actions and to prevent or correct environmental problems such as the negative effects of pesticide use. Some biological scientists will find opportunities in environmental regulatory agencies, while others will use their expertise to advise lawmakers on legislation to save environmentally sensitive areas. New industrial applications of biotechnology, such as new methods for making ethanol for transportation fuel, also will spur demand for biological scientists.

There will continue to be demand for biological scientists specializing in botany, zoology, and marine biology, but opportunities will be limited because of the small size of these fields. Marine biology, despite its attractiveness as a career, is a very small specialty within biological science.

Job prospects. Doctoral degree holders are expected to face competition for basic research positions. Furthermore, should the number of advanced degrees awarded continue to grow, applicants for research grants are likely to face even more competition. Currently, about 1 in 4 grant proposals are approved for long-term research projects. In addition, applied research positions in private industry may become more difficult to obtain if increasing numbers of scientists seek jobs in private industry because of the competitive job market for independent research positions in universities and for college and university faculty.

Prospective marine biology students should be aware that those who would like to enter this specialty far outnumber the very few openings that occur each year for the type of glamorous research jobs that many would like to obtain. Almost all marine biologists who do basic research have a Ph.D.

People with bachelor's and master's degrees are expected to have more opportunities in nonscientist jobs related to biology. The number of science-related jobs in sales, marketing, and research management is expected to exceed the number of independent research positions. Non-Ph.D.s also may fill positions as science or engineering technicians or as medical health technologists and technicians. Some become high school biology teachers.

Biological scientists are less likely to lose their jobs during recessions than are those in many other occupations because many are employed on long-term research projects. However, an economic downturn could influence the amount of money allocated to new research and development efforts, particularly in areas of risky or innovative research. An economic downturn also could limit the possibility of extension or renewal of existing projects.

Earnings

Median annual earnings of biochemists and biophysicists were $76,320 in 2006. The middle 50 percent earned between $53,390 and $100,060. The lowest 10 percent earned less than $40,820, and the highest 10 percent earned more than $129,510. Median annual earnings of biochemists and biophysicists employed in scientific research and development services were $79,990 in 2006.

Median annual earnings of microbiologists were 57,980 in 2006. The middle 50 percent earned between $43,850 and $80,550. The lowest 10 percent earned less than $35,460, and the highest 10 percent earned more than $108,270.

Median annual earnings of zoologists and wildlife biologists were $53,300 in 2006. The middle 50 percent earned between $41,400 and $67,200. The lowest 10 percent earned less than $32,800, and the highest 10 percent earned more than $84,580.

According to the National Association of Colleges and Employers, beginning salary offers in 2007 averaged $34,953 a year for bachelor's degree recipients in biological and life sciences.

In the Federal Government in 2007, general biological scientists earned an average salary of $72,146; microbiologists, $87,206; ecologists, $76,511; physiologists, $100,745; geneticists, $91,470; zoologists, $110,456; and botanists, $67,218.

Related Occupations

Many other occupations deal with living organisms and require a level of training similar to that of biological scientists. These include medical scientists, agricultural and food scientists, conservation scientists and foresters, and engineering and natural sciences managers, as well as health occupations such as physicians and surgeons, dentists, and veterinarians.

Sources of Additional Information

For information on careers in the biological sciences, contact:

➤ American Institute of Biological Sciences, 1444 I St.NW., Suite 200, Washington, DC 20005.
Internet: **http://www.aibs.org**

For information on careers in biochemistry or biological sciences, contact:

➤ Federation of American Societies for Experimental Biology, 9650 Rockville Pike, Bethesda, MD 20814.
Internet: **http://www.faseb.org**

For information on careers in botany, contact:

➤ The Botanical Society of America, 4475 Castleman Ave., P.O. Box 299, St.Louis, MO 63166.
Internet: **http://www.botany.org**

For information on careers in physiology, contact:

➤ American Physiology Society, 9650 Rockville Pike, Bethesda, MD 20814. Internet: **http://www.the-aps.org**

Information on obtaining a biological scientist position with the Federal Government is available from the Office of Personnel Management through USAJOBS, the Federal Government's official employment information system. This resource for locating and applying for job opportunities can be accessed through the Internet at **http://www.usajobs.opm.gov** or through an interactive voice response telephone system at (703) 724-1850 or TDD (978) 461-8404. These numbers are not tollfree, and charges may result.

Chemists and Materials Scientists

(O*NET 19-2031.00, 19-2032.00)

Significant Points

- A bachelor's degree in chemistry or a related discipline is the minimum educational requirement; however, many research jobs require a master's degree or, more often, a Ph.D.
- Job growth will occur in professional, scientific, and technical services firms as manufacturing companies continue to outsource their research and development and testing operations to these smaller, specialized firms.
- New chemists at all levels may experience competition for jobs, particularly in declining chemical manufacturing industries; graduates with a master's degree, and particularly those with a Ph.D., will enjoy better opportunities at larger pharmaceutical and biotechnology firms.

Nature of the Work

Everything in the environment, whether naturally occurring or of human design, is composed of chemicals. Chemists and materials scientists search for and use new knowledge about chemicals. Chemical research has led to the discovery and development of new and improved synthetic fibers, paints, adhesives, drugs, cosmetics, electronic components, lubricants, and thousands of other products. Chemists and materials scientists also develop processes such as improved oil refining and petrochemical processing that save energy and reduce pollution. Applications of materials science include studies of superconducting materials, graphite materials, integrated-circuit chips, and fuel cells. Research on the chemistry of living things spurs advances in medicine, agriculture, food processing, and other fields.

Many chemists and materials scientists work in research and development (R&D). In basic research, they investigate the properties, composition, and structure of matter and the laws that govern the combination of elements and reactions of substances to each other. In applied R&D, these scientists create new products and processes or improve existing ones, often using knowledge gained from basic research. For example, synthetic rubber and plastics resulted from research on small molecules uniting to form large ones, a process called polymerization. R&D chemists and materials scientists use computers and a wide variety of sophisticated laboratory instrumentation for modeling, simulation, and experimental analysis.

The use of computers to analyze complex data has allowed chemists and materials scientists to practice combinatorial chemistry. This technique makes and tests large quantities of chemical compounds simultaneously to find those with certain desired properties. Combinatorial chemistry has allowed chemists to produce thousands of compounds more quickly and inexpensively than was formerly possible and assisted in the sequencing of human genes. Specialty chemists, such as medicinal and organic chemists, work with life scientists to translate this knowledge into new drugs.

Developments in the field of chemistry that involve life sciences will expand, resulting in more interaction among biologists, engineers, computer specialists, and chemists. (*Biochemists*, whose work encompasses both biology and chemistry, are discussed in the *Handbook* statement on biological scientists.)

Chemists also work in production and quality control in chemical manufacturing plants. They prepare instructions for plant workers that specify ingredients, mixing times, and temperatures for each stage in the process. They also monitor automated processes to ensure proper product yield and test samples of raw materials or finished products to ensure that they meet industry and government standards, including regulations governing pollution. Chemists report and document test results and analyze those results in hopes of improving existing theories or developing new test methods.

Chemists often specialize. *Analytical chemists* determine the structure, composition, and nature of substances by examining and identifying their various elements or compounds. These chemists are absolutely crucial to the pharmaceutical industry because pharmaceutical companies need to know the identity of compounds that they hope to turn into drugs. Furthermore, analytical chemists develop analytical techniques and study the relationships and interactions among the parts of compounds. They also identify the presence and concentration of chemical pollutants in air, water, and soil.

Organic chemists study the chemistry of the vast number of carbon compounds that make up all living things. Organic chemists who synthesize elements or simple compounds to create new compounds or substances that have different properties and applications have developed many commercial products, such as drugs, plastics, and elastomers (elastic substances similar to rubber). *Inorganic chemists* study compounds consisting mainly of elements other than carbon, such as those in electronic components.

Physical and *theoretical chemists* study the physical characteristics of atoms and molecules and the theoretical properties of matter; and they investigate how chemical reactions work. Their research may result in new and better energy sources. *Macromolecular chemists* study the behavior of atoms and molecules. *Medicinal chemists* study the structural properties of compounds intended for applications to human medicine.

Materials chemists study and develop new materials to improve existing products or make new ones. In fact, virtually all chemists are involved in this quest in one way or another.

The work of materials chemists is similar to, but separate from, the work of materials scientists. Materials scientists apply physics as well as chemistry to study all aspects of materials. Chemistry, however, plays an increasingly dominant role in materials science because it provides information about the structure and composition of materials.

Materials scientists study the structures and chemical properties of various materials to develop new products or enhance existing ones. They also determine ways to strengthen or combine materials or develop new materials for use in a variety of products. Materials science encompasses the natural and synthetic materials used in a wide range of products and structures, from airplanes, cars, and bridges to clothing and household goods. Materials scientists often specialize in specific areas such as ceramics or metals.

Work environment. Chemists and materials scientists usually work regular hours in offices and laboratories. R&D chemists and materials scientists spend much time in laboratories but also work in offices when they do theoretical research or plan, record, and report on their lab research. Although some laboratories are small, others are large enough to incorporate proto-

Opportunities will be best for chemists and material scientists at large biotechnology and pharmaceutical firms.

type chemical manufacturing facilities as well as advanced testing equipment. In addition to working in a laboratory, materials scientists also work with engineers and processing specialists in industrial manufacturing facilities. Chemists do some of their work in a chemical plant or outdoors—gathering water samples to test for pollutants, for example. Some chemists are exposed to health or safety hazards when handling certain chemicals, but there is little risk if proper procedures are followed.

Chemists and materials scientists typically work regular hours. A 40-hour workweek is usual, but longer hours are not uncommon. Researchers may be required to work odd hours in laboratories or other locations, depending on the nature of their research.

Training, Other Qualifications, and Advancement

A bachelor's degree in chemistry or a related discipline is the minimum educational requirement; however, many research jobs require a master's degree or, more often, a Ph.D.

Education and training. A bachelor's degree in chemistry or a related discipline usually is the minimum educational requirement for entry-level chemist jobs. While some materials scientists hold a degree in materials science, degrees in chemistry, physics, or electrical engineering are also common. Most research jobs in chemistry and materials science require a master's degree or, more frequently, a Ph.D.

Many colleges and universities offer degree programs in chemistry. In 2007, the American Chemical Society (ACS) had approved approximately 640 bachelors, 310 masters, and 200 doctoral degree programs. In addition to these programs, other advanced degree programs in chemistry were offered at several hundred colleges and universities. The number of colleges that offer a degree program in materials science is small but gradually increasing.

Students planning careers as chemists and materials scientists should take courses in science and mathematics, should like working with their hands building scientific apparatus and performing laboratory experiments, and should like computer modeling.

In addition to taking required courses in analytical, inorganic, organic, and physical chemistry, undergraduate chemistry majors usually study biological sciences; mathematics; physics; and increasingly, computer science. Computer courses are essential because employers prefer job applicants who are able to apply computer skills to modeling and simulation tasks and operate computerized laboratory equipment. This is increasingly important as combinatorial chemistry and advanced screening techniques are more widely applied. Courses in statistics are useful because both chemists and materials scientists need the ability to apply basic statistical techniques.

People interested in environmental specialties also should take courses in environmental studies and become familiar with current legislation and regulations. Specific courses should include atmospheric, water, and soil chemistry, and energy.

Graduate students studying chemistry commonly specialize in a subfield, such as analytical chemistry or polymer chemistry, depending on their interests and the kind of work they wish to do. For example, those interested in doing drug research in the pharmaceutical industry usually develop a strong background in medicinal or synthetic organic chemistry. However, students normally need not specialize at the undergraduate level. In fact, undergraduates who are broadly trained have more flexibility when searching for jobs than if they have narrowly defined their interests. Most employers provide new graduates additional training or education.

In government or industry, beginning chemists with a bachelor's degree work in quality control, perform analytical testing, or assist senior chemists in R&D laboratories. Many employers prefer chemists and materials scientists with a Ph.D., or at least a master's degree, to lead basic and applied research. Within materials science, a broad background in various sciences is preferred. This broad base may be obtained through degrees in physics, engineering, or chemistry. Although many companies prefer hiring Ph.D.s, some may employ materials scientists with bachelor's and master's degrees.

Other qualifications. Because R&D chemists and materials scientists are increasingly expected to work on interdisciplinary teams, some understanding of other disciplines, including business and marketing or economics, is desirable, along with leadership ability and good oral and written communication skills. Interaction among specialists in this field is increasing, especially for specialty chemists in drug development. One type of chemist often relies on the findings of another type of chemist. For example, an organic chemist must understand findings on the identity of compounds prepared by an analytical chemist.

Experience, either in academic laboratories or through internships, fellowships, or work-study programs in industry, also is useful. Some employers of research chemists, particularly in the pharmaceutical industry, prefer to hire individuals with several years of postdoctoral experience.

Perseverance, curiosity, and the ability to concentrate on detail and to work independently are essential.

Advancement. Advancement among chemists and materials scientists usually takes the form of greater independence in their work or larger budgets. Others choose to move into managerial positions and become natural science managers (listed elsewhere in the *Handbook*). Those who pursue management careers spend more time preparing budgets and schedules and setting research strategy. Chemists or materials scientists who develop new products or processes sometimes form their own companies or join new firms to develop these ideas.

Employment

Chemists and materials scientists held about 93,000 jobs in 2006. Chemists accounted for about 84,000 of these, while materials scientists accounted for about 9,700 jobs. In addition, many chemists and materials scientists held faculty positions in colleges and universities but are not included in these numbers. (See the statement on teachers—postsecondary, elsewhere in the *Handbook*.)

About 41 percent of all chemists and material scientists are employed in manufacturing firms—mostly in the chemical manufacturing industry; firms in this industry produce plastics and synthetic materials, drugs, soaps and cleaners, pesticides and fertilizers, paint, industrial organic chemicals, and other chemical products. About 18 percent of chemists and material scientists work in scientific research and development services; 12 percent work in architectural, engineering, and related ser-

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Chemists and materials scientists	19-2030	93,000	102,000	8,500	9
Chemists	19-2031	84,000	91,000	7,600	9
Materials scientists	19-2032	9,700	11,000	800	9

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

vices. Companies whose products are made of metals, ceramics, and rubber employ most materials scientists. In addition, thousands of people with a background in chemistry and materials science hold teaching positions in high schools and in colleges and universities. (See the statements on teachers—postsecondary, and teachers—preschool, kindergarten, elementary, middle, and secondary, elsewhere in the *Handbook*.)

Chemists and materials scientists are employed in all parts of the country, but they are mainly concentrated in large industrial areas.

Job Outlook

Average job growth is expected. New chemists at all levels may experience competition for jobs, particularly in declining chemical manufacturing industries. Graduates with a master's degree or a Ph.D., will enjoy better opportunities, especially at larger pharmaceutical and biotechnology firms.

Employment change. Employment of chemists and materials scientists is expected to grow 9 percent over the 2006-16 decade, about as fast as the average for all occupations. Job growth will occur in professional, scientific, and technical services firms as manufacturing companies continue to outsource their R&D and testing operations to these smaller, specialized firms.

Chemists should experience employment growth in pharmaceutical and biotechnology research, as recent advances in genetics open new avenues of treatment for diseases. Employment of chemists in the nonpharmaceutical chemical manufacturing industries is expected to decline over the projection period, along with overall declining employment in these industries.

Employment of materials scientists should continue to grow as manufacturers of diverse products seek to improve their quality by using new materials and manufacturing processes.

Within the chemical manufacturing industries, job growth for chemists is expected to be strongest in pharmaceutical and biotechnology firms. Biotechnological research, including studies of human genes, continues to offer possibilities for the development of new drugs and products to combat illnesses and diseases that have previously been unresponsive to treatments derived by traditional chemical processes. Stronger competition among drug companies and an aging population are contributing to the need for new drugs.

The remaining chemical manufacturing industries are expected to employ fewer chemists as companies divest their R&D operations. To control costs, most chemical companies, including many large pharmaceutical and biotechnology companies, will increasingly turn to scientific R&D services firms to perform specialized research and other work formerly done by in-house chemists. As a result, these firms will experience healthy growth. Also, some companies are expected to conduct an increasing amount of manufacturing and research in lower-wage countries, further limiting domestic employment growth. Quality control will continue to be an important issue in chemical manufacturing and other industries that use chemicals in their manufacturing processes.

Chemists also will be employed to develop and improve the technologies and processes used to produce chemicals for all purposes, and to monitor and measure air and water pollutants to ensure compliance with local, State, and Federal environmental regulations. Environmental research will offer many new opportunities for chemists and materials scientists. To satisfy public concerns and to comply with government regulations, chemical manufacturing industries will continue to invest billions of dollars each year in technology that reduces pollution and cleans up existing waste sites. Research into traditional and alternative energy sources should also lead to employment growth among chemists.

Job prospects. New chemists at all levels may experience competition for jobs, particularly in declining chemical manufacturing industries. Graduates with a bachelor's degree in chemistry may find science-related jobs in sales, marketing, and middle management. Some become chemical technicians or technologists or high school chemistry teachers. In addition, bachelor's degree holders are increasingly finding assistant research positions at smaller research organizations.

Graduates with an advanced degree, and particularly those with a Ph.D., will enjoy better opportunities. Larger pharmaceutical and biotechnology firms will offer more openings for these workers. Furthermore, chemists with an advanced degree will continue to fill most senior research and upper management positions; however, similar to other occupations, applicants face strong competition for the limited number of upper management jobs.

In addition to jobs openings resulting from employment growth, some job openings will result from the need to replace chemists and materials scientists who retire or otherwise leave the labor force, although not all positions will be filled.

During periods of economic recession, layoffs of chemists may occur—especially in the industrial chemicals industry. Layoffs are less likely in the pharmaceutical industry, where long development cycles generally overshadow short-term economic conditions. The traditional chemical industries, however, provide many raw materials to the automotive manufacturing and construction industries, both of which are vulnerable to temporary slowdowns during recessions.

Earnings

Median annual earnings of chemists in 2006 were $59,870. The middle 50 percent earned between $44,780 and $82,610. The lowest 10 percent earned less than $35,480, and the highest 10 percent earned more than $106,310. Median annual earnings of materials scientists in 2006 were $74,610. The middle 50 percent earned between $55,170 and $96,800. The lowest

10 percent earned less than $41,810, and the highest 10 percent earned more than $118,670. Median annual earnings in the industries employing the largest numbers of chemists in 2006 are shown below:

Federal executive branch	$88,930
Scientific research and development services	68,760
Basic chemical manufacturing	62,340
Pharmaceutical and medicine manufacturing	57,210
Testing laboratories	45,730

According to the National Association of Colleges and Employers, beginning salary offers in July 2007 for graduates with bachelor's degrees in chemistry averaged $41,506 a year.

In 2007, annual earnings of chemists in nonsupervisory, supervisory, and managerial positions in the Federal Government averaged $89,954.

Related Occupations

The research and analysis conducted by chemists and materials scientists is closely related to work done by agricultural and food scientists, biological scientists, medical scientists, engineering and natural sciences managers, chemical engineers, materials engineers, physicists and astronomers, and science technicians.

Sources of Additional Information

General information on career opportunities and earnings for chemists is available from:

➤ American Chemical Society, Education Division, 1155 16th St.NW., Washington, DC 20036. Internet: **http://www.acs.org**

Information on obtaining a position as a chemist with the Federal Government is available from the Office of Personnel Management through USAJOBS, the Federal Government's official employment information system. This resource for locating and applying for job opportunities can be accessed through the Internet at **http://www.usajobs.opm.gov** or through an interactive voice response telephone system at (703) 724-1850 or TDD (978) 461-8404. These numbers are not toll free, and charges may result.

Conservation Scientists and Foresters

(O*NET 19-1031.00, 19-1031.01, 19-1031.02, 19-1031.03, 19-1032.00)

Significant Points

- About 2 of 3 conservation scientists and foresters work for Federal, State, or local governments.
- Workers in this occupation need, at a minimum, a bachelor's degree in forestry, environmental science, range management, or a related discipline.
- Slower than average job growth is projected; most new jobs will be in governments and in private sector forestry and conservation consulting.

Nature of the Work

Forests and rangelands supply wood products, livestock forage, minerals, and water. They serve as sites for recreational activities and provide habitats for wildlife. Conservation scientists and foresters manage the use and development of these lands and help to protect them. Some advise landowners on the use and management of their land. Conservation scientists and foresters often specialize in one area, such as wildlife management, soil conservation, urban forestry, pest management, native species, or forest economics. But most work falls into one of three categories: forestry, conservation science focusing on range lands, and conservation science focusing on farming and soil.

Foresters oversee our Nation's forests and direct activities on them for economic, recreational, conservational, and environmental purposes. Individual landowners, the public, and industry own most of the forested land in this country, and they require the expertise of foresters to keep the forests healthy and sustainable. Often this means coming up with a plan to keep the forests free from disease, harmful insects, and damaging wildfires, for example, planning when and where to plant trees and vegetation and when to cut timber. It may also mean coming up with ways to make the land profitable but still protected for future generations.

Foresters have a wide range of duties, often depending on who they are working for. Some primary duties of foresters include drawing up plans to regenerate forested lands, monitoring their progress, and supervising harvests. Land management foresters choose and direct the preparation of sites on which trees will be planted. They oversee controlled burning and the use of bulldozers or herbicides to clear weeds, brush, and logging debris. They advise on the type, number, and placement of trees to be planted. Foresters then monitor the seedlings to ensure healthy growth and to determine the best time for harvesting. If they detect signs of disease or harmful insects, they consult with specialists in forest pest management to decide on the best course of treatment. When the trees reach a certain size, foresters decide which trees and how many should be harvested and sold to sawmills.

Procurement foresters make up a large share of foresters. Their job is to buy timber, typically for a sawmill or wood products manufacturer, by contacting local forest owners and negotiating a sale contract. This typically involves taking inventory of the type, amount, and location of all standing timber on the property, a process known as timber cruising. They then appraise the timber's worth, negotiate its purchase, and draw up a contract for purchase. The forester next subcontracts with loggers or pulpwood cutters for tree removal and to aid in laying out roads to access the timber. Throughout the process, foresters maintain close contact with the subcontractor and the landowner to ensure that the work meets the landowner's requirements and Federal, State, and local environmental regulations.

Throughout the forest management and procurement processes, foresters are often responsible for conserving wildlife habitats and creek beds within forests, maintaining water quality and soil stability, and complying with environmental regulations. Foresters must balance the desire to conserve forested ecosystems with the need to use forest resources for recreational or economic purposes. For example, foresters are increasingly working with landowners to find ways to generate money from forested lands, such as for hunting or other recreational activity, without cutting down trees. An increasing concern of foresters is the prevention of devastating wildfires. Using a variety of techniques, including the thinning of forests or using controlled burns to clear brush, foresters work with governments and private landowners to minimize the impact of fire on the forest. During fires, they work with or supervise fire fighters and plan ways to attack the fire.

Some foresters, mostly in the Federal Government, perform research on issues facing forests and related natural resources. They may study tree improvement and harvesting techniques; global change; protection of forests from pests, diseases, and fire; improving wildlife habitats; forest recreation; and other topics. State foresters may perform some research but more often work with private landowners in developing forest management plans. Both Federal and State foresters enforce relevant environmental laws, including laws on water quality and fire suppression.

Relatively new fields in forestry are urban forestry and conservation education. Urban foresters live and work in larger cities and manage urban forests. They are concerned with quality of life issues, such as air quality, shade, beautification, storm water runoff, and property values. Conservation education foresters train teachers and students about sound forest stewardship.

Foresters use a number of tools to perform their jobs. Clinometers measure the height of trees; diameter tapes measure tree diameter; and increment borers and bark gauges measure the growth of trees so that timber volumes can be computed and growth rates estimated. Remote sensing (aerial photographs and other imagery taken from airplanes and satellites) and Geographic Information Systems (GIS) data often are used for mapping large forest areas and for detecting widespread trends of forest and land use. Once a map is generated, data are digitized to create a computerized inventory of information required to manage the forest land and its resources. Moreover, hand-held computers, Global Positioning Systems (GPS), and Internet-based applications are used extensively.

Conservation scientists manage, improve, and protect the country's natural resources. They work with landowners and Federal, State, and local governments to devise ways to use and improve the land while safeguarding the environment. Conservation scientists mainly advise farmers, farm managers, and ranchers on how they can improve their land for agricultural purposes and to control erosion. A growing number of conservation scientists are also advising landowners and governments on recreational uses for the land.

Two of the more common conservation scientists are range managers and soil conservationists. Range managers, also called range conservationists, range ecologists, or range scientists, study, manage, improve, and protect rangelands to maximize their use without damaging the environment. Rangelands cover hundreds of millions of acres of the United States, mostly in Western States and Alaska. They contain many natural resources, including grass and shrubs for animal grazing, wildlife habitats, water from vast watersheds, recreation facilities, and valuable mineral and energy resources. Range managers may inventory soils, plants, and animals; develop resource management plans; help to restore degraded ecosystems; or assist in managing a ranch. For example, they may help ranchers attain optimum livestock production by determining the number and kind of animals to graze, the grazing system to use, and the best season for grazing. At the same time, however, range managers maintain soil stability and vegetation for other uses such as wildlife habitats and outdoor recreation. They also plan and implement revegetation of disturbed sites.

Conservation scientsts and foresters keep careful data on plant growth to protect natural resources.

Soil and water conservationists provide technical assistance to farmers, ranchers, forest managers, State and local agencies, and others concerned with the conservation of soil, water, and related natural resources. They develop programs for private landowners designed to make the most productive use of land without damaging it. Soil conservationists also assist landowners by visiting areas with erosion problems, finding the source of the problem, and helping landowners and managers develop management practices to combat it. Water conservationists also assist private landowners and Federal, State, and local governments by advising on water quality, preserving water supplies, groundwater contamination, and management and conservation of water resources.

Work environment. Working conditions vary considerably. Some foresters and conservation scientists work regular hours in offices or labs, but others may split their time between fieldwork and office work. Independent consultants and new, less experienced workers spend the majority of their time outdoors overseeing or participating in hands-on work. Fieldwork can involve long hours alone.

The work can be physically demanding. Some conservation scientists and foresters work outdoors in all types of weather, sometimes in isolated areas, and consequently may need to walk long distances through densely wooded land to carry out their work. Natural disasters may also cause foresters and conservation scientists to work long hours during emergencies. For example, foresters often have to work long hours during fire season, and conservation scientists often are called to prevent erosion after a forest fire and to provide emergency help after floods, mudslides, and tropical storms.

Foresters employed by the Federal Government and the States usually work 40 hours a week, but not always on a standard schedule. In field positions, foresters often work for long blocks of time, working 10 days straight, followed by 4 days off, for example. Overtime may be necessary when working in fire fighting, law enforcement, or natural disaster response.

Training, Other Qualifications, and Advancement

Most forester and conservation scientist jobs require a bachelor's degree. Research and teaching positions usually need a graduate degree.

Education and training. A bachelor's degree in forestry, biology, natural resource management, environmental sciences, or a related discipline is the minimum educational requirement for careers in forestry. In the Federal Government, a combination of experience and appropriate education occasionally may substitute for a bachelor's degree, but competition for jobs makes this difficult. Foresters who wish to do research or to teach usually need an advanced degree, preferably a Ph.D.

Conservation scientists generally have at least a bachelor's degree in fields such as ecology, natural resource management, agriculture, biology, or environmental science. A master's degree or Ph.D. is usually required for teaching and research positions.

Most land-grant colleges and universities offer degrees in forestry. The Society of American Foresters accredits about 50 degree programs throughout the country. Curricula focus on four areas: forest ecology and biology, measurement of forest resources, management of forest resources, and public policy. Students should balance general science courses such as ecology, biology, tree physiology, taxonomy, and soil formation with technical forestry courses, such as forest inventory, wildlife habitat assessment, remote sensing, land surveying, GPS technology, integrated forest resource management, forest protection, and silviculture, which is the care and cultivation of forest trees. In addition, mathematics, statistics, and computer science courses are recommended. Courses in resource policy and administration, specifically forest economics and business administration, are also helpful. Forestry curricula increasingly include courses on wetlands analysis and sustainability and regulatory issues because prospective foresters need a strong grasp of Federal, State, and local policy issues and an understanding of complex environmental regulations.

Many colleges require students to complete a field session either in a camp operated by the college or in a cooperative work-study program with a Federal or State agency or with private industry. All schools encourage students to take summer jobs that provide experience in forestry or conservation work.

Range managers usually have a degree in range management or range science. Nine colleges and universities offer degrees in range management that are accredited by the Society of Range Management. More than 40 other schools offer coursework in range science or in a closely related discipline. Range management courses combine plant, animal, and soil sciences with principles of ecology and resource management. Desirable electives include statistics, forestry, hydrology, agronomy, wildlife, animal husbandry, computer science, and recreation. Selection of a minor in range management, such as wildlife ecology, watershed management, animal science, or agricultural economics, can often enhance qualifications for certain types of employment.

Very few colleges and universities offer degrees in soil conservation. Most soil conservationists have degrees in environmental studies, agronomy, general agriculture, hydrology, or crop or soil science; a few have degrees in related fields such as wildlife biology, forestry, and range management. Programs of study usually include 30 semester hours in natural resources or agriculture, including at least 3 hours in soil science.

Licensure. Sixteen States sponsor some type of credentialing process for foresters. Alabama, California, Connecticut, Maine, Maryland, Massachusetts, and New Hampshire have licensing statutes. Arkansas, Georgia, Mississippi, North Carolina, and South Carolina have mandatory registration statutes, and Michigan, New Jersey, Oklahoma, and West Virginia have voluntary registration statutes. Both licensing and registration requirements usually entail completing a 4-year degree in forestry and several years of forestry work experience. Candidates pursuing licensing also may be required to pass a comprehensive written exam.

Other qualifications. Foresters and conservation scientists usually enjoy working outdoors, are able to tolerate extensive walking and other types of physical exertion, and are willing to relocate to find work. They also must work well with people and have good communication skills.

Certification and advancement. One option to advance in these occupations is to become certified. The Society of American Foresters certifies foresters who have at least a bachelor's degree from one of the 50 forestry programs accredited by the Society or from a forestry program that, though not accredited by the Society, is substantially equivalent. In addition, the candidate must have 5 years of qualifying professional experience and pass an examination.

The Society for Range Management offers two types of certification: one as a certified professional in rangeland management and another as a certified range management consultant. Candidates seeking certification must have at least a bachelor's degree in range science or a closely related field, a minimum of 6 years of full-time work experience, and a passing score on an exam.

Additionally, a graduate with the proper coursework in college can seek certification as a wetland scientist through the Society of Wetland Scientists.

Recent forestry and conservation scientist graduates usually work under the supervision of experienced foresters or scientists. After gaining experience, they may advance to more responsible positions. In the Federal Government, most entry-level foresters work in forest resource management. An experienced Federal forester may supervise a ranger district and may advance to forest supervisor, regional forester, or a top administrative position in the national headquarters.

In private industry, foresters start by learning the practical and administrative aspects of the business and by acquiring comprehensive technical training. They are then introduced to contract writing, timber harvesting, and decision making. Some foresters work their way up to top managerial positions. Foresters in management usually leave fieldwork behind, spending more of their time in an office, working with teams to develop management plans and supervising others. After gaining several years of experience, some foresters may become consultants, working alone or with one or several partners. They contract with State or local governments, private landowners, private industry, or other forestry consulting groups.

Soil conservationists usually begin working within one county or conservation district and, with experience, may advance to the area, State, regional, or national level. Also, soil conservationists can transfer to related occupations, such as farm or ranch management advisor or land appraiser.

Employment

Conservation scientists and foresters held about 33,000 jobs in 2006. Conservation scientist jobs are heavily concentrated in government where nearly 3 in 4 are employed. Soil conservationists are employed primarily in the U.S. Department of Agriculture's (USDA) Natural Resource Conservation Service. Most range managers work in the USDA's Forest Service, the U.S. Department of the Interior's Bureau of Land Management, and the Natural Resource Conservation Service. A small number are self-employed and others work for nonprofit organizations or in consulting firms.

More than half of all foresters work for Federal, State and local governments. Federal Government foresters are concentrated in the USDA's Forest Service. A few foresters are self-employed, generally working as consultants or procurement foresters. Others work for sawmills, wood products manufacturers, logging companies, and the forestry industry.

Although conservation scientists and foresters work in every State, employment of foresters is concentrated in the Western and Southeastern States, where many national and private forests and parks—and most of the lumber and pulpwood-producing forests—are located. Range managers work almost entirely in the Western States, where most of the rangeland is located. Soil conservationists, on the other hand, are employed in almost every county in the country. Besides the jobs described above, some foresters and conservation scientists held faculty positions in colleges and universities. (See the section on teachers—postsecondary elsewhere in the *Handbook*.)

Job Outlook

Employment of conservation scientists and foresters is expected to grow more slowly than the average for all occupations through 2016. In addition to job openings from growth, many openings are expected as today's scientists and foresters retire.

Employment change. Employment of conservation scientists and foresters is expected to grow by 5 percent during the 2006-16 decade, more slowly than the average for all occupations. Recent large-scale sales of forestlands by industry has resulted in a loss of jobs within the traditional forest industry while creating limited opportunities with Timber Investment Management Organizations and Real Estate Investment Trusts.

Fire prevention and suppression will become a main activity for some conservation scientists and foresters, especially within the Federal Government, as the human population spreads into previously uninhabited lands. The Federal Government employs more conservation scientists and foresters than any other industry. Overall employment of conservation scientists and foresters in the Federal government is expected to grow more slowly than the average for all occupations, mostly because of budgetary constraints and the trend toward contracting these functions out to private consulting firms. Also, Federal land management agencies, such as the United States Forest Service, have de-emphasized their timber programs and increasingly focused on wildfire suppression and law enforcement, which may require hiring people with other skills.

State governments are the second largest employer of conservation and forest workers, and they are expected to have little or no growth in their employment of conservation scientists and foresters due to budgetary restrictions. A few States are now working to provide market-based incentives to private landowners to encourage them to use forest land for the public benefit by cleaning watersheds, keeping trees, or doing other environmentally focused activities. More State foresters are being asked to design and help implement such eco-management plans.

The management of storm water and coastlines has created demand for people knowledgeable about runoff and erosion on farms and in cities and suburbs. The opening of Federal lands to leasing by oil and gas companies is creating healthy demand for range scientists and range managers, who are finding work with consulting companies to help write environmental impact statements. Additionally, soil and water quality experts will still be needed as States design initiatives to improve water resources by preventing pollution by agricultural producers and industrial plants. A small number of new jobs will result from the need for range and soil conservationists to provide technical assistance to owners of grazing land through the Natural Resource Conservation Service. Salaried foresters working for private industry—such as paper companies, sawmills, and pulpwood mills—will be needed, though in smaller numbers than in the past, to provide technical assistance and management plans to landowners.

Establishments in management, scientific, and technical consulting services have increased their hiring of conservation scientists and foresters in recent years in response to demand for professionals to prepare environmental impact statements and

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Conservation scientists and foresters	19-1030	33,000	35,000	1,700	5
Conservation scientists	19-1031	20,000	21,000	1,100	5
Foresters	19-1032	13,000	14,000	700	5

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

erosion and sediment control plans, monitor water quality near logging sites, and advise on tree harvesting practices required by Federal, State, or local regulations. Hiring by these firms should continue during the 2006-16 decade.

Job prospects. The Federal Government and some State governments expect a large number of workers to retire over the next decade. This is likely to create a large number of job openings for foresters and conservation scientists in government despite the projection for slower than average growth of this occupation in all State, local, and Federal governments combined. However, the best opportunities for foresters and conservation scientists will be in consulting. Government and businesses are increasingly contracting out forestry and conservation services to companies that specialize in providing them.

Foresters involved with timber harvesting will find better opportunities in the Southeast, where much forested land is privately owned. However, the recent opening of public lands, especially in the West, to commercial activity will also help the outlook for foresters.

Earnings

Median annual earnings of conservation scientists in May 2006 were $54,970. The middle 50 percent earned between $40,950 and $68,460. The lowest 10 percent earned less than $29,860, and the highest 10 percent earned more than $80,260.

Median annual earnings of foresters in 2006 were $51,190. The middle 50 percent earned between $40,870 and $62,290. The lowest 10 percent earned less than $33,490, and the highest 10 percent earned more than $74,570.

In 2006, most bachelor's degree graduates entering the Federal Government as foresters, range managers, or soil conservationists started at $28,862 or $35,752, depending on academic achievement. Those with a master's degree could start at $43,731 or $52,912. Holders of doctorates could start at $63,417. Beginning salaries were slightly higher in selected areas where the prevailing local pay level was higher. In 2007, the average Federal salary for foresters was $65,964; for soil conservationists, $64,284; and for rangeland managers, $60,828.

According to the National Association of Colleges and Employers, graduates with a bachelor's degree in conservation and renewable natural resources received an average starting salary offer of $34,678 in July 2007.

In private industry, starting salaries for students with a bachelor's degree were comparable with starting salaries in the Federal Government, but starting salaries in State and local governments were usually lower.

Conservation scientists and foresters who work for Federal, State, and local governments and large private firms generally receive more generous benefits than do those working for smaller firms. Governments usually have good pension, health, and leave plans.

Related Occupations

Conservation scientists and foresters manage, develop, and protect natural resources. Other workers with similar responsibilities include environmental engineers, agricultural and food scientists, biological scientists, environmental scientists and hydrologists, geoscientists, and farmers, ranchers, and agricultural managers.

Sources of Additional Information

For information about forestry careers and schools offering education in forestry, send a self-addressed, stamped business envelope to:

➤ Society of American Foresters, 5400 Grosvenor Ln., Bethesda, MD 20814-2198. Internet: **http://www.safnet.org**

Information about a career as a range manager, and a list of schools offering training, is available from:

➤ Society for Range Management, 10030 West 27th Ave., Wheat Ridge, CO 80215-6601.
Internet: **http://www.rangelands.org/srm.shtml**

Information on getting a job as a conservation scientist or forester with the Federal Government is available from the Office of Personnel Management (OPM) through USAJOBS, the Federal Government's official employment information system. This resource for locating and applying for job opportunities can be accessed through the Internet at **http://www.usajobs.opm.gov** or through an interactive voice response telephone system at (703) 724-1850 or TDD (978) 461-8404. These numbers are not toll free, and charges may result. For advice on how to find and apply for jobs, see the Occupational Outlook Quarterly article "How to get a job in the Federal Government," online at: **http://www.bls.gov/opub/ooq/2004/summer/art01.pd**f.

Drafters

(O*NET 17-3011.00, 17-3011.01, 17-3011.02, 17-3012.00, 17-3012.01, 17-3012.02, 17-3013.00, 17-3019.99)

Significant Points

- The type and quality of training programs vary considerably so prospective students should be careful in selecting a program.
- Opportunities should be best for individuals with at least 2 years of postsecondary training in drafting and considerable skill and experience using computer-aided design and drafting systems.
- Employment is projected to grow more slowly than average.
- Demand for drafters varies by specialty and depends on the needs of local industry.

Nature of the Work

Drafters prepare technical drawings and plans, which are used to build everything from manufactured products such as toys, toasters, industrial machinery, and spacecraft to structures such as houses, office buildings, and oil and gas pipelines.

In the past, drafters sat at drawing boards and used pencils, pens, compasses, protractors, triangles, and other drafting devices to prepare a drawing by hand. Now, most drafters use Computer Aided Design and Drafting (CADD) systems to prepare drawings. Consequently, some drafters may be referred to as *CADD operators*.

With CADD systems, drafters can create and store drawings electronically so that they can be viewed, printed, or programmed directly into automated manufacturing systems. CADD systems also permit drafters to quickly prepare variations of a design. Although drafters use CADD extensively, it is only a tool. Drafters still need knowledge of traditional drafting techniques, in addition to CADD skills. Despite the nearly universal use of CADD systems, manual drafting and sketching are used in certain applications.

Drafters' drawings provide visual guidelines and show how to construct a product or structure. Drawings include technical details and specify dimensions, materials, and procedures. Drafters fill in technical details using drawings, rough sketches, specifications, and calculations made by engineers, surveyors, architects, or scientists. For example, drafters use their knowledge of standardized building techniques to draw in the details of a structure. Some use their understanding of engineering and manufacturing theory and standards to draw the parts of a machine; they determine design elements, such as the numbers and kinds of fasteners needed to assemble the machine. Drafters use technical handbooks, tables, calculators, and computers to complete their work.

Drafting work has many specialties:

Drafters pay careful attention to detail in their technical drawings.

Aeronautical drafters prepare engineering drawings detailing plans and specifications used in the manufacture of aircraft, missiles, and related parts.

Architectural drafters draw architectural and structural features of buildings and other structures. These workers may specialize in a type of structure, such as residential or commercial, or in a kind of material used, such as reinforced concrete, masonry, steel, or timber.

Civil drafters prepare drawings and topographical and relief maps used in major construction or civil engineering projects, such as highways, bridges, pipelines, flood control projects, and water and sewage systems.

Electrical drafters prepare wiring and layout diagrams used by workers who erect, install, and repair electrical equipment and wiring in communication centers, power plants, electrical distribution systems, and buildings.

Electronics drafters draw wiring diagrams, circuit board assembly diagrams, schematics, and layout drawings used in the manufacture, installation, and repair of electronic devices and components.

Mechanical drafters prepare drawings showing the detail and assembly of a wide variety of machinery and mechanical devices, indicating dimensions, fastening methods, and other requirements.

Process piping or pipeline drafters prepare drawings used in the layout, construction, and operation of oil and gas fields, refineries, chemical plants, and process piping systems.

Work environment. Drafters usually work in comfortable offices. They may sit at adjustable drawing boards or drafting tables when doing manual drawings, although most drafters work at computer terminals much of the time. Because they spend long periods in front of computers doing detailed work, drafters may be susceptible to eyestrain, back discomfort, and hand and wrist problems. Most drafters work a standard 40-hour week; only a small number work part time.

Training, Other Qualifications, and Advancement

Employers prefer applicants who have completed postsecondary school training in drafting, which is offered by technical institutes, community colleges, and some 4-year colleges and universities. Employers are most interested in applicants with well-developed drafting and mechanical drawing skills; knowledge of drafting standards, mathematics, science, and engineering technology; and a solid background in CADD techniques.

Education and training. High school courses in mathematics, science, computer technology, design, computer graphics, and, where available, drafting are useful for people considering a drafting career. Employers prefer applicants who have also completed training after high school at a technical institute, community college, or 4-year college or university.

The kind and quality of drafting training programs vary considerably so prospective students should be careful in selecting a program. They should contact prospective employers to ask which schools they prefer and contact schools to ask for information about the kinds of jobs their graduates have, the type and condition of instructional facilities and equipment, and teacher qualifications.

Technical institutes offer intensive technical training, but they provide a less general education than do community colleges. Either certificates or diplomas may be awarded. Many technical institutes offer 2-year associate degree programs, which are similar to, or part of, the programs offered by community colleges or State university systems. Their programs vary considerably in length and in the type of courses offered. Some public vocational-technical schools serve local students and emphasize the type of training preferred by local employers. Most require a high school diploma or its equivalent for admission. Other technical institutes are run by private, often for-profit, organizations sometimes called proprietary schools.

Community colleges offer courses similar to those in technical institutes but include more classes in theory and liberal arts. Often, there is little or no difference between technical institute and community college programs. However, courses taken at community colleges are more likely to be accepted for credit at 4-year colleges. After completing a 2-year associate degree program, graduates may obtain jobs as drafters or continue their education in a related field at a 4-year college. Most 4-year colleges do not offer training in drafting, but they do offer classes in engineering, architecture, and mathematics that are useful for obtaining a job as a drafter.

Technical training obtained in the Armed Forces also can be applied in civilian drafting jobs. Some additional training may be necessary, depending on the technical area or military specialty.

Training differs somewhat within the drafting specialties, although the basics, such as mathematics, are similar. In an electronics drafting program, for example, students learn how to depict electronic components and circuits in drawings. In architectural drafting, they learn the technical specifications of buildings.

Certification and other qualifications. Mechanical ability and visual aptitude are important for drafters. Prospective drafters should be able to draw well and perform detailed work accurately and neatly. Artistic ability is helpful in some specialized fields, as is knowledge of manufacturing and construction methods. In addition, prospective drafters should have good interpersonal skills because they work closely with engineers, surveyors, architects, and other professionals and, sometimes, with customers.

The American Design Drafting Association (ADDA) has established a certification program for drafters. Although employers usually do not require drafters to be certified, certification demonstrates knowledge and an understanding of nationally recognized practices. Individuals who wish to become certified must pass the Drafter Certification Test, administered periodically at ADDA-authorized sites. Applicants are tested on basic drafting concepts, such as geometric construction, working drawings, and architectural terms and standards.

Advancement. Entry-level or junior drafters usually do routine work under close supervision. After gaining experience, they may become intermediate drafters and progress to more difficult work with less supervision. At the intermediate level, they may need to exercise more judgment and perform calculations when preparing and modifying drawings. Drafters may eventually advance to senior drafter, designer, or supervisor. Many employers pay for continuing education, and, with appropriate college degrees, drafters may go on to become engineering technicians, engineers, or architects.

Employment

Drafters held about 253,000 jobs in 2006. Architectural and civil drafters held 46 percent of all jobs for drafters, mechanical drafters held about 31 percent, and electrical and electronics drafters held about 14 percent.

About 49 percent of all jobs for drafters were in architectural, engineering, and related services firms that design construction projects or do other engineering work on a contract basis for other industries. Another 25 percent of jobs were in manufacturing industries such as machinery manufacturing, including metalworking and other general machinery; fabricated metal products manufacturing, including architectural and structural metals; computer and electronic products manufacturing, including navigational, measuring, electromedical, and control instruments; and transportation equipment manufacturing, including aerospace products and parts manufacturing, as well as ship and boat building. Most of the rest were employed in construction, government, wholesale trade, utilities, and employment services. Approximately 5 percent were self-employed in 2006.

Job Outlook

Drafters can expect slower than average employment growth through 2016, with the best opportunities expected for those with 2 years of professional training.

Employment change. Employment of drafters is expected to grow by 6 percent between 2006 and 2016, which is slower than the average for all occupations. Industrial growth and increasingly complex design problems associated with new products and manufacturing processes will increase the demand for drafting services. Furthermore, drafters are beginning to break out of the traditional drafting role and do work traditionally performed by engineers and architects, also increasing demand. However, drafters tend to be concentrated in slow-growing or declining manufacturing industries. In addition, CADD systems that are more powerful and easier to use are also expected to limit demand for lesser skilled drafters because simple tasks

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Drafters	17-3010	253,000	268,000	15,000	6
Architectural and civil drafters	17-3011	116,000	123,000	7,000	6
Electrical and electronics drafters	17-3012	35,000	36,000	1,400	4
Mechanical drafters	17-3013	78,000	82,000	4,100	5
Drafters, all other	17-3019	25,000	27,000	2,700	11

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

will be made easier or able to be done by other technical professionals. Employment growth also should be slowed by the offshore outsourcing to other countries of some drafting work because some drafting can be done by sending CADD files over the Internet.

Although growth is expected to be greatest for mechanical, architectural, and civil drafters, demand for particular drafting specialties varies throughout the country because employment usually is contingent on the needs of local industry.

Job prospects. Most job openings are expected to arise from the need to replace drafters who transfer to other occupations, leave the labor force, or retire.

Opportunities should be best for individuals with at least 2 years of postsecondary training in a drafting program that provides strong technical skills and considerable experience with CADD systems. CADD has increased the complexity of drafting applications while enhancing the productivity of drafters. It also has enhanced the nature of drafting by creating more possibilities for design and drafting. As technology continues to advance, employers will look for drafters with a strong background in fundamental drafting principles, a high level of technical sophistication, and the ability to apply their knowledge to a broader range of responsibilities.

Employment of drafters remains highly concentrated in industries that are sensitive to cyclical changes in the economy, primarily manufacturing industries. During recessions, drafters may be laid off. However, a growing number of drafters should continue to find employment on a temporary or contract basis as more companies turn to the employment services industry to meet their changing needs.

Earnings

Drafters' earnings vary by specialty, location, and level of responsibility. Median annual earnings of architectural and civil drafters were $41,960 in May 2006. The middle 50 percent earned between $33,550 and $52,220. The lowest 10 percent earned less than $27,010, and the highest 10 percent earned more than $63,310.

Median annual earnings of mechanical drafters were $43,700 in May 2006. The middle 50 percent earned between $34,680 and $55,130. The lowest 10 percent earned less than $28,230, and the highest 10 percent earned more than $67,860. Median annual earnings for mechanical drafters in architectural, engineering, and related services were $44,120.

Median annual earnings of electrical and electronics drafters were $46,830 in May 2006. The middle 50 percent earned between $36,660 and $60,160. The lowest 10 percent earned less than $29,290, and the highest 10 percent earned more than $74,490. In architectural, engineering, and related services, median annual earnings for electrical and electronics drafters were $44,140.

Related Occupations

Other workers who prepare or analyze detailed drawings and make precise calculations and measurements include architects, except landscape and naval; landscape architects; commercial and industrial designers; engineers; engineering technicians; science technicians; and surveyors, cartographers, photogrammetrists, and surveying technicians.

Sources of Additional Information

Information on schools offering programs in drafting and related fields is available from:

➤ Accrediting Commission of Career Schools and Colleges of Technology, 2101 Wilson Blvd., Suite 302, Arlington, VA 22201. Internet: **http://www.accsct.org**

Information about certification is available from:

➤ American Design Drafting Association, 105 E. Main St., Newbern, TN 38059. Internet: **http://www.adda.org**

Engineering and Natural Sciences Managers

(O*NET 11-9041.00, 11-9121.00)

Significant Points

- Most engineering and natural sciences managers have formal education and work experience as engineers, scientists, or mathematicians.
- Projected employment growth for engineering and natural sciences managers is closely related to growth in employment of the engineers and scientists they supervise and the industries in which they work.
- Opportunities will be best for workers with strong communication and business management skills.

Nature of the Work

Engineering and natural sciences managers plan, coordinate, and direct research, design, and production activities. They may supervise engineers, scientists, and technicians, along with support personnel. These managers use their knowledge of engineering and natural sciences to oversee a variety of activities. They determine scientific and technical goals within broad outlines provided by top executives, who are discussed elsewhere in the *Handbook*. These goals may include improving manufacturing processes, advancing scientific research, or developing new products. Managers make detailed plans to accomplish these goals. For example, they may develop the overall concepts of a new product or identify technical problems preventing the completion of a project.

To perform effectively, these managers also must apply knowledge of administrative procedures, such as budgeting, hiring, and supervision. They propose budgets for projects and programs and determine staff, training, and equipment needs. They hire and assign scientists, engineers, and support personnel to carry out specific parts of each project. They also supervise the work of these employees, check the technical accuracy of their work and the soundness of their methods, review their output, and establish administrative procedures and policies—including environmental standards, for example.

In addition, these managers use communication skills extensively. They spend a great deal of time coordinating the activities of their unit with those of other units or organizations. They confer with higher levels of management; with financial, production, marketing, and other managers; and with contractors and equipment and materials suppliers.

Engineering and science managers must have well-developed business and communication skills.

Engineering managers may supervise people who design and develop machinery, products, systems, and processes. They might also direct and coordinate production, operations, quality assurance, testing, or maintenance in industrial plants. Many are plant engineers, who direct and coordinate the design, installation, operation, and maintenance of equipment and machinery in industrial plants. Others manage research and development teams that produce new products and processes or improve existing ones.

Natural sciences managers oversee the work of life and physical scientists, including agricultural scientists, chemists, biologists, geologists, medical scientists, and physicists. These managers direct research and development projects and coordinate activities such as testing, quality control, and production. They may work on basic research projects or on commercial activities. Science managers sometimes conduct their own research in addition to managing the work of others.

Work environment. Engineering and natural sciences managers spend most of their time in an office. Some managers, however, also may work in laboratories, where they may be exposed to the same conditions as research scientists, or in industrial plants, where they may be exposed to the same conditions as production workers. Most managers work at least 40 hours a week and may work much longer on occasion to meet project deadlines. Some may experience considerable pressure to meet technical or scientific goals on a short deadline or within a tight budget.

Training, Other Qualifications, and Advancement

Strong technical knowledge is essential for engineering and natural sciences managers, who must understand and guide the work of their subordinates and explain the work in nontechnical terms to senior management and potential customers. Therefore, most managers have formal education and work experience as an engineer, scientist, or mathematician.

Education and training. These managers usually have education similar to that of the workers they supervise. Most engineering managers, for example, begin their careers as engineers, after completing a bachelor's degree in the field. Many engineers gain business management skills by completing a master's degree in engineering management (MEM) or business administration (MBA). Employers often pay for such training. In large firms, some courses required in these degree programs may be offered onsite. Typically, engineers who prefer to manage in technical areas pursue an MEM, and those interested in less technical management earn an MBA.

Similarly, many science managers begin their careers as scientists, such as chemists, biologists, geologists, or mathematicians. Most scientists and mathematicians engaged in basic research have a Ph.D. degree; some who work in applied research and other activities may have a bachelor's or master's degree. Graduate programs allow scientists to augment their undergraduate training with instruction in other fields, such as management or computer technology. Natural science managers interested in more technical management may earn traditional master's or Ph.D. degrees in natural sciences or master's degrees in science that incorporate business management skills. Those interested in more general management may pursue an MBA. Given the rapid pace of scientific developments, science managers must continuously upgrade their knowledge.

Other qualifications. Engineering and natural sciences managers must be specialists in the work they supervise. To advance to these positions, engineers and scientists generally must gain experience and assume management responsibility. To fill management positions, employers seek engineers and scientists who possess administrative and communication skills in addition to technical knowledge in their specialty. In fact, because engineering and natural sciences managers must effectively lead groups and coordinate projects, they usually need excellent communication and administrative skills.

Advancement. Engineering and natural sciences managers may advance to progressively higher leadership positions within their disciplines. Some may become managers in nontechnical areas such as marketing, human resources, or sales. In high technology firms, managers in nontechnical areas often must possess the same specialized knowledge as do managers in technical areas. For example, employers in an engineering firm may prefer to hire experienced engineers as sales workers because the complex services offered by the firm can be marketed only by someone with specialized engineering knowledge. Such sales workers could eventually advance to jobs as sales managers.

Employment

Engineering and natural sciences managers held about 228,000 jobs in 2006. Manufacturing industries employed 38 percent of engineering and natural sciences managers. Manufacturing industries with the largest employment are those which produce computer and electronic equipment and those which produce transportation equipment, including aerospace products and parts. Another 31 percent worked in professional, scientific, and technical services industries, primarily for firms providing architectural, engineering, and related services and firms providing scientific research and development services. Other large employers include Federal, State, and local government agencies.

Job Outlook

Employment of engineering and natural sciences managers is projected to grow about as fast as the average for all occupations, similar to the growth rate of engineers and life and physi-

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-16 Number	Change, 2006-16 Percent
Engineering and natural sciences managers	—	228,000	246,000	18,000	8
Engineering managers	11-9041	187,000	201,000	14,000	7
Natural sciences managers	11-9121	41,000	45,000	4,600	11

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

cal scientists. Opportunities will be best for workers with strong communication and business management skills.

Employment change. Employment of engineering and natural sciences managers is expected to grow 8 percent over the 2006-16 decade, about as fast as the average for all occupations. Projected employment growth for engineering and natural sciences managers should be in line with growth of the engineers and scientists they supervise and the industries in which they work. Because many employers find it more efficient to contract engineering and science work to specialty firms, there should be strong demand for engineering managers in the scientific research and development services industry and for both engineering and natural science managers in the architectural, engineering, and related services industry.

Job prospects. Opportunities for engineering managers should be better in rapidly growing areas of engineering—such as environmental and biomedical engineering—than in more slowly growing areas—such as electronics and materials engineering. Opportunities for natural sciences managers should likewise be best in the rapidly growing medical and environmental sciences. (See the statements on engineers and life and physical scientists elsewhere in the *Handbook*.) Engineers and scientists with advanced technical knowledge and strong communication skills will be in the best position to become managers. Because engineering and natural sciences managers are involved in the financial, production, and marketing activities of their firm, business management skills are also advantageous for those seeking management positions. In addition to those openings resulting from employment growth, job openings will result from the need to replace managers who retire or move into other occupations.

Earnings

Earnings for engineering and natural sciences managers vary by specialty and by level of responsibility. Median annual earnings of wage and salary engineering managers were $105,430 in May 2006. The middle 50 percent earned between $84,090 and $130,170. Median annual earnings in the industries employing the largest numbers of engineering managers were:

Semiconductor and other electronic component manufacturing	$120,740
Federal executive branch	116,140
Navigational, measuring, electromedical, and control instruments manufacturing	115,150
Aerospace product and parts manufacturing	111,020
Engineering services	103,570

Median annual earnings of wage and salary natural sciences managers were $100,080 in May 2006. The middle 50 percent earned between $77,320 and $130,900. Median annual earnings in the industries employing the largest numbers of natural sciences managers were:

Research and development in the physical, engineering, and life sciences	$120,780
Pharmaceutical and medicine manufacturing	111,070
Federal executive branch	96,100
Architectural, engineering, and related services	88,990
State government	65,570

In addition, engineering and natural sciences managers, especially those at higher levels, often receive more benefits—such as expense accounts, stock option plans, and bonuses—than do nonmanagerial workers in their organizations.

Related Occupations

The work of engineering and natural sciences managers is closely related to that of engineers; mathematicians; and physical and life scientists, including agricultural and food scientists, atmospheric scientists, biological scientists, conservation scientists and foresters, chemists and materials scientists, environmental scientists and hydrologists, geoscientists, medical scientists, and physicists and astronomers. It also is related to the work of other managers, especially top executives.

Sources of Additional Information

For information about a career as an engineering and natural sciences manager, contact the sources of additional information for engineers, life scientists, and physical scientists that are listed at the end of statements on these occupations elsewhere in the *Handbook*.

Additional information on science and engineering master's degrees is available from:

➤ Commission on Professionals in Science and Technology, 1200 New York Ave. NW., Suite 113, Washington, DC 20005. Internet: **http://www.sciencemasters.org**

To learn more about managing scientists and engineers in research and development, see the *Occupational Outlook Quarterly* article, "Careers for scientists—and others—in scientific research and development," in print at many libraries and career centers. and online at**:**
http://www.bls.gov/opub/ooq/2005/summer/art04.htm

Engineering Technicians

(O*NET 17-3021.00, 17-3022.00, 17-3023.00, 17-3023.01, 17-3023.03, 17-3024.00, 17-3025.00, 17-3026.00, 17-3027.00, 17-3029.99)

Significant Points

- Because the type and quality of training programs vary considerably, prospective students should carefully investigate training programs before enrolling.
- Electrical and electronic engineering technicians make up 33 percent of all engineering technicians.
- Employment of engineering technicians often is influenced by the same economic conditions that affect engineers; as a result, job outlook varies by specialty.
- Opportunities will be best for individuals with an associate degree or extensive job training in engineering technology.

Nature of the Work

Engineering technicians use the principles and theories of science, engineering, and mathematics to solve technical problems in research and development, manufacturing, sales, construction, inspection, and maintenance. Their work is more narrowly focused and application-oriented than that of scientists and engineers. Many engineering technicians assist engineers and scientists, especially in research and development. Others work in quality control, inspecting products and processes, conducting tests, or collecting data. In manufacturing, they may assist in product design, development, or production. Although many workers who repair or maintain various types of electrical, electronic, or mechanical equipment are called technicians, these workers are covered in the *Handbook* section on installation, maintenance, and repair occupations.

Engineering technicians who work in research and development build or set up equipment; prepare and conduct experiments; collect data; calculate or record results; and help engineers or scientists in other ways, such as making prototype versions of newly designed equipment. They also assist in design work, often using computer-aided design and drafting (CADD) equipment.

Some engineering technicians assist engineers and scientists in data analysis.

Most engineering technicians specialize, learning skills and working in the same disciplines as engineers. Occupational titles, therefore, tend to reflect this similarity. The *Handbook* does not cover in detail some branches of engineering technology, such as chemical engineering technology (the development of new chemical products and processes) and bioengineering technology (the development and implementation of biomedical equipment), for which there are accredited programs of study.

Aerospace engineering and operations technicians construct, test, and maintain aircraft and space vehicles. They may calibrate test equipment and determine causes of equipment malfunctions. Using computer and communications systems, aerospace engineering and operations technicians often record and interpret test data.

Civil engineering technicians help civil engineers plan and oversee the building of highways, buildings, bridges, dams, wastewater treatment systems, and other structures and do related research. Some estimate construction costs and specify materials to be used, and some may even prepare drawings or perform land-surveying duties. Others may set up and monitor instruments used to study traffic conditions. (Cost estimators; construction and building inspectors; drafters; and surveyors, cartographers, photogrammetrists, and surveying technicians are covered elsewhere in the *Handbook*.)

Electrical and electronics engineering technicians help design, develop, test, and manufacture electrical and electronic equipment such as communication equipment; radar, industrial, and medical monitoring or control devices; navigational equipment; and computers. They may work in product evaluation and testing, using measuring and diagnostic devices to adjust, test, and repair equipment. (Workers whose jobs primarily involve repairing electrical and electronic equipment are often are referred to as electronics technicians, but they are included with electrical and electronics installers and repairers discussed elsewhere in the *Handbook*.)

Electromechanical engineering technicians combine knowledge of mechanical engineering technology with knowledge of electrical and electronic circuits to design, develop, test, and manufacture electronic and computer-controlled mechanical systems. Their work often overlaps that of both electrical and electronics engineering technicians and mechanical engineering technicians.

Environmental engineering technicians work closely with environmental engineers and scientists in developing methods and devices used in the prevention, control, or correction of environmental hazards. They inspect and maintain equipment related to air pollution and recycling. Some inspect water and wastewater treatment systems to ensure that pollution control requirements are met.

Industrial engineering technicians study the efficient use of personnel, materials, and machines in factories, stores, repair shops, and offices. They prepare layouts of machinery and equipment, plan the flow of work, conduct statistical studies of production time or quality, and analyze production costs.

Mechanical engineering technicians help engineers design, develop, test, and manufacture industrial machinery, consumer products, and other equipment. They may assist in product tests by, for example, setting up instrumentation for auto crash tests. They may make sketches and rough layouts, record and analyze data, make calculations and estimates, and report on their findings. When planning production, mechanical engineering technicians prepare layouts and drawings of the assembly process and of parts to be manufactured. They estimate labor costs, equipment life, and plant space. Some test and inspect machines and equipment or work with engineers to eliminate production problems.

Work environment. Most engineering technicians work 40 hours a week in laboratories, offices, manufacturing or industrial plants, or on construction sites. Some may be exposed to hazards from equipment, chemicals, or toxic materials.

Training, Other Qualifications, and Advancement

Most engineering technicians enter the occupation with an associate degree in engineering technology. Training is available at technical institutes, community colleges, extension divisions of colleges and universities, public and private vocational-technical schools, and in the Armed Forces. Because the type and quality of training programs vary considerably, prospective students should carefully investigate training programs before enrolling.

Education and training. Although it may be possible to qualify for certain engineering technician jobs without formal training, most employers prefer to hire someone with at least a 2-year associate degree in engineering technology. People with college courses in science, engineering, and mathematics may qualify for some positions but may need additional specialized training and experience. Prospective engineering technicians should take as many high school science and math courses as possible to prepare for programs in engineering technology after high school.

Most 2-year associate degree programs accredited by the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET) include at least college algebra and trigonometry and one or two basic science courses. Depending on the specialty, more math or science may be required. About 710 ABET-accredited programs are offered in engineering technology specialties.

The type of technical courses required depends on the specialty. For example, prospective mechanical engineering technicians may take courses in fluid mechanics, thermodynamics, and mechanical design; electrical engineering technicians may need classes in electrical circuits, microprocessors, and digital electronics; and those preparing to work in environmental engineering technology need courses in environmental regulations and safe handling of hazardous materials.

Many publicly and privately operated schools provide technical training, but the type and quality of training vary considerably. Therefore, prospective students should carefully select a program in line with their goals. They should ascertain prospective employers' preferences and ask schools to provide information about the kinds of jobs obtained by program graduates, about instructional facilities and equipment, and about faculty qualifications. Graduates of ABET-accredited programs usually are recognized as having achieved an acceptable level of competence in the mathematics, science, and technical courses required for this occupation.

Technical institutes offer intensive technical training through application and practice, but they provide less theory and general education than do community colleges. Many technical institutes offer 2-year associate degree programs and are similar to or part of a community college or State university system. Other technical institutes are run by private organizations, with programs that vary considerably in length and types of courses offered.

Community colleges offer curriculums that are similar to those in technical institutes but include more theory and liberal arts. There may be little or no difference between programs at technical institutes and community colleges, as both offer associate degrees. After completing the 2-year program, some graduates get jobs as engineering technicians, whereas others continue their education at 4-year colleges. However, an associate degree in pre-engineering is different from one in engineering technology. Students who enroll in a 2-year pre-engineering program may find it very difficult to find work as an engineering technician if they decide not to enter a 4-year engineering program because pre-engineering programs usually focus less on hands-on applications and more on academic preparatory work. Conversely, graduates of 2-year engineering technology programs may not receive credit for some of the courses they have taken if they choose to transfer to a 4-year engineering program. Colleges having 4-year programs usually do not offer engineering technician training, but college courses in science, engineering, and mathematics are useful for obtaining a job as an engineering technician. Many 4-year colleges offer bachelor's degrees in engineering technology, but graduates of these programs often are hired to work as technologists or applied engineers, not technicians.

Area vocational-technical schools, another source of technical training, include postsecondary public institutions that serve local students and emphasize training needed by local employers. Most require a high school diploma or its equivalent for admission.

Other training in technical areas may be obtained in the Armed Forces. Many military technical training programs are highly regarded by employers. However, skills acquired in military programs are often narrowly focused and may be of limited applicability in civilian industry, which often requires broader training. Therefore, some additional training may be needed, depending on the acquired skills and the kind of job.

Other qualifications. Because many engineering technicians assist in design work, creativity is desirable. Good communication skills and the ability to work well with others also are important as engineering technicians are typically part of a team of engineers and other technicians.

Certification and advancement. Although employers usually do not require engineering technicians to be certified, such certification may provide jobseekers a competitive advantage. The National Institute for Certification in Engineering Technologies has established voluntary certification programs for several engineering technology specialties. Certification is available at various levels, each level combining a written examination in a specialty with a certain amount of job-related experience, a supervisory evaluation, and a recommendation.

Engineering technicians usually begin by performing routine duties under the close supervision of an experienced technician, technologist, engineer, or scientist. As they gain experience, they are given more difficult assignments with only general supervision. Some engineering technicians eventually become supervisors.

Employment

Engineering technicians held 511,000 jobs in 2006. Approximately 33 percent were electrical and electronics engineering technicians, as indicated by the following tabulation.

Electrical and electronic engineering technicians	170,000
Civil engineering technicians	91,000
Industrial engineering technicians	75,000
Mechanical engineering technicians	48,000
Environmental engineering technicians	21,000
Electro-mechanical technicians	16,000
Aerospace engineering and operations technicians	8,500
Engineering technicians, except drafters, all other	82,000

About 35 percent of all engineering technicians worked in manufacturing, mainly in the computer and electronic equipment, transportation equipment, and machinery manufacturing industries. Another 25 percent worked in professional, scientific, and technical service industries, mostly in engineering or business services companies that do engineering work on contract for government, manufacturing firms, or other organizations.

In 2006, the Federal Government employed 37,000 engineering technicians. State governments employed 29,000, and local governments employed 25,000.

Job Outlook

Overall employment of engineering technicians is expected to grow about as fast as the average for all occupations, but projected growth and job prospects vary by specialty. Opportunities will be best for individuals with an associate degree or extensive job training in engineering technology.

Employment change. Overall employment of engineering technicians is expected to grow 7 percent between 2006 and 2016, about as fast as the average for all occupations. Competitive pressures will force companies to improve and update manufacturing facilities and product designs, resulting in more jobs for engineering technicians.

Growth of engineering technician employment in some design functions may be dampened by increasing globalization of the development process. To reduce costs and speed project completion, some companies may relocate part of their development operations to facilities overseas, impacting both engineers and engineering technicians—particularly in electronics and computer-related specialties. However, much of the work of engineering technicians requires on-site presence, so demand for engineering technicians within the U.S. should continue to grow—particularly in the environmental, civil, and industrial specialties.

Because engineering technicians work closely with engineers, employment of engineering technicians is often influenced by the same local and national economic conditions that affect engineers. As a result, the employment outlook varies with industry and specialization.

Aerospace engineering and operations technicians are expected to have 10 percent employment growth between 2006 and 2016, about as fast as the average for all occupations. Increases in the number and scope of military aerospace projects likely will generate new jobs. New technologies to be used on commercial aircraft produced during the next decade should also spur demand for these workers.

Civil engineering technicians are expected to have 10 percent employment growth between 2006 and 2016, about as fast as the average for all occupations. Spurred by population growth and the related need to improve the Nation's infrastructure, more civil engineering technicians will be needed to expand transportation, water supply, and pollution control systems, as well as large buildings and building complexes. They also will be needed to repair or replace existing roads, bridges, and other public structures.

Electrical and electronic engineering technicians are expected to have 4 percent employment growth between 2006 and 2016, more slowly than the average for all occupations. Although rising demand for electronic goods—including communications equipment, defense-related equipment, medical electronics, and consumer products—should continue to drive demand, foreign competition in design and manufacturing will limit employment growth.

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Engineering technicians, except drafters	17-3020	511,000	545,000	34,000	7
Aerospace engineering and operations technicians	17-3021	8,500	9,400	900	10
Civil engineering technicians	17-3022	91,000	100,000	9,200	10
Electrical and electronic engineering technicians	17-3023	170,000	177,000	6,100	4
Electro-mechanical technicians	17-3024	16,000	16,000	400	3
Environmental engineering technicians	17-3025	21,000	26,000	5,200	25
Industrial engineering technicians	17-3026	75,000	82,000	7,500	10
Mechanical engineering technicians	17-3027	48,000	51,000	3,100	6
Engineering technicians, except drafters, all other	17-3029	82,000	83,000	1,600	2

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

Electro-mechanical technicians are expected to have 3 percent employment growth between 2006 and 2016, more slowly than the average for all occupations. As with the closely-related electrical and electronic engineering technicians and mechanical engineering technicians, job growth should be driven by increasing demand for electro-mechanical products such as unmanned aircraft and robotic equipment. However, growth will be tempered by advances in productivity and strong foreign competition.

Environmental engineering technicians are expected to have 25 percent employment growth between 2006 and 2016, much faster than the average for all occupations. More environmental engineering technicians will be needed to comply with environmental regulations and to develop methods of cleaning up existing hazards. A shift in emphasis toward preventing problems rather than controlling those that already exist, as well as increasing public health concerns resulting from population growth, also will spur demand.

Industrial engineering technicians are expected to have 10 percent employment growth between 2006 and 2016, about as fast as the average for all occupations. As firms continue to seek new means of reducing costs and increasing productivity, demand for industrial engineering technicians to analyze and improve production processes should increase. This should lead to some job growth even in manufacturing industries with slowly growing or declining employment.

Mechanical engineering technicians are expected to have 6 percent employment growth between 2006 and 2016, more slowly than the average for all occupations. As mechanical products and components become increasingly complex, demand for improvements in these products should drive employment growth of mechanical engineering technicians. However, growth is expected to be limited by foreign competition in both design services and manufacturing.

Job prospects. Job prospects will vary by specialty and location, depending on the health and composition of local industry. In general, opportunities will be best for individuals with an associate degree or extensive job training in engineering technology. As technology becomes more sophisticated, employers will continue to look for technicians who are skilled in new technology and require little additional training. An increase in the number of jobs related to public health and safety should create job opportunities for engineering technicians with the appropriate training and certification. In addition to openings from job growth, many job openings will stem from the need to replace technicians who retire or leave the labor force.

Earnings

Median annual earnings in May 2006 of engineering technicians by specialty are shown in the following tabulation.

Aerospace engineering and operations technicians	$53,300
Electrical and electronic engineering technicians	50,660
Industrial engineering technicians	46,810
Mechanical engineering technicians	45,850
Electro-mechanical technicians	44,720
Civil engineering technicians	40,560
Environmental engineering technicians	40,560

Median annual earnings of wage-and-salary electrical and electronics engineering technicians were $50,660 in May 2006. The middle 50 percent earned between $39,270 and $60,470. The lowest 10 percent earned less than $30,120, and the highest 10 percent earned more than $73,200. Median annual earnings in the industries employing the largest numbers of electrical and electronics engineering technicians are:

Wired telecommunications carriers	$54,780
Engineering services	48,330
Semiconductor and other electronic component manufacturing	45,720
Navigational, measuring, electromedical, and control instruments manufacturing	45,140
Employment services	38,910

Median annual earnings of wage-and-salary civil engineering technicians were $40,560 in May 2006. The middle 50 percent earned between $31,310 and $51,230. The lowest 10 percent earned less than $25,250, and the highest 10 percent earned more than $62,920. Median annual earnings in the industries employing the largest numbers of civil engineering technicians are:

Local government	$45,800
Architectural services	42,310
Engineering services	41,180
State government	35,870
Testing laboratories	31,800

In May 2006, the median annual salary for aerospace engineering and operations technicians in the aerospace products and parts manufacturing industry was $52,060, and the median annual salary for environmental engineering technicians in the architectural, engineering, and related services industry was $38,060. The median annual salary for industrial engineering technicians in the aerospace product and parts manufacturing industry was $57,330. In the architectural, engineering, and related services industry, the median annual salary for mechanical engineering technicians was $43,920. Electro-mechanical technicians earned a median salary of $41,550 in the navigational, measuring, electromedical, and control instruments manufacturing industry.

Related Occupations

Engineering technicians apply scientific and engineering skills usually gained in postsecondary programs below the bachelor's degree level. Similar occupations include science technicians; drafters; surveyors, cartographers, photogrammetrists, and surveying technicians; and broadcast and sound engineering technicians and radio operators.

Sources of Additional Information

For information about careers in engineering technology, contact:

➤ JETS (Junior Engineering Technical Society) Guidance, 1420 King St., Suite 405, Alexandria, VA 22314.
Internet: **http://www.jets.org**

Information on engineering technology programs accredited by the Accreditation Board for Engineering and Technology is available from:

➤ ABET, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202. Internet: **http://www.abet.org**

Information on certification, as well as job and career information, is available from:

➤ National Institute for Certification in Engineering Technologies, 1420 King St., Alexandria, VA 22314. Internet: **http://www.nicet.org**

Engineers

(O*NET 17-2011.00, 17-2021.00, 17-2031.00, 17-2041.00, 17-2051.00, 17-2061.00, 17-2071.00, 17-2072.00, 17-2081.00, 17-2111.00, 17-2111.01, 17-2111.02, 17-2111.03, 17-2112.00, 17-2121.00, 17-2121.01, 17-2121.02, 17-2131.00, 17-2141.00, 17-2151.00, 17-2161.00, 17-2171.00, 17-2199.99)

Significant Points

- Overall job opportunities in engineering are expected to be good, but will vary by specialty.
- A bachelor's degree in engineering is required for most entry-level jobs.
- Starting salaries are among the highest of all college graduates.
- Continuing education is critical for engineers as technology evolves.

Nature of the Work

Engineers apply the principles of science and mathematics to develop economical solutions to technical problems. Their work is the link between scientific discoveries and the commercial applications that meet societal and consumer needs.

Many engineers develop new products. During this process, they consider several factors. For example, in developing an industrial robot, engineers precisely specify the functional requirements; design and test the robot's components; integrate the components to produce the final design; and evaluate the design's overall effectiveness, cost, reliability, and safety. This process applies to the development of many different products, such as chemicals, computers, power plants, helicopters, and toys.

In addition to design and development, many engineers work in testing, production, or maintenance. These engineers supervise production in factories, determine the causes of component failure, and test manufactured products to maintain quality. They also estimate the time and cost to complete projects. Supervisory engineers are responsible for major components or entire projects. (See the statement on engineering and natural sciences managers elsewhere in the *Handbook*.)

Engineers use computers extensively to produce and analyze designs; to simulate and test how a machine, structure, or system operates; to generate specifications for parts; and to monitor product quality and control process efficiency. Nanotechnology, which involves the creation of high-performance materials and components by integrating atoms and molecules, also is introducing entirely new principles to the design process.

Most engineers specialize. Following are details on the 17 engineering specialties covered in the Federal Government's Standard Occupational Classification (SOC) system. Numerous other specialties are recognized by professional societies, and each of the major branches of engineering has numerous subdivisions. Civil engineering, for example, includes structural and transportation engineering, and materials engineering includes ceramic, metallurgical, and polymer engineering. Engineers also may specialize in one industry, such as motor vehicles, or in one type of technology, such as turbines or semiconductor materials.

- Aerospace engineers design, develop, and test aircraft, spacecraft, and missiles and supervise the manufacture of these products. Those who work with aircraft are called *aeronautical engineers*, and those working specifically with spacecraft are *astronautical engineers*. Aerospace engineers develop new technologies for use in aviation, defense systems, and space exploration, often specializing in areas such as structural design, guidance, navigation and control, instrumentation and communication, or production methods. They also may specialize in a particular type of aerospace product, such as commercial aircraft, military fighter jets, helicopters, spacecraft, or missiles and rockets, and may become experts in aerodynamics, thermodynamics, celestial mechanics, propulsion, acoustics, or guidance and control systems.
- Agricultural engineers apply knowledge of engineering technology and science to agriculture and the efficient use of biological resources. Because of this, they are also referred to as *biological and agricultural engineers*. They design agricul-

Engineers sometimes perform tests in laboratories.

tural machinery, equipment, sensors, processes, and structures, such as those used for crop storage. Some engineers specialize in areas such as power systems and machinery design; structures and environment engineering; and food and bioprocess engineering. They develop ways to conserve soil and water and to improve the processing of agricultural products. Agricultural engineers often work in research and development, production, sales, or management.

• Biomedical engineers develop devices and procedures that solve medical and health-related problems by combining their knowledge of biology and medicine with engineering principles and practices. Many do research, along with life scientists, chemists, and medical scientists, to develop and evaluate systems and products such as artificial organs, prostheses (artificial devices that replace missing body parts), instrumentation, medical information systems, and health management and care delivery systems. Biomedical engineers may also design devices used in various medical procedures, imaging systems such as magnetic resonance imaging (MRI), and devices for automating insulin injections or controlling body functions. Most engineers in this specialty need a sound background in another engineering specialty, such as mechanical or electronics engineering, in addition to specialized biomedical training. Some specialties within biomedical engineering include biomaterials, biomechanics, medical imaging, rehabilitation engineering, and orthopedic engineering.

• Chemical engineers apply the principles of chemistry to solve problems involving the production or use of chemicals and biochemicals. They design equipment and processes for large-scale chemical manufacturing, plan and test methods of manufacturing products and treating byproducts, and supervise production. Chemical engineers also work in a variety of manufacturing industries other than chemical manufacturing, such as those producing energy, electronics, food, clothing, and paper. They also work in health care, biotechnology, and business services. Chemical engineers apply principles of physics, mathematics, and mechanical and electrical engineering, as well as chemistry. Some may specialize in a particular chemical process, such as oxidation or polymerization. Others specialize in a particular field, such as nanomaterials, or in the development of specific products. They must be aware of all aspects of chemicals manufacturing and how the manufacturing process affects the environment and the safety of workers and consumers.

• Civil engineers design and supervise the construction of roads, buildings, airports, tunnels, dams, bridges, and water supply and sewage systems. They must consider many factors in the design process, from the construction costs and expected lifetime of a project to government regulations and potential environmental hazards such as earthquakes and hurricanes. Civil engineering, considered one of the oldest engineering disciplines, encompasses many specialties. The major ones are structural, water resources, construction, environmental, transportation, and geotechnical engineering. Many civil engineers hold supervisory or administrative positions, from supervisor of a construction site to city engineer. Others may work in design, construction, research, and teaching.

• Computer hardware engineers research, design, develop, test, and oversee the manufacture and installation of computer hardware. Hardware includes computer chips, circuit boards, computer systems, and related equipment such as keyboards, modems, and printers. (Computer software engineers—often simply called computer engineers—design and develop the software systems that control computers. These workers are covered elsewhere in the *Handbook*.) The work of computer hardware engineers is very similar to that of electronics engineers in that they may design and test circuits and other electronic components, but computer hardware engineers do that work only as it relates to computers and computer-related equipment. The rapid advances in computer technology are largely a result of the research, development, and design efforts of these engineers.

• Electrical engineers design, develop, test, and supervise the manufacture of electrical equipment. Some of this equipment includes electric motors; machinery controls, lighting, and wiring in buildings; automobiles; aircraft; radar and navigation systems; and power generation, control, and transmission devices used by electric utilities. Although the terms “electrical” and “electronics” engineering often are used interchangeably in academia and industry, electrical engineers have traditionally focused on the generation and supply of power, whereas electronics engineers have worked on applications of electricity to control systems or signal processing. Electrical engineers specialize in areas such as power systems engineering or electrical equipment manufacturing.

• Electronics engineers, except computer are responsible for a wide range of technologies, from portable music players to the global positioning system (GPS), which can continuously provide the location, for example, of a vehicle. Electronics engineers design, develop, test, and supervise the manufacture of electronic equipment such as broadcast and communications systems. Many electronics engineers also work in areas closely related to computers. However, engineers whose work is related exclusively to computer hardware are considered computer hardware engineers. Electronics engineers specialize in areas such as communications, signal processing, and control systems or have a specialty within one of these areas—control systems or aviation electronics, for example.

• Environmental engineers develop solutions to environmental problems using the principles of biology and chemistry. They are involved in water and air pollution control, recycling, waste disposal, and public health issues. Environmental engineers conduct hazardous-waste management studies in which they evaluate the significance of the hazard, advise on treatment and containment, and develop regulations to prevent mishaps. They design municipal water supply and industrial wastewater treatment systems. They conduct research on the environmental impact of proposed construction projects, analyze scientific data, and perform quality-control checks. Environmental engineers are concerned with local and worldwide environmental issues. They study and attempt to minimize the effects of acid rain, global warming, automobile emissions, and ozone depletion. They may also be involved in the protection of wildlife. Many environmental engineers work as consultants, helping their clients to comply with regulations, to prevent environmental damage, and to clean up hazardous sites.

• Health and safety engineers, except mining safety engineers and inspectors prevent harm to people and property by applying knowledge of systems engineering and mechanical, chemical, and human performance principles. Using this specialized knowledge, they identify and measure potential hazards, such as the risk of fires or the dangers involved in handling of toxic chemicals. They recommend appropriate loss prevention measures according to the probability of harm and potential damage. Health and safety engineers develop procedures and designs to reduce the risk of illness, injury, or damage. Some work in manufacturing industries to ensure the designs of new products do not create unnecessary hazards. They must be able to anticipate, recognize, and evaluate hazardous conditions, as well as develop hazard control methods.

• Industrial engineers determine the most effective ways to use the basic factors of production—people, machines, materials, information, and energy—to make a product or provide a service. They are primarily concerned with increasing productivity through the management of people, methods of business organization, and technology. To maximize efficiency, industrial engineers carefully study the product requirements and design manufacturing and information systems to meet those requirements with the help of mathematical methods and models. They develop management control systems to aid in financial planning and cost analysis, and design production planning and control systems to coordinate activities and ensure product quality. They also design or improve systems for the physical distribution of goods and services and determine the most efficient plant locations. Industrial engineers develop wage and salary administration systems and job evaluation programs. Many industrial engineers move into management positions because the work is closely related to the work of managers.

• Marine engineers and naval architects are involved in the design, construction, and maintenance of ships, boats, and related equipment. They design and supervise the construction of everything from aircraft carriers to submarines, and from sailboats to tankers. Naval architects work on the basic design of ships, including hull form and stability. Marine engineers work on the propulsion, steering, and other systems of ships. Marine engineers and naval architects apply knowledge from a range of fields to the entire design and production process of all water vehicles. Other workers who operate or supervise the operation of marine machinery on ships and other vessels sometimes may be called marine engineers or, more frequently, ship engineers, but they do different work and are covered under water transportation occupations elsewhere in the *Handbook*.

• Materials engineers are involved in the development, processing, and testing of the materials used to create a range of products, from computer chips and aircraft wings to golf clubs and snow skis. They work with metals, ceramics, plastics, semiconductors, and composites to create new materials that meet certain mechanical, electrical, and chemical requirements. They also are involved in selecting materials for new applications. Materials engineers have developed the ability to create and then study materials at an atomic level, using advanced processes to replicate the characteristics of materials and their

A bachelor's degree in engineering is required for most entry-level jobs.

components with computers. Most materials engineers specialize in a particular material. For example, metallurgical engineers specialize in metals such as steel, and ceramic engineers develop ceramic materials and the processes for making them into useful products such as glassware or fiber optic communication lines.

• Mechanical engineers research, design, develop, manufacture, and test tools, engines, machines, and other mechanical devices. Mechanical engineering is one of the broadest engineering disciplines. Engineers in this discipline work on power-producing machines such as electric generators, internal combustion engines, and steam and gas turbines. They also work on power-using machines such as refrigeration and air-conditioning equipment, machine tools, material handling systems, elevators and escalators, industrial production equipment, and robots used in manufacturing. Mechanical engineers also design tools that other engineers need for their work. In addition, mechanical engineers work in manufacturing or agriculture production, maintenance, or technical sales; many become administrators or managers.

• Mining and geological engineers, including mining safety engineers find, extract, and prepare coal, metals, and minerals for use by manufacturing industries and utilities. They design open-pit and underground mines, supervise the construction of mine shafts and tunnels in underground operations, and devise methods for transporting minerals to processing plants. Mining engineers are responsible for the safe, economical, and environmentally sound operation of mines. Some mining engineers work with geologists and metallurgical engineers to locate and appraise new ore deposits. Others develop new mining equipment or direct mineral-processing operations that separate minerals from the dirt, rock, and other materials with which they are mixed. Mining engineers frequently specialize in the mining of one mineral or metal, such as coal or gold. With increased emphasis on protecting the environment, many mining engineers work to solve problems related to land reclamation and water and air pollution. Mining safety engineers use their knowledge of mine design and practices to ensure the safety of workers and to comply with State and Federal safety regulations. They in-

Some engineers, such as these mining engineers, work part of their time outdoors.

spect walls and roof surfaces, monitor air quality, and examine mining equipment for compliance with safety practices.

- Nuclear engineers research and develop the processes, instruments, and systems used to derive benefits from nuclear energy and radiation. They design, develop, monitor, and operate nuclear plants to generate power. They may work on the nuclear fuel cycle—the production, handling, and use of nuclear fuel and the safe disposal of waste produced by the generation of nuclear energy—or on the development of fusion energy. Some specialize in the development of nuclear power sources for naval vessels or spacecraft; others find industrial and medical uses for radioactive materials, as in equipment used to diagnose and treat medical problems.
- Petroleum engineers search the world for reservoirs containing oil or natural gas. Once these resources are discovered, petroleum engineers work with geologists and other specialists to understand the geologic formation and properties of the rock containing the reservoir, determine the drilling methods to be used, and monitor drilling and production operations. They design equipment and processes to achieve the maximum profitable recovery of oil and gas. Because only a small proportion of oil and gas in a reservoir flows out under natural forces, petroleum engineers develop and use various enhanced recovery methods. These include injecting water, chemicals, gases, or steam into an oil reservoir to force out more of the oil and doing computer-controlled drilling or fracturing to connect a larger area of a reservoir to a single well. Because even the best techniques in use today recover only a portion of the oil and gas in a reservoir, petroleum engineers research and develop technology and methods to increase recovery and lower the cost of drilling and production operations.

Work environment. Most engineers work in office buildings, laboratories, or industrial plants. Others may spend time outdoors at construction sites and oil and gas exploration and production sites, where they monitor or direct operations or solve onsite problems. Some engineers travel extensively to plants or worksites here and abroad.

Many engineers work a standard 40-hour week. At times, deadlines or design standards may bring extra pressure to a job, requiring engineers to work longer hours.

Training, Other Qualifications, and Advancement

Engineers typically enter the occupation with a bachelor's degree in an engineering specialty, but some basic research positions may require a graduate degree. Engineers offering their services directly to the public must be licensed. Continuing education to keep current with rapidly changing technology is important for engineers.

Education and training. A bachelor's degree in engineering is required for almost all entry-level engineering jobs. College graduates with a degree in a natural science or mathematics occasionally may qualify for some engineering jobs, especially in specialties in high demand. Most engineering degrees are granted in electrical, electronics, mechanical, or civil engineering. However, engineers trained in one branch may work in related branches. For example, many aerospace engineers have training in mechanical engineering. This flexibility allows employers to meet staffing needs in new technologies and specialties in which engineers may be in short supply. It also allows engineers to shift to fields with better employment prospects or to those that more closely match their interests.

Most engineering programs involve a concentration of study in an engineering specialty, along with courses in both mathematics and the physical and life sciences. Many programs also include courses in general engineering. A design course, sometimes accompanied by a computer or laboratory class or both, is part of the curriculum of most programs. General courses not directly related to engineering, such as those in the social sciences or humanities, are also often required.

In addition to the standard engineering degree, many colleges offer 2-year or 4-year degree programs in engineering technology. These programs, which usually include various hands-on laboratory classes that focus on current issues in the application of engineering principles, prepare students for practical design and production work, rather than for jobs that require more theoretical and scientific knowledge. Graduates of 4-year technology programs may get jobs similar to those obtained by graduates with a bachelor's degree in engineering. Engineering technology graduates, however, are not qualified to register as professional engineers under the same terms as graduates with degrees in engineering. Some employers regard technology program graduates as having skills between those of a technician and an engineer.

Graduate training is essential for engineering faculty positions and many research and development programs, but is not required for the majority of entry-level engineering jobs. Many experienced engineers obtain graduate degrees in engineering or business administration to learn new technology and broaden their education. Many high-level executives in government and industry began their careers as engineers.

About 1,830 programs at colleges and universities offer bachelor's degrees in engineering that are accredited by the Accreditation Board for Engineering and Technology (ABET), Inc., and there are another 710 accredited programs in engineering technology. ABET accreditation is based on a program's faculty, curriculum, and facilities; the achievement of a program's students; program improvements; and institutional commitment to specific principles of quality and ethics. Although most institutions offer programs in the major branches of engineering, only a few offer programs in the smaller specialties. Also, programs of the same title may vary in content. For example, some programs emphasize industrial practices, preparing students for a job in industry, whereas others are more theoretical and are designed to prepare students for graduate work. Therefore, students should investigate curriculums and check accreditations carefully before selecting a college.

Admissions requirements for undergraduate engineering schools include a solid background in mathematics (algebra, geometry, trigonometry, and calculus) and science (biology, chemistry, and physics), with courses in English, social studies, and humanities. Bachelor's degree programs in engineering typically are designed to last 4 years, but many students find that it takes between 4 and 5 years to complete their studies. In a typical 4-year college curriculum, the first 2 years are spent studying mathematics, basic sciences, introductory engineering, humanities, and social sciences. In the last 2 years, most courses are in engineering, usually with a concentration in one specialty. Some programs offer a general engineering curriculum; students then specialize on the job or in graduate school.

Some engineering schools have agreements with 2-year colleges whereby the college provides the initial engineering education, and the engineering school automatically admits students for their last 2 years. In addition, a few engineering schools have arrangements that allow students who spend 3 years in a liberal arts college studying pre-engineering subjects and 2 years in an engineering school studying core subjects to receive a bachelor's degree from each school. Some colleges and universities offer 5-year master's degree programs. Some 5-year or even 6-year cooperative plans combine classroom study and practical work, permitting students to gain valuable experience and to finance part of their education.

Licensure. All 50 States and the District of Columbia require licensure for engineers who offer their services directly to the public. Engineers who are licensed are called professional engineers (PE). This licensure generally requires a degree from an ABET-accredited engineering program, 4 years of relevant work experience, and successful completion of a State examination. Recent graduates can start the licensing process by taking the examination in two stages. The initial Fundamentals of Engineering (FE) examination can be taken upon graduation. Engineers who pass this examination commonly are called engineers in training (EIT) or engineer interns (EI). After acquiring suitable work experience, EITs can take the second examination, the Principles and Practice of Engineering exam. Several States have imposed mandatory continuing education requirements for relicensure. Most States recognize licensure from other States, provided that the manner in which the initial license was obtained meets or exceeds their own licensure requirements. Many civil, electrical, mechanical, and chemical engineers are licensed PEs. Independent of licensure, various certification programs are offered by professional organizations to demonstrate competency in specific fields of engineering.

Other qualifications. Engineers should be creative, inquisitive, analytical, and detail oriented. They should be able to work as part of a team and to communicate well, both orally and in writing. Communication abilities are becoming increasingly important as engineers frequently interact with specialists in a wide range of fields outside engineering.

Certification and advancement. Beginning engineering graduates usually work under the supervision of experienced engineers and, in large companies, also may receive formal classroom or seminar-type training. As new engineers gain knowledge and experience, they are assigned more difficult projects with greater independence to develop designs, solve problems, and make decisions. Engineers may advance to become technical specialists or to supervise a staff or team of engineers and technicians. Some may eventually become engineering managers or enter other managerial or sales jobs. In sales, an engineering background enables them to discuss a product's technical aspects and assist in product planning, installation, and use. (See the statements under management and business and financial operations occupations, and the statement on sales engineers elsewhere in the *Handbook*.)

Numerous professional certifications for engineers exist and may be beneficial for advancement to senior technical or managerial positions. Many certification programs are offered by the professional societies listed as sources of additional information for engineering specialties at the end of this statement.

Employment

In 2006, engineers held about 1.5 million jobs. The distribution of employment by engineering specialty follows:

Civil engineers	256,000
Mechanical engineers	227,000
Industrial engineers	201,000
Electrical engineers	153,000
Electronics engineers, except computer	138,000
Aerospace engineers	90,000
Computer hardware engineers	79,000
Environmental engineers	54,000
Chemical engineers	30,000
Health and safety engineers, except mining safety engineers and inspectors	25,000
Materials engineers	22,000
Petroleum engineers	17,000
Nuclear engineers	15,000
Biomedical engineers	14,000
Marine engineers and naval architects	9,200
Mining and geological engineers, including mining safety engineers	7,100
Agricultural engineers	3,100
All other engineers	170,000

About 37 percent of engineering jobs were found in manufacturing industries and another 28 percent were in the professional, scientific, and technical services sector, primarily in architectural, engineering, and related services. Many engineers also worked in the construction, telecommunications, and wholesale trade industries.

Federal, State, and local governments employed about 12 percent of engineers in 2006. About half of these were in the Federal Government, mainly in the U.S. Departments of Defense, Transportation, Agriculture, Interior, and Energy, and in the National Aeronautics and Space Administration. Most en-

Table 1. Percent concentration of engineering specialty employment in key industries, 2006

Specialty	Industry	Percent
Aerospace engineers	Aerospace product and parts manufacturing	49
Agricultural engineers	Food manufacturing	25
	Architectural, engineering, and related services	15
Biomedical engineers	Medical equipment and supplies manufacturing	20
	Scientific research and development services	20
Chemical engineers	Chemical manufacturing	29
	Architectural, engineering, and related services	15
Civil engineers	Architectural, engineering, and related services	49
Computer hardware engineers	Computer and electronic product manufacturing	41
	Computer systems design and related services	19
Electrical engineers	Architectural, engineering, and related services	21
Electronics engineers, except computer	Computer and electronic product manufacturing	26
	Telecommunications	15
Environmental engineers	Architectural, engineering, and related services	29
	State and local government	21
Health and safety engineers, except mining safety engineers and inspectors	State and local government	10
Industrial engineers	Transportation equipment manufacturing	18
	Machinery manufacturing	8
Marine engineers and naval architects	Architectural, engineering, and related services	29
Materials engineers	Primary metal manufacturing	11
	Semiconductor and other electronic component manufacturing	9
Mechanical engineers	Architectural, engineering, and related services	22
	Transportation equipment manufacturing	14
Mining and geological engineers, including mining safety engineers	Mining	58
Nuclear engineers	Research and development in the physical, engineering, and life sciences	30
	Electric power generation, transmission and distribution	27
Petroleum engineers	Oil and gas extraction	43

gineers in State and local government agencies worked in highway and public works departments. In 2006, about 3 percent of engineers were self-employed, many as consultants.

Engineers are employed in every State, in small and large cities and in rural areas. Some branches of engineering are concentrated in particular industries and geographic areas—for example, petroleum engineering jobs tend to be located in areas with sizable petroleum deposits, such as Texas, Louisiana, Oklahoma, Alaska, and California. Others, such as civil engineering, are widely dispersed, and engineers in these fields often move from place to place to work on different projects.

Engineers are employed in every major industry. The industries employing the most engineers in each specialty are given in table 1, along with the percent of occupational employment in the industry.

Job Outlook

Employment of engineers is expected to grow about as fast as the average for all occupations over the next decade, but growth will vary by specialty. Environmental engineers should experience the fastest growth, while civil engineers should see the largest employment increase. Overall job opportunities in engineering are expected to be good.

Overall employment change. Overall engineering employment is expected to grow by 11 percent over the 2006-16 decade, about as fast as the average for all occupations. Engineers have traditionally been concentrated in slower growing or declining manufacturing industries, in which they will continue to be needed to design, build, test, and improve manufactured products. However, increasing employment of engineers in faster growing service industries should generate most of the employment growth. Job outlook varies by engineering specialty, as discussed later.

Competitive pressures and advancing technology will force companies to improve and update product designs and to optimize their manufacturing processes. Employers will rely on engineers to increase productivity and expand output of goods and services. New technologies continue to improve the design process, enabling engineers to produce and analyze various product designs much more rapidly than in the past. Unlike in some other occupations, however, technological advances are not expected to substantially limit employment opportunities in engineering because engineers will continue to develop new products and processes that increase productivity.

Offshoring of engineering work will likely dampen domestic employment growth to some degree. There are many well-trained, often English-speaking engineers available around the world willing to work at much lower salaries than U.S. engineers. The rise of the Internet has made it relatively easy for part of the engineering work previously done by engineers in this country to be done by engineers in other countries, a factor that will tend to hold down employment growth. Even so, there will always be a need for onsite engineers to interact with other employees and clients.

Overall job outlook. Overall job opportunities in engineering are expected to be good because the number of engineering graduates should be in rough balance with the number of job openings between 2006 and 2016. In addition to openings from job growth, many openings will be created by the need to replace current engineers who retire; transfer to management, sales, or other occupations; or leave engineering for other reasons.

Many engineers work on long-term research and development projects or in other activities that continue even during economic slowdowns. In industries such as electronics and aerospace, however, large cutbacks in defense expenditures and in government funding for research and development have resulted in significant layoffs of engineers in the past. The trend toward contracting for engineering work with engineering services firms, both domestic and foreign, has also made engineers more vulnerable to layoffs during periods of lower demand.

It is important for engineers, as it is for workers in other technical and scientific occupations, to continue their education throughout their careers because much of their value to their employer depends on their knowledge of the latest technology. Engineers in high-technology areas, such as biotechnology or information technology, may find that technical knowledge becomes outdated rapidly. By keeping current in their field, engineers are able to deliver the best solutions and greatest value to their employers. Engineers who have not kept current in their field may find themselves at a disadvantage when seeking promotions or during layoffs.

Employment change and job outlook by engineering specialty.

- Aerospace engineers are expected to have 10 percent growth in employment over the projections decade, about as fast as the average for all occupations. Increases in the number and scope of military aerospace projects likely will generate new jobs. In addition, new technologies expected to be used on commercial aircraft produced during the next decade should spur demand for aerospace engineers. The employment outlook for aerospace engineers appears favorable. The number of degrees granted in aerospace engineering has declined for many years because of a perceived lack of opportunities in this field. Although this trend has reversed, new graduates continue to be needed to replace aerospace engineers who retire or leave the occupation for other reasons.
- Agricultural engineers are expected to have employment growth of 9 percent over the projections decade, about as fast as the average for all occupations. More engineers will be needed to meet the increasing demand for using biosensors to determine the optimal treatment of crops. Employment growth should also result from the need to increase crop yields to feed an expanding population and produce crops used as renewable energy sources. Moreover, engineers will be needed to develop more efficient agricultural production and conserve resources.
- Biomedical engineers are expected to have 21 percent employment growth over the projections decade, much faster than the average for all occupations. The aging of the population and the focus on health issues will drive demand for better medical devices and equipment designed by biomedical engineers. Along with the demand for more sophisticated medical equipment and procedures, an increased concern for cost-effectiveness will boost demand for biomedical engineers, particularly in pharmaceutical manufacturing and related industries. However, because of the growing interest in this field, the number of degrees granted in biomedical engineering has increased

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Engineers	17-2000	1,512,000	1,671,000	160,000	11
Aerospace engineers	17-2011	90,000	99,000	9,200	10
Agricultural engineers	17-2021	3,100	3,400	300	9
Biomedical engineers	17-2031	14,000	17,000	3,000	21
Chemical engineers	17-2041	30,000	33,000	2,400	8
Civil engineers	17-2051	256,000	302,000	46,000	18
Computer hardware engineers	17-2061	79,000	82,000	3,600	5
Electrical and electronics engineers	17-2070	291,000	306,000	15,000	5
Electrical engineers	17-2071	153,000	163,000	9,600	6
Electronics engineers, except computer	17-2072	138,000	143,000	5,100	4
Environmental engineers	17-2081	54,000	68,000	14,000	25
Industrial engineers, including health and safety	17-2110	227,000	270,000	43,000	19
Health and safety engineers, except mining safety engineers and inspectors	17-2111	25,000	28,000	2,400	10
Industrial engineers	17-2112	201,000	242,000	41,000	20
Marine engineers and naval architects	17-2121	9,200	10,000	1,000	11
Materials engineers	17-2131	22,000	22,000	900	4
Mechanical engineers	17-2141	226,000	235,000	9,400	4
Mining and geological engineers, including mining safety engineers	17-2151	7,100	7,800	700	10
Nuclear engineers	17-2161	15,000	16,000	1,100	7
Petroleum engineers	17-2171	17,000	18,000	900	5
Engineers, all other	17-2199	170,000	180,000	9,400	6

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

greatly. Biomedical engineers, particularly those with only a bachelor's degree, may face competition for jobs. Unlike many other engineering specialties, a graduate degree is recommended or required for many entry-level jobs.

• Chemical engineers are expected to have employment growth of 8 percent over the projections decade, about as fast as the average for all occupations. Although overall employment in the chemical manufacturing industry is expected to decline, chemical companies will continue to research and develop new chemicals and more efficient processes to increase output of existing chemicals. Among manufacturing industries, pharmaceuticals may provide the best opportunities for jobseekers. However, most employment growth for chemical engineers will be in service-providing industries such as professional, scientific, and technical services, particularly for research in energy and the developing fields of biotechnology and nanotechnology.

• Civil engineers are expected to experience 18 percent employment growth during the projections decade, faster than the average for all occupations. Spurred by general population growth and the related need to improve the Nation's infrastructure, more civil engineers will be needed to design and construct or expand transportation, water supply, and pollution control systems and buildings and building complexes. They also will be needed to repair or replace existing roads, bridges, and other public structures. Because construction industries and architectural, engineering and related services employ many civil engineers, employment opportunities will vary by geographic area and may decrease during economic slowdowns, when construction is often curtailed.

• Computer hardware engineers are expected to have 5 percent employment growth over the projections decade, slower than the average for all occupations. Although the use of information technology continues to expand rapidly, the manufacture of computer hardware is expected to be adversely affected by intense foreign competition. As computer and semiconductor manufacturers contract out more of their engineering needs to both domestic and foreign design firms, much of the growth in employment of hardware engineers is expected in the computer systems design and related services industry.

• Electrical engineers are expected to have employment growth of 6 percent over the projections decade, slower than the average for all occupations. Although strong demand for electrical devices—including electric power generators, wireless phone transmitters, high-density batteries, and navigation systems—should spur job growth, international competition and the use of engineering services performed in other countries will limit employment growth. Electrical engineers working in firms providing engineering expertise and design services to manufacturers should have better job prospects.

• Electronics engineers, except computer are expected to have employment growth of 4 percent during the projections decade, slower than the average for all occupations. Although rising demand for electronic goods—including communications equipment, defense-related equipment, medical electronics, and consumer products—should continue to increase demand for electronics engineers, foreign competition in electronic products development and the use of engineering services performed

Overall job opportunities in engineering are expected to be good.

in other countries will limit employment growth. Growth is expected to be fastest in service-providing industries—particularly in firms that provide engineering and design services.

• Environmental engineers should have employment growth of 25 percent during the projections decade, much faster than the average for all occupations. More environmental engineers will be needed to comply with environmental regulations and to develop methods of cleaning up existing hazards. A shift in emphasis toward preventing problems rather than controlling those that already exist, as well as increasing public health concerns resulting from population growth, also are expected to spur demand for environmental engineers. Because of this employment growth, job opportunities should be good even as more students earn degrees. Even though employment of environmental engineers should be less affected by economic conditions than most other types of engineers, a significant economic downturn could reduce the emphasis on environmental protection, reducing job opportunities.

• Health and safety engineers, except mining safety engineers and inspectors are projected to experience 10 percent employment growth over the projections decade, about as fast as the average for all occupations. Because health and safety engineers make production processes and products as safe as possible, their services should be in demand as concern increases for health and safety within work environments. As new technologies for production or processing are developed, health and safety engineers will be needed to ensure that they are safe.

- Industrial engineers are expected to have employment growth of 20 percent over the projections decade, faster than the average for all occupations. As firms look for new ways to reduce costs and raise productivity, they increasingly will turn to industrial engineers to develop more efficient processes and reduce costs, delays, and waste. This should lead to job growth for these engineers, even in manufacturing industries with slowly growing or declining employment overall. Because their work is similar to that done in management occupations, many industrial engineers leave the occupation to become managers. Many openings will be created by the need to replace industrial engineers who transfer to other occupations or leave the labor force.
- Marine engineers and naval architects are expected to experience employment growth of 11 percent over the projections decade, about as fast as the average for all occupations. Strong demand for naval vessels and recreational small craft should more than offset the long-term decline in the domestic design and construction of large oceangoing vessels. Good prospects are expected for marine engineers and naval architects because of growth in employment, the need to replace workers who retire or take other jobs, and the limited number of students pursuing careers in this occupation.
- Materials engineers are expected to have employment growth of 4 percent over the projections decade, slower than the average for all occupations. Although employment is expected to decline in many of the manufacturing industries in which materials engineers are concentrated, growth should be strong for materials engineers working on nanomaterials and biomaterials. As manufacturing firms contract for their materials engineering needs, employment growth is expected in professional, scientific, and technical services industries also.
- Mechanical engineers are projected to have 4 percent employment growth over the projections decade, slower than the average for all occupations. This is because total employment in manufacturing industries—in which employment of mechanical engineers is concentrated—is expected to decline. Some new job opportunities will be created due to emerging technologies in biotechnology, materials science, and nanotechnology. Additional opportunities outside of mechanical engineering will exist because the skills acquired through earning a degree in mechanical engineering often can be applied in other engineering specialties.
- Mining and geological engineers, including mining safety engineers are expected to have 10 percent employment growth over the projections decade, about as fast as the average for all occupations. Following a lengthy period of decline, strong growth in demand for minerals and increased use of mining engineers in the oil and gas extraction industry is expected to create some employment growth over the 2006-16 period. Moreover, many mining engineers currently employed are approaching retirement age, a factor that should create additional job openings. Furthermore, relatively few schools offer mining engineering programs, resulting in good job opportunities for graduates. The best opportunities may require frequent travel or even living overseas for extended periods of time as mining operations around the world recruit graduates of U.S. mining engineering programs.
- Nuclear engineers are expected to have employment growth of 7 percent over the projections decade, about as fast as the average for all occupations. Most job growth will be in research and development and engineering services. Although no commercial nuclear power plants have been built in the United States for many years, nuclear engineers will be needed to operate existing plants and design new ones, including researching future nuclear power sources. They also will be needed to work in defense-related areas, to develop nuclear medical technology, and to improve and enforce waste management and safety standards. Nuclear engineers are expected to have good employment opportunities because the small number of nuclear engineering graduates is likely to be in rough balance with the number of job openings.

Table 2: Earnings distribution by engineering specialty, May 2006

Specialty	Lowest 10%	Lowest 25%	Median	Highest 25%	Highest 10%
Aerospace engineers	59,610	71,360	87,610	106,450	124,550
Agricultural engineers	42,390	53,040	66,030	80,370	96,270
Biomedical engineers	44,930	56,420	73,930	93,420	116,330
Chemical engineers	50,060	62,410	78,860	98,100	118,670
Civil engineers	44,810	54,520	68,600	86,260	104,420
Computer hardware engineers	53,910	69,500	88,470	111,030	135,260
Electrical engineers	49,120	60,640	75,930	94,050	115,240
Electronics engineers, except computer	52,050	64,440	81,050	99,630	119,900
Environmental engineers	43,180	54,150	69,940	88,480	106,230
Health and safety engineers, except mining safety engineers and inspectors	41,050	51,630	66,290	83,240	100,160
Industrial engineers	44,790	55,060	68,620	84,850	100,980
Marine engineers and naval architects	45,200	56,280	72,990	90,790	113,320
Materials engineers	46,120	57,850	73,990	92,210	112,140
Mechanical engineers	45,170	55,420	69,850	87,550	104,900
Mining and geological engineers, including mining safety engineers	42,040	54,390	72,160	94,110	128,410
Nuclear engineers	65,220	77,920	90,220	105,710	124,510
Petroleum engineers	57,960	75,880	98,380	123,130	145,600+
All other engineers	46,080	62,710	81,660	100,320	120,610

Table 3: Average starting salary by engineering specialty and degree , 2007

Curriculum	Bachelor's	Master's	Ph.D.
Aerospace/aeronautical/ astronautical	$53,408	$62,459	$73,814
Agricultural	49,764	—	—
Architectual	48,664	—	—
Bioengineering and biomedical	51,356	59,240	—
Chemical	59,361	68,561	73,667
Civil	48,509	48,280	62,275
Computer	56,201	60,000	92,500
Electrical/electronics and communications	55,292	66,309	75,982
Environmental/ environmental health	47,960	—	—
Industrial/manufacturing	55,067	64,759	77,364
Materials	56,233	—	—
Mechanical	54,128	62,798	72,763
Mining and mineral	54,381	—	—
Nuclear	56,587	59,167	—
Petroleum	60,718	57,000	—

Source: National Association of Colleges and Employers

•Petroleum engineers are expected to have 5 percent employment growth over the projections decade, more slowly than the average for all occupations. Even though most of the potential petroleum-producing areas in the United States already have been explored, petroleum engineers will increasingly be needed to develop new methods of extracting more resources from existing sources. Favorable opportunities are expected for petroleum engineers because the number of job openings is likely to exceed the relatively small number of graduates. Petroleum engineers work around the world and, in fact, the best employment opportunities may include some work in other countries.

Earnings

Earnings for engineers vary significantly by specialty, industry, and education. Variation in median earnings and in the earnings distributions for engineers in various specialties is especially significant. Table 2 shows wage-and-salary earnings distributions in May 2006 for engineers in specialties covered in this statement.

In the Federal Government, mean annual salaries for engineers ranged from $75,144 in agricultural engineering to $107,546 in ceramic engineering in 2007.

As a group, engineers earn some of the highest average starting salaries among those holding bachelor's degrees. Table 3 shows average starting salary offers for engineers, according to a 2007 survey by the National Association of Colleges and Employers.

Related Occupations

Engineers apply the principles of physical science and mathematics in their work. Other workers who use scientific and mathematical principles include architects, except landscape and naval; engineering and natural sciences managers; computer and information systems managers; computer programmers; computer software engineers; mathematicians; drafters; engineering technicians; sales engineers; science technicians; and physical and life scientists, including agricultural and food scientists, biological scientists, conservation scientists and foresters, atmospheric scientists, chemists and materials scientists, environmental scientists and hydrologists, geoscientists, and physicists and astronomers.

Sources of Additional Information

Information about careers in engineering is available from:

➤ JETS, 1420 King St., Suite 405, Alexandria, VA 22314. Internet: **http://www.jets.org**

Information on ABET-accredited engineering programs is available from:

➤ ABET, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202. Internet: **http://www.abet.org**

Those interested in information on the Professional Engineer licensure should contact:

➤ National Council of Examiners for Engineering and Surveying, P.O. Box 1686, Clemson, SC 29633.
Internet: **http://www.ncees.org**

➤ National Society of Professional Engineers, 1420 King St., Alexandria, VA 22314. Internet: **http://www.nspe.org**

Information on general engineering education and career resources is available from:

➤ American Society for Engineering Education, 1818 N St.NW., Suite 600, Washington, DC 20036.
Internet: **http://www.asee.org**

Information on obtaining engineering positions with the Federal Government is available from the Office of Personnel Management through USAJOBS, the Federal Government's official employment information system. This resource for locating and applying for job opportunities can be accessed through the Internet at **http://www.usajobs.opm.gov** or through an interactive voice response telephone system at (703) 724-1850 or TDD (978) 461-8404. These numbers are not toll free, and charges may result. For advice on how to find and apply for Federal jobs, see the Occupational Outlook Quarterly article "How to get a job in the Federal Government," online at:
http://www.bls.gov/opub/ooq/2004/summer/art01.pdf.

For more detailed information on an engineering specialty, contact societies representing the individual branches of engineering. Each can provide information about careers in the particular branch.

Aerospace engineers

➤ Aerospace Industries Association, 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209.
Internet: **http://www.aia-aerospace.org**

➤ American Institute of Aeronautics and Astronautics, Inc., 1801 Alexander Bell Dr., Suite 500, Reston, VA 20191.
Internet: **http://www.aiaa.org**

Agricultural engineers

➤ American Society of Agricultural and Biological Engineers, 2950 Niles Rd., St.Joseph, MI 49085.
Internet: **http://www.asabe.org**

Biomedical engineers

➤ Biomedical Engineering Society, 8401 Corporate Dr., Suite 140, Landover, MD 20785. Internet: **http://www.bmes.org**

Chemical engineers

➤ American Chemical Society, Department of Career Services, 1155 16th St.NW., Washington, DC 20036.
Internet: **http://www.chemistry.org**

➤ American Institute of Chemical Engineers, 3 Park Ave., New York, NY 10016. Internet: **http://www.aiche.org**

Civil engineers

➤ American Society of Civil Engineers, 1801 Alexander Bell Dr., Reston, VA 20191.
Internet: **http://www.asce.org**

Computer hardware engineers

➤ IEEE Computer Society, 1730 Massachusetts Ave. NW., Washington, DC 20036. Internet: **http://www.computer.org**

Electrical and electronics engineers

➤ Institute of Electrical and Electronics Engineers–USA, 1828 L St.NW., Suite 1202, Washington, DC 20036.
Internet: **http://www.ieeeusa.org**

Environmental engineers

➤ American Academy of Environmental Engineers, 130 Holiday Court, Suite 100, Annapolis, MD 21401.
Internet: **http://www.aaee.net**

Health and safety engineers

➤ American Society of Safety Engineers, 1800 E Oakton St., Des Plaines, IL 60018. Internet: **http://www.asse.org**

➤ Board of Certified Safety Professionals, 208 Burwash Ave., Savoy, IL 61874. Internet: **http://www.bcsp.org**

Industrial engineers

➤ Institute of Industrial Engineers, 3577 Parkway LaNE., Suite 200, Norcross, GA 30092. Internet: **http://www.iienet.org**

Marine engineers and naval architects

➤ Society of Naval Architects and Marine Engineers, 601 Pavonia Ave., Jersey City, NJ 07306. Internet: **http://www.sname.org**

Materials engineers

➤ ASM International, 9639 Kinsman Rd., Materials Park, OH 44073. Internet: **http://www.asminternational.org**

➤ Minerals, Metals, and Materials Society, 184 Thorn Hill Rd., Warrendale, PA 15086. Internet: **http://www.tms.org**

Mechanical engineers

➤ American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle NE., Atlanta, GA 30329. Internet: **http://www.ashrae.org**

➤ American Society of Mechanical Engineers, 3 Park Ave., New York, NY 10016. Internet: **http://www.asme.org**

➤ SAE International, 400 Commonwealth Dr., Warrendale, PA 15096. Internet: **http://www.sae.org**

Mining and geological engineers, including mining safety engineers

➤ Society for Mining, Metallurgy, and Exploration, Inc., 8307 Shaffer Parkway, Littleton, CO 80127.
Internet: **http://www.smenet.org**

Nuclear engineers

➤ American Nuclear Society, 555 North Kensington Ave., La Grange Park, IL 60526. Internet: **http://www.ans.org**

Petroleum engineers

➤ Society of Petroleum Engineers, P.O. Box 833836, Richardson, TX 75083. Internet: **http://www.spe.org**

Environmental Scientists and Hydrologists

(O*NET 19-2041.00, 19-2043.00)

Significant Points

- Environmental scientists and hydrologists often work in offices, laboratories, and field sites.
- Federal, State, and local governments employ 43 percent of all environmental scientists and hydrologists.
- Although a bachelor's degree in an earth science is adequate for a few entry-level jobs, employers prefer a master's degree; a Ph.D. degree generally is required for research or college teaching positions.
- Job prospects are expected to be favorable, particularly for hydrologists.

Nature of the Work

Environmental scientists and hydrologists use their knowledge of the physical makeup and history of the Earth to protect the environment, study the properties of underground and surface waters, locate water and energy resources, predict water-related geologic hazards, and provide environmental site assessments and advice on indoor air quality and hazardous-waste-site remediation.

Environmental scientists conduct research to identify, abate, and eliminate hazards that affect people, wildlife, and their environments. These workers analyze measurements or observations of air, food, water, and soil to determine the way to clean and preserve the environment. Understanding the issues involved in protecting the environment—degradation, conservation, recycling, and replenishment—is central to the work of environmental scientists. They often use this understanding to design and monitor waste disposal sites, preserve water supplies, and reclaim contaminated land and water to comply with Federal environmental regulations. They also write risk assessments, describing the likely affect of construction and other environmental changes; write technical proposals; and give presentations to managers and regulators.

Hydrologists study the quantity, distribution, circulation, and physical properties of bodies of water. Often, they specialize in either underground water or surface water. They examine the form and intensity of precipitation, its rate of infiltration into the soil, its movement through the Earth, and its return to the ocean and atmosphere. Hydrologists use sophisticated techniques and instruments. For example, they may use remote sensing technology, data assimilation, and numerical modeling to monitor the change in regional and global water cycles. Some surface-water hydrologists use sensitive stream-measuring devices to assess flow rates and water quality.

Many environmental scientists and hydrologists work at consulting firms, helping businesses and government agencies comply with environmental policy, particularly with regard to ground-water decontamination and flood control. They are usually hired to solve problems. Most consulting firms fall into two categories: large multidisciplinary engineering companies, the largest of which may employ thousands of workers, and small niche firms that may employ only a few workers. When looking for jobs, environmental scientists and hydrologists should consider the type of firm and the scope of the projects it undertakes. In larger firms, environmental scientists are more likely to engage in large, long-term projects in which they will work with people in other scientific disciplines. In smaller specialty firms, however, they work more often with business professionals and clients in government and the private sector.

Environmental scientists who work on policy formation may help identify ways that human behavior can be modified in the future to avoid such problems as ground-water contamination and depletion of the ozone layer. Some environmental scientists work in managerial positions, usually after spending some time performing research or learning about environmental laws and regulations.

Many environmental scientists do work and have training that is similar to other physical or life scientists, but they focus on environmental issues. Many specialize in subfields such as environmental ecology and conservation, environmental chemistry, environmental biology, or fisheries science. Specialties affect the specific activities that environmental scientists perform, although recent understandings of the interconnectedness of life processes have blurred some traditional classifications. For example, *environmental ecologists* study the relationships between organisms and their environments and the effects of factors such as population size, pollutants, rainfall, temperature, and altitude, on both. They may collect, study, and report data on air, soil, and water using their knowledge of various scientific disciplines. *Ecological modelers* study ecosystems, pollution control, and resource management using mathematical modeling, systems analysis, thermodynamics, and computer techniques. *Environmental chemists* study the toxicity of various chemicals, that is, how those chemicals affect plants, animals, and people. (Information on geoscientists, who also study the Earth, is located elsewhere in the *Handbook*.)

Environmental scientists and hydrologists in research positions with the Federal Government or in colleges and universities often have to find funding for their work by writing grant proposals. Consultants face similar pressures to market their skills and write proposals so that they will have steady work.

Work environment. Most entry-level environmental scientists and hydrologists spend the majority of their time in the field, while more experienced workers generally devote more time to office or laboratory work. Many beginning hydrologists and some environmental scientists, such as environmental ecologists and environmental chemists, often take field trips that involve physical activity. Environmental scientists and hydrologists in the field may work in warm or cold climates, in all kinds of weather. In their research, they may dig or chip with a hammer, scoop with a net, come in contact with water, and carry equipment. Travel often is required to meet with prospective clients or investors.

Researchers and consultants might face stress when looking for funding. Occasionally, those who write technical reports to business clients and regulators may be under pressure to meet deadlines and thus have to work long hours.

Environmental scientists and hydrologists work in labratories, offices, and in the field.

Training, Other Qualifications, and Advancement

Most environmental scientists and hydrologists need a master's degree. A Ph.D. is usually necessary for jobs in college teaching or research.

Education and training. A bachelor's degree in an earth science is adequate for a few entry-level positions, but environmental scientists increasingly need a master's degree in environmental science, hydrology, or a related natural science. A master's degree also is the minimum educational requirement for most entry-level applied research positions in private industry, in State and Federal agencies, and at State geological surveys. A doctoral degree generally is necessary for college teaching and most research positions.

Some environmental scientists have a degree in environmental science. Many, however, earn degrees in life science, chemistry, geology, geophysics, atmospheric science, or physics and then apply their education to the environment. They often need research or work experience related to environmental science.

A bachelor's degree in environmental science offers an interdisciplinary approach to the natural sciences, with an emphasis on biology, chemistry, and geology. Undergraduate environmental science majors typically focus on data analysis and physical geography, which are particularly useful in studying pollution abatement, water resources, or ecosystem protection, restoration, and management. Understanding the geochemistry of inorganic compounds is becoming increasingly important in developing remediation goals. Students interested in working in the environmental or regulatory fields, either in environmental consulting firms or for Federal or State governments, should take courses in hydrology, hazardous-waste management, environmental legislation, chemistry, fluid mechanics, and geologic logging, which is the gathering of geologic data. An understanding of environmental regulations and government permit issues also is valuable for those planning to work in mining and oil and gas extraction.

Students interested in hydrology should take courses in the physical sciences, geophysics, chemistry, engineering science, soil science, mathematics, aquatic biology, atmospheric science, geology, oceanography, hydrogeology, and the management or conservation of water resources. In some cases, a bachelor's degree in a hydrologic science is sufficient for positions consulting about water quality or wastewater treatment.

For environmental scientists and hydrologists who consult, courses in business, finance, marketing, or economics may be useful. In addition, combining environmental science training with other disciplines such as engineering or business, qualifies these scientists for the widest range of jobs.

Other qualifications. Computer skills are essential for prospective environmental scientists and hydrologists. Students who have some experience with computer modeling, data analysis and integration, digital mapping, remote sensing, and Geographic Information Systems (GIS) will be the most prepared to enter the job market. Familiarity with the Global Positioning System (GPS)—a locator system that uses satellites—is vital.

Environmental scientists and hydrologists must have good interpersonal skills, because they usually work as part of a team with other scientists, engineers, and technicians. Strong oral and written communication skills also are essential because writing technical reports and research proposals and communicating results to company managers, regulators, and the public are important aspects of the work. Because international work is becoming increasingly pervasive, knowledge of a second language can be an advantage. Those involved in fieldwork must have physical stamina.

Certification and advancement. Environmental scientists and hydrologists often begin their careers in field exploration or, occasionally, as research assistants or technicians in laboratories or offices. They are given more difficult assignments as they gain experience. Eventually, they may be promoted to project leader, program manager, or some other management and research position. (Information on engineering and natural science managers is located elsewhere in the *Handbook*.)

The American Institute of Hydrology offers certification programs in professional hydrology. Certification may be beneficial for those seeking advancement.

Employment

Environmental scientists and hydrologists held about 92,000 jobs in 2006. Jobs for hydrologists accounted for only 9 percent of the total. Many more individuals held environmental science faculty positions in colleges and universities, but they are classified as postsecondary teachers. (See the statement on teachers—postsecondary elsewhere in the *Handbook*.)

About 35 percent of environmental scientists were employed in State and local governments; 21 percent in management, scientific, and technical consulting services; 15 percent in architectural, engineering and related services; and 8 percent in the Federal Government. About 2 percent were self-employed.

Among hydrologists, 26 percent were employed in architectural, engineering, and related services, and 18 percent worked for management, scientific, and technical consulting services. In 2006, the Federal Government employed about 28 percent of hydrologists, mostly within the U.S. Department of the Interior for the U.S. Geological Survey (USGS) and within the U.S. Department of Defense. Another 21 percent worked for State agencies, such as State geological surveys and State departments of conservation. About 2 percent of hydrologists were self-employed, most as consultants to industry or government.

Job Outlook

Employment of environmental scientists and hydrologists is expected to grow much faster than the average for all occupations. Job prospects are expected to be favorable, particularly for hydrologists.

Employment change. Employment of environmental scientists is expected to increase by 25 percent between 2006 and 2016, much faster than the average for all occupations. Over the same period, employment of hydrologists should increase by 24 percent, also much faster than the average. Job growth for environmental scientists and hydrologists should be strongest in private-sector consulting firms. Growth in employment of environmental scientists and hydrologists will be spurred largely by the increasing demands placed on the environment and water resources by population growth. Further demand should result from the need to comply with complex environmental laws and regulations, particularly those regarding ground-water decontamination, clean air, and flood control.

Much job growth will result from a continued need to monitor the quality of the environment, to interpret the impact of human actions on terrestrial and aquatic ecosystems, and to develop strategies for restoring ecosystems. In addition, environmental scientists will be needed to help planners develop and construct buildings, transportation corridors, and utilities that protect water resources and reflect efficient and beneficial land use.

Demand for hydrologists should also be strong as the population increases and moves to more environmentally sensitive locations. As people increasingly migrate toward coastal regions, for example, hydrologists will be needed to assess building sites for potential geologic hazards and to mitigate the effects of natural hazards such as floods, landslides, and hurricanes.

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Environmental scientists and hydrologists	—	92,000	114,000	23,000	25
Environmental scientists and specialists, including health	19-2041	83,000	104,000	21,000	25
Hydrologists	19-2043	8,300	10,000	2,000	24

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

Hydrologists also will be needed to study hazardous-waste sites and determine the effect of pollutants on soil and ground water so that engineers can design remediation systems. Increased government regulations, such as those regarding the management of storm water, and issues related to water conservation, deteriorating coastal environments, and rising sea levels also will stimulate employment growth for these workers.

Many environmental scientists and hydrologists work in consulting. Consulting firms have hired these scientists to help businesses and government address issues related to underground tanks, land disposal areas, and other hazardous-waste-management facilities. Currently, environmental consulting is evolving from investigations to creating remediation and engineering solutions. At the same time, the regulatory climate is moving from a rigid structure to a more flexible risk-based approach. These factors, coupled with new Federal and State initiatives that integrate environmental activities into the business process itself, will result in a greater focus on waste minimization, resource recovery, pollution prevention, and the consideration of environmental effects during product development. This shift in focus to preventive management will provide many new opportunities for environmental scientists and hydrologists in consulting roles.

Job prospects. In addition to job openings due to growth, there will be additional demand for new environmental scientists and hydrologists to replace those who retire, advance to management positions, or change careers. Job prospects for hydrologists should be favorable, particularly for those with field experience. Demand for hydrologists who understand both the scientific and engineering aspects of waste remediation should be strong. Few colleges and universities offer programs in hydrology, so the number of qualified workers may be limited.

Job prospects for environmental scientists also will be good, but less favorable than for hydrologists because of the larger number of workers seeking to enter the field.

Funding for Federal and State geological surveys depend largely on the political climate and the current budget. Thus, job security for environmental scientists and hydrologists may vary. During periods of economic recession, layoffs of environmental scientists and hydrologists may occur in consulting firms; layoffs are much less likely in government.

Earnings

Median annual earnings of environmental scientists were $56,100 in May 2006. The middle 50 percent earned between $42,840 and $74,480. The lowest 10 percent earned less than $34,590, and the highest 10 percent earned more than $94,670.

Median annual earnings of hydrologists were $66,260 in 2006, with the middle 50 percent earning between $51,370 and $82,140, the lowest 10 percent earning less than $42,080, and the highest 10 percent earning more than $98,320.

Median annual earnings in the industries employing the largest number of environmental scientists in 2006 were as follows:

Federal executive branch	$82,490
Management, scientific, and technical consulting services	57,280
Engineering services	56,080
Local government	52,100
State government	50,590

According to the National Association of Colleges and Employers, beginning salary offers in July 2007 for graduates with bachelor's degrees in an environmental science averaged $38,336 a year.

In 2007, the Federal Government's average salary for hydrologists was $82,217.

Related Occupations

Environmental scientists and hydrologists perform investigations for the purpose of abating or eliminating pollutants or hazards that affect the environment or plants, animals, and humans. Many other occupations deal with preserving or researching the natural environment, including conservation scientists and foresters, atmospheric scientists, and some biological scientists, science technicians, and engineering technicians. Environmental scientists and hydrologists have extensive training in physical sciences, and many apply their knowledge of chemistry, physics, biology, and mathematics to the study of the Earth, work closely related to that of geoscientists.

Using problem-solving skills, physicists; chemists; engineers; mathematicians; surveyors, cartographers, photogrammetrists, and surveying technicians; computer systems analysts; and computer scientists and database administrators may also perform similar work related to the environment.

Sources of Additional Information

Information on training and career opportunities for environmental scientists is available from:

➤ American Geological Institute, 4220 King St., Alexandria, VA 22302. Internet: **http://www.agiweb.org**

For information on careers in hydrology, contact:

➤ American Institute of Hydrology, 300 Village Green Circle, Suite #201, Smyrna, GA 30080.
Internet: **http://www.aihydro.org**

Information on obtaining a position as a hydrologist or an environmental protection specialist with the Federal Government is available from the Office of Personnel Management through USAJOBS, the Federal Government's official employment information system. This resource for locating and applying for job opportunities can be accessed through the Internet at **http://www.usajobs.opm.gov** or through an interactive voice response telephone system at (703) 724-1850 or TDD (978) 461-8404. These numbers are not toll free, and charges may result.

Geoscientists

(O*NET 19-2042)

Significant Points

- Work at remote field sites is common.
- Federal, State, and local governments employ 18 percent of all geoscientists.
- Employers prefer applicants with a master's degree for most positions; a Ph.D. degree is required for most high-level research and college teaching positions.
- Excellent job opportunities are expected for graduates with a master's degree.

Nature of the Work

Geoscientists study the composition, structure, and other physical aspects of the Earth. They study the Earth's geologic past and present by using sophisticated instruments to analyze the composition of earth, rock, and water. Many geoscientists help to search for natural resources such as groundwater, metals, and petroleum. Others work closely with environmental and other scientists to preserve and clean up the environment.

Geoscientists usually study and work in one of several closely related fields of geoscience. *Geologists* study the composition, processes, and history of the Earth. They try to find out how rocks were formed and what has happened to them since their formation. They also study the evolution of life by analyzing plant and animal fossils. *Geophysicists* use the principles of physics, mathematics, and chemistry to study not only the Earth's surface, but also its internal composition, ground and surface waters, atmosphere, oceans, and magnetic, electrical, and gravitational forces.

Within these two major disciplines of geology and geophysics are numerous subspecialties. For example, *petroleum geologists* map the subsurface of the ocean or land as they explore the terrain for oil and gas deposits. They use sophisticated instrumentation and computers to interpret geological information. *Engineering geologists* apply geologic principles to the fields of civil and environmental engineering, offering advice on major construction projects and assisting in environmental remediation and natural hazard-reduction projects. *Mineralogists* analyze and classify minerals and precious stones according to their composition and structure. They study the environment surrounding rocks in order to find new mineral resources. *Sedimentologists* study the nature, origin, distribution, and alteration of sediments, such as sand, silt, and mud. These sediments may contain oil, gas, coal, and many other mineral deposits. *Paleontologists* study fossils found in geological formations to trace the evolution of plant and animal life and the geologic history of the Earth. *Stratigraphers* examine the formation and layering of rocks to understand the environment which formed them. *Volcanologists* investigate volcanoes and volcanic phenomena to try to predict the potential for future eruptions and hazards to human health and welfare. *Glacial geologists* study the physical properties and movement of glaciers and ice sheets. *Geochemists* study the nature and distribution of chemical elements in groundwater and earth materials.

Geophysicists specialize in areas such as geodesy, seismology, and magnetic geophysics. *Geodesists* study the Earth's size, shape, gravitational field, tides, polar motion, and rotation. *Seismologists* interpret data from seismographs and other geophysical instruments to detect earthquakes and locate earthquake-related faults. *Geomagnetists* measure the Earth's magnetic field and use measurements taken over the past few centuries to devise theoretical models that explain the Earth's origin. *Paleomagnetists* interpret fossil magnetization in rocks and sediments from the continents and oceans to record the spreading of the sea floor, the wandering of the continents, and the many reversals of polarity that the Earth's magnetic field has undergone through time. Other geophysicists study atmospheric sciences and space physics. (See the statement on atmospheric scientists, and physicists and astronomers, elsewhere in the *Handbook*.)

Oceanographers use their knowledge of geology and geophysics, in addition to biology and chemistry, to study the world's oceans and coastal waters. They study the motion and circulation of the ocean waters; the physical and chemical properties of the oceans; and how these properties affect coastal areas, climate, and weather. Oceanographers are further broken down according to their areas of expertise. For example, *physical oceanographers* study the tides, waves, currents, temperatures, density, and salinity of the ocean. They examine the interaction of various forms of energy, such as light, radar, sound, heat, and wind, with the sea, in addition to investigating the relationship between the sea, weather, and climate. *Chemical oceanographers* study the distribution of chemical compounds and chemical interactions that occur in the ocean and on the sea floor. They may investigate how pollution affects the chemistry of the ocean. *Geological and geophysical oceanographers* study the topographic features and the physical makeup of the ocean floor. Their knowledge can help companies find oil and gas off coastal waters. (*Biological oceanographers*, often called marine biologists, study the distribution and migration patterns of the many diverse forms of sea life in the ocean; the statement on biological scientists discusses this occupation elsewhere in the *Handbook*.)

Geoscientists in research positions with the Federal Government or in colleges and universities frequently are required to design programs and write grant proposals in order to fund their research. Geoscientists in consulting jobs face similar pressures

Excellent employment opportunities are expected for geoscientists with a master's degree.

to market their skills and write proposals so that they will have steady work.

Work environment. Geoscientists can spend a large part of their time in the field, identifying and examining rocks, studying information collected by remote sensing instruments in satellites, conducting geological surveys, constructing field maps, and using instruments to measure the Earth's gravity and magnetic field. They often perform seismic studies, for example, which involve bouncing energy waves off buried layers of rock, to search for oil and gas or to understand the structure of the subsurface layers. Similarly, they use seismic signals generated by an earthquake to determine the earthquake's location and intensity. In laboratories, geologists and geophysicists examine the chemical and physical properties of specimens. They study fossil remains of animal and plant life or experiment with the flow of water and oil through rocks.

Some geoscientists spend the majority of their time in an office, but many others divide their time between fieldwork and office or laboratory work. Work at remote field sites is common. Many geoscientists, such as volcanologists, often take field trips that involve physical activity. Geoscientists in the field may work in warm or cold climates and in all kinds of weather. In their research, they may dig or chip with a hammer, scoop with a net, and carry equipment in a backpack. Oceanographers may spend considerable time at sea on academic research ships. Geologists frequently travel to remote field sites by helicopter or 4-wheel-drive vehicles and cover large areas on foot. Many exploration geologists and geophysicists work in foreign countries, sometimes in remote areas and under difficult conditions. Travel often is required to meet with prospective clients or investors. Fieldwork often requires working long hours.

Training, Other Qualifications, and Advancement

A master's degree is the primary educational requirement for most entry-level positions. A Ph.D. is necessary for most high-level research and college teaching positions, but a master's degree is preferred for most other geoscience jobs.

Education and training. A bachelor's degree is adequate for a few entry-level positions, but most geoscientists need a master's degree in geology or earth science. A master's degree is the preferred educational requirement for most entry-level research positions in private industry, Federal agencies, and State geological surveys. A Ph.D. is necessary for most high-level research and college teaching positions, but it may not be preferred for other jobs.

Many colleges and universities offer a bachelor's or higher degree in a geoscience. Traditional geoscience courses emphasizing classical geologic methods and topics (such as mineralogy, petrology, paleontology, stratigraphy, and structural geology) are important for all geoscientists. People who study physics, chemistry, biology, mathematics, engineering, or computer science may also qualify for some geoscience positions if their course work includes geology.

Licensure. A number of States require geoscientists who offer their services directly to the public, particularly geologists, to obtain a license from a State licensing board. Licensing requirements vary but often include education, experience, and a passing score on an examination.

Other qualifications. Computer skills are essential for prospective geoscientists; students who have experience with computer modeling, data analysis and integration, digital mapping, remote sensing, and Geographic Information Systems (GIS) will be the most prepared entering the job market. Knowledge of the Global Positioning System (GPS)—a locator system that uses satellites—has also become essential. Some employers seek applicants with field experience, so a summer internship is often helpful.

Geoscientists must have good interpersonal skills because they usually work as part of a team with other geoscientists and with environmental scientists, engineers, and technicians. Strong oral and written communication skills also are important because writing technical reports and research proposals and explaining research results in person are important aspects of the work. Because many jobs require foreign travel, knowledge of a second language is becoming increasingly beneficial.

Geoscientists must be inquisitive, able to think logically, and capable of complex analytical thinking, including spatial visualization and the ability to infer conclusions from sparse data. Those involved in fieldwork must have physical stamina.

Advancement. Geoscientists often begin their careers in field exploration or as research assistants or technicians in laboratories or offices. As they gain experience, they get more assignments that are difficult. Eventually, some are promoted to project leader, program manager, or to a senior research position. Those who choose to work in management will spend more time scheduling, budgeting, and reporting to top executives or clients. (See the statement on engineering and natural sciences managers elsewhere in the *Handbook*.)

Employment

Geoscientists held about 31,000 jobs in 2006. Many more individuals held geoscience faculty positions in colleges and universities, but they are classified as college and university faculty. (See the statement on teachers—postsecondary elsewhere in the *Handbook*.)

About 24 percent of geoscientists were employed in architectural, engineering, and related services, and 18 percent worked for oil and gas extraction companies. In 2006, State agencies such as State geological surveys and State departments of conservation employed about 2,900 geoscientists. Another 2,600 worked for the Federal Government, including geologists, geophysicists, and oceanographers, mostly within the U.S. Department of the Interior for the U.S. Geological Survey (USGS) and within the U.S. Department of Defense. About 2 percent of geoscientists were self-employed, most as consultants to industry or government.

Job Outlook

Although employment growth will vary by industry, overall employment of geoscientists is expected to grow much faster than the average for all occupations. Graduates with a master's degree can expect excellent job opportunities; very few geoscientist jobs are available to bachelor's degree holders. Ph.D.s should face competition for basic research and college teaching jobs.

Employment change. Employment growth of 22 percent for geoscientists is expected between 2006 and 2016, much faster than the average for all occupations. The need for energy, environmental protection, and responsible land and water management will spur employment demand. Employment in management, scientific, and technical consulting services should continue to

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Geoscientists, except hydrologists and geographers.........................	19-2042	31,000	38,000	6,800	22

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

grow as more geoscientists work as consultants. These services have increased their hiring of geoscientists in recent years because of increased government contracting, and private corporations' need for technical assistance and environmental management plans. Moreover, many geoscientists monitor the quality of the environment, including aquatic ecosystems, deteriorating coastal environments, and rising sea levels—all of which will create employment growth for them. An expected increase in highway building and other infrastructure projects will also be a source of jobs for engineering geologists.

Employment is also expected to increase in the oil and gas extraction industry. Many geoscientists work in the exploration and production of oil and gas. Historically, employment of petroleum geologists, geophysicists, and some other geoscientists has been cyclical and affected considerably by the price of oil and gas. When prices are low, oil and gas producers curtail exploration activities and lay off geologists. When prices were higher, companies had the funds and incentive to renew exploration efforts and to hire geoscientists in larger numbers. In recent years, however, a growing worldwide demand for oil and gas and for new exploration and recovery techniques—particularly in deep water and previously inaccessible sites in Alaska and the Gulf of Mexico—has created some stability to the petroleum industry. Geoscientists who speak a foreign language and who are willing to work abroad should enjoy the best opportunities, as the need for energy, construction materials, and a broad range of geoscience expertise grows in developing nations.

Job prospects. Graduates with a master's degree should have excellent opportunities, especially in the management, scientific and technical consulting industry and in the engineering services industries. In addition to demand resulting from job growth, replacing those who leave the occupation for retirement, managerial positions, or other careers will generate a number of jobs. With relatively few students earning master's degrees in the geosciences, job openings may exceed the number of qualified job seekers over the 2006-16 projection decade. However, geoscientists with doctoral degrees, who primarily work as college and university faculty or do basic research, may face competition. There are few openings for new graduates with only a bachelor's degree in geoscience, but these graduates may have favorable opportunities in related occupations, such as high school science teacher or science technician.

There will be fewer opportunities for geoscientists in Federal and State government, mostly because of budget constraints at key agencies, such as the USGS, and the trend among governments toward contracting out to consulting firms instead of hiring new government employees. However, departures of geoscientists who retire or leave the government for other reasons will result in some job openings over the next decade.

Geoscientists may face layoffs during periods of economic recession. Especially vulnerable are those in consulting and, to a lesser extent, workers in Government. Employment for those working in the production of oil and gas, however, will largely be dictated by the cyclical nature of the energy sector and changes in government policy, although less so than in the past.

Earnings

Median annual earnings of geoscientists were $72,660 in May 2006. The middle 50 percent earned between $51,860 and $100,650; the lowest 10 percent earned less than $39,740, the highest 10 percent more than $135,950.

The petroleum, mineral, and mining industries offer higher salaries, but less job security, than other industries because economic downturns sometimes cause layoffs.

According to the National Association of Colleges and Employers, beginning salary offers in July 2007 for graduates with bachelor's degrees in geology and related sciences averaged $40,786 a year.

In 2007, the Federal Government's average salary was $87,392 for geologists, $100,585 for geophysicists, and 93,461 for oceanographers.

Related Occupations

Many geoscientists work in the petroleum and natural gas industry, an industry that also employs numerous other workers whose jobs deal with the scientific and technical aspects of the exploration and extraction of petroleum and natural gas. Among these other workers are engineering technicians; science technicians; petroleum engineers; and surveyors, cartographers, photogrammetrists, and surveying technicians. Also, some physicists and astronomers, chemists and materials scientists, atmospheric scientists, biological scientists, and environmental scientists and hydrologists perform related work both in the exploration and extraction of petroleum and natural gas and in activities having to do with the environment.

Sources of Additional Information

Information on training and career opportunities for geologists is available from either of the following organizations:

- American Association of Petroleum Geologists, P.O. Box 979, Tulsa, OK 74101. Internet: **http://www.aapg.org**
- American Geological Institute, 4220 King St., Alexandria, VA 22302-1502. Internet: **http://www.agiweb.org**

Information on obtaining a position as a geologist, geophysicist, or oceanographer with the Federal Government is available from the Office of Personnel Management through USAJOBS, the Federal Government's official employment information system. This resource for locating and applying for job opportunities can be accessed through the Internet at **http://www.usajobs.opm.gov** or through an interactive voice response telephone system at (703) 724-1850 or TDD (978) 461-8404. These numbers are not toll free, and charges may result.

Landscape Architects

(O*NET 17-1012.00)

Significant Points

- Almost 19 percent of all landscape architects are self-employed—more than 2 times the proportion for all occupations.
- 49 States require landscape architects to be licensed.
- New graduates can expect to face competition for jobs in the largest and most prestigious landscape architecture firms, but there should be good job opportunities overall as demand for landscape architecture services increases.

Nature of the Work

Everyone enjoys attractively designed residential areas, public parks and playgrounds, college campuses, shopping centers, golf courses, and parkways. Landscape architects design these areas so that they are not only functional, but also beautiful, and compatible with the natural environment. They plan the location of buildings, roads, and walkways, and the arrangement of flowers, shrubs, and trees. They also design and plan the restoration of natural places disturbed by humans such as wetlands, stream corridors, mined areas and forested land.

Landscape architects work for many types of organizations—from real estate development firms starting new projects to municipalities constructing airports or parks—and they often are involved with the development of a site from its conception. Working with architects, surveyors, and engineers, landscape architects help determine the best arrangement of roads and buildings. They also collaborate with environmental scientists, foresters, and other professionals to find the best way to conserve or restore natural resources. Once these decisions are made, landscape architects create detailed plans indicating new topography, vegetation, walkways, and other landscaping details, such as fountains and decorative features.

In planning a site, landscape architects first study the project holistically. They also consider the purpose of the project and the funds available. They analyze the natural elements of the site, such as the climate, soil, slope of the land, drainage, and vegetation; observe where sunlight falls on the site at different times of the day; and assess the effect of existing buildings, roads, walkways, and utilities.

After studying and analyzing the site, landscape architects prepare a preliminary design. To address the needs of the client as well as the conditions at the site, they frequently make changes before a final design is approved. They also take into account any local, State, or Federal regulations, such as those protecting wetlands or historic resources. In preparing designs, computer-aided design (CAD) has become an essential tool for most landscape architects. Many landscape architects also use video simulation to help clients envision the proposed ideas and plans. For larger scale site planning, landscape architects also use geographic information systems (GIS) technology, a computer mapping system.

Throughout all phases of planning and design, landscape architects consult with other professionals, such as civil engineers, hydrologists, or architects, involved in the project. Once the design is complete, they prepare a proposal for the client. They produce detailed plans of the site, including written reports, sketches, models, photographs, land-use studies, and cost estimates, and submit them for approval by the client and by regulatory agencies. When the plans are approved, landscape architects prepare working drawings showing all existing and proposed features. They also outline in detail the methods of construction and draw up a list of necessary materials. Landscape architects then monitor the implementation of their design, while general contractors or landscape contractors usually direct the actual construction of the site and installation of plantings.

Some landscape architects work on a variety of projects. Others specialize in a particular area, such as street and highway beautification, waterfront improvement projects, parks and playgrounds, or shopping centers. Still others work in regional planning and resource management; feasibility, environmental impact, and cost studies; or site construction. Increasingly, landscape architects work in environmental remediation, such as preservation and restoration of wetlands or abatement of stormwater run-off in new developments. Historic landscape preservation and restoration is another area where landscape architects increasingly play a role.

Landscape architects who work for government agencies do site and landscape design for government buildings, parks, and other public lands, as well as park and recreation planning in national parks and forests. In addition, they prepare environmental impact statements and studies on environmental issues such as public land-use planning. Some restore degraded land, such as mines or landfills. Others use their skills in traffic-calming, the "art" of slowing traffic through the use of traffic

Landscape architects consult with clients and other professionals throughout the plannining and design of a project.

design, enhancement of the physical environment, and greater attention to aesthetics.

Work environment. Landscape architects spend most of their time in offices creating plans and designs, preparing models and cost estimates, doing research, or attending meetings with clients and other professionals involved in a design or planning project. The remainder of their time is spent at the site. During the design and planning stage, landscape architects visit and analyze the site to verify that the design can be incorporated into the landscape. After the plans and specifications are completed, they may spend additional time at the site observing or supervising the construction. Those who work in large national or regional firms may spend considerably more time out of the office, traveling to sites.

Salaried employees in both government and landscape architectural firms usually work regular hours. However, they may occasionally work overtime to meet a project deadline. Hours of self-employed landscape architects vary depending on the demands of their projects.

Training, Other Qualifications, and Advancement

Almost every state requires landscape architects to be licensed. While requirements vary among the states, they usually include a degree in landscape architecture from an accredited school, work experience, and the passage of the Landscape Architect Registration Exam.

Education and training. A bachelor's or master's degree in landscape architecture usually is necessary for entry into the profession. There are two undergraduate professional degrees: a Bachelor of Landscape Architecture (BLA) and a Bachelor of Science in Landscape Architecture (BSLA). These usually require four or five years of study in design, construction techniques, art, history, natural and social sciences. There are generally two types of graduate degree programs. For those who hold an undergraduate degree in a field other than landscape architecture and intend to become landscape architecture practitioners, the Master of Landscape Architecture (MLA) typically takes three years of full-time study. Those who hold undergraduate degrees in landscape architecture can earn their MLA in two years.

In 2007, 61 colleges and universities offered 79 undergraduate and graduate programs in landscape architecture that were accredited by the Landscape Architecture Accreditation Board of the American Society of Landscape Architects. Courses required in these programs usually include subjects such as surveying, landscape design and construction, landscape ecology, site design, and urban and regional planning. Other courses include history of landscape architecture, plant and soil science, geology, professional practice, and general management. The design studio is another important aspect of many curriculums. Whenever possible, students are assigned real projects, providing them with valuable hands-on experience. While working on these projects, students become proficient in the use of computer-aided design, geographic information systems, and video simulation.

Licensure and certification. As of January 2008, 49 states required landscape architects to be licensed. Licensing is based on the Landscape Architect Registration Examination (L.A.R.E.), sponsored by the Council of Landscape Architectural Registration Boards and administered in two portions, graphic and multiple choice. Admission to the exam usually requires a degree from an accredited school plus 1 to 4 years of work experience under the supervision of a licensed landscape architect, although standards vary from State to State. For those without an accredited landscape architecture degree, most states provide alternative paths to qualify to take the L.A.R.E., usually requiring more work experience. Currently, 15 States require that a State examination be passed in addition to the L.A.R.E. to satisfy registration requirements. State examinations focus on laws, environmental regulations, plants, soils, climate, and any other characteristics unique to the State.

Because requirements for licensure are not uniform, landscape architects may find it difficult to transfer their registration from one State to another. However, those who meet the national standards of graduating from an accredited program, serving 3 years of internship under the supervision of a registered landscape architect, and passing the L.A.R.E. can satisfy requirements in most States. By meeting national requirements, a landscape architect can also obtain certification from the Council of Landscape Architectural Registration Boards which can be useful in obtaining reciprocal licensure in other states.

In States where licensure is required, new hires may be called "apprentices" or "intern landscape architects" until they become licensed. Their duties vary depending on the type and size of the employing firm. They may do project research or prepare working drawings, construction documents, or base maps of the area to be designed. Some are allowed to participate in the actual design of a project. However, interns must perform all work under the supervision of a licensed landscape architect. Additionally, all drawings and specifications must be signed and sealed by the licensed landscape architect, who takes legal responsibility for the work. After gaining experience and becoming licensed, landscape architects usually can carry a design through all stages of development.

Many States require some form of continuing education to maintain a license. Requirements usually involve the completion of workshops, seminars, formal university classes, conferences, self-study courses, or other classes.

The Federal Government does not require its landscape architects to be licensed. Candidates for entry positions with the Federal Government should have a bachelor's or master's degree in landscape architecture.

Other qualifications. People planning a career in landscape architecture should appreciate nature, enjoy working with their hands, and possess strong analytical skills. Creative vision and artistic talent also are desirable qualities. Good oral communication skills are essential. Landscape architects must be able to convey their ideas to other professionals and clients and to make presentations before large groups. Strong writing skills also are valuable, as is knowledge of computer applications of all kinds, including word processing, desktop publishing, and spreadsheets. Landscape architects use these tools to develop presentations, proposals, reports, and land impact studies for clients, colleagues, and superiors. Landscape architects must also be able to draft and design using CAD software. Many employers recommend that prospective landscape architects complete at least one summer internship with a landscape archi-

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Landscape architects	17-1012	28,000	32,000	4,600	16

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

tecture firm to hone their technical skills and to gain an understanding of the day-to-day operations of the business, including how to win clients, generate fees, and work within a budget.

Advancement. After several years, landscape architects may become project managers, taking on the responsibility for meeting schedules and budgets, in addition to overseeing the project design. Later, they may become associates or partners of a firm, with a proprietary interest in the business.

Many landscape architects are self-employed. Self-discipline, business acumen, and good marketing skills are important qualities for those who choose to open their own business. Even with these qualities, however, some may struggle while building a client base.

Those with landscape architecture training also qualify for jobs closely related to landscape architecture, and may, after gaining some experience, become construction supervisors, land or environmental planners, or landscape consultants.

Employment

Landscape architects held about 28,000 jobs in 2006. More than 1 out of 2 landscape architects were employed in architectural, engineering, and related services. State and local governments employed approximately 6 percent of all landscape architects. About 2 out of 10 landscape architects were self-employed.

Employment of landscape architects is concentrated in urban and suburban areas throughout the country; some landscape architects work in rural areas, particularly those employed by the Federal Government to plan and design parks and recreation areas.

Job Outlook

Employment of landscape architects is expected to grow faster than the average for all occupations through the year 2016. There should be good job prospects for landscape architects overall, but opportunities may depend on geographic location and local real estate and construction markets.

Employment change. Employment of landscape architects is expected to increase by 16 percent during the 2006-16 decade, which is faster than the average for all occupations. Employment will grow because the expertise of landscape architects will be sought after in the planning and development of new construction to meet the needs of a growing population. With land costs rising and the public desiring more beautiful spaces, the importance of good site planning and landscape design is growing.

New construction will spur demand for landscape architects to help plan sites that meet with environmental regulations and zoning laws and integrate new structures with the natural environment in the least disruptive way. For example, landscape architects will be needed to manage stormwater run-off to avoid pollution of waterways and conserve water resources. Landscape architects also will be increasingly involved in preserving and restoring wetlands and other environmentally sensitive sites.

Continuation of the Safe, Accountable, Flexible, Efficient, Transportation, Equity Act: A Legacy for Users also is expected to spur employment for landscape architects, particularly in State and local governments. This Act, known as SAFETEA-LU, provides funds for surface transportation and transit programs, such as interstate highway construction and maintenance, pedestrian and bicycle trails, and safe routes to schools.

In addition to the work related to new development and construction, landscape architects are expected to be involved in historic preservation, land reclamation, and refurbishment of existing sites. Additionally, landscape architects will be needed to create security perimeters that are better integrated with their surroundings for many of the Nation's landmarks, monuments, and buildings.

Job prospects. In addition to growth, the need to replace landscape architects who retire or leave the labor force will produce some additional job openings.

Opportunities will vary by year and geographic region, depending on local economic conditions. During a recession, when real estate sales and construction slow down, landscape architects may face greater competition for jobs and sometimes layoffs. But because landscape architects can work on many different types of projects, they may have steadier work than other design professionals when traditional construction slows.

New graduates can expect to face competition for jobs in the largest and most prestigious landscape architecture firms, but there should be good job opportunities overall as demand for landscape architecture services increases. Many employers prefer to hire entry-level landscape architects who have internship experience, which significantly reduces the amount of on-the-job training required. Opportunities will be best for landscape architects who develop strong technical skills—such as computer design—communication skills, and knowledge of environmental codes and regulations. Those with additional training or experience in urban planning increase their opportunities for employment in landscape architecture firms that specialize in site planning as well as landscape design.

Earnings

In May 2006, median annual earnings for landscape architects were $55,140. The middle 50 percent earned between $42,720 and $73,240. The lowest 10 percent earned less than $34,230 and the highest 10 percent earned over $95,420. Architectural, engineering, and related services employed more landscape architects than any other group of industries, and there the median annual earnings were $56,060 in May 2006.

Related Occupations

Landscape architects use their knowledge of design, construction, land-use planning, and environmental issues to develop a landscape project. Others whose work requires similar skills are architects, except landscape and naval; surveyors, cartographers, photogrammetrists, and surveying technicians; civil engineers; and urban and regional planners. Landscape architects also must know how to grow and use plants in the landscape. Some conservation scientists and foresters and biological scientists also study plants and do related work. Environmental scientists and hydrologists, and geoscientists, like many landscape architects, work in the area of environmental remediation.

Sources of Additional Information

Additional information, including a list of colleges and universities offering accredited programs in landscape architecture, is available from:

➤ American Society of Landscape Architects, Career Information, 636 Eye St.NW., Washington, DC 20001-3736. Internet: **http://www.asla.org**

General information on registration or licensing requirements is available from:

➤ Council of Landscape Architectural Registration Boards, 3949 Pender Dr., Suite 120, Vienna, VA 22030.
Internet: **http://www.clarb.org**

Medical Scientists

(O*NET 19-1041.00, 19-1042.00)

Significant Points

- Most medical scientists need a Ph.D. in a biological science; some hold a medical degree.
- Epidemiologists typically need a master's degree in public health or, in some cases, a Ph.D. or medical degree.
- Competition is expected for most positions; however, those with both a Ph.D. and M.D. are likely to have very good opportunities.

Nature of the Work

Medical scientists research human diseases to improve human health. Most medical scientists conduct biomedical research and development to advance knowledge of life processes and living organisms, including viruses, bacteria, and other infectious agents. Past research has resulted in advances in diagnosis, treatment, and prevention of many diseases. Basic medical research continues to build the foundation for new vaccines, drugs, and treatment procedures. Medical scientists engage in laboratory research, clinical investigation, technical writing, drug application review, and related activities.

Medical scientists study biological systems to understand the causes of disease and other health problems. They develop treatments and design research tools and techniques that have medical applications. Some try to identify changes in cells or in chromosomes that signal the development of medical problems. For example, medical scientists involved in cancer research may formulate a combination of drugs that will lessen the effects of the disease. Medical scientists who are also physicians can administer these drugs to patients in clinical trials, monitor their reactions, and observe the results. They may draw blood, excise tissue, or perform other invasive procedures. Those who are not physicians normally collaborate with physicians who deal directly with patients. Medical scientists examine the results of clinical trials and adjust the dosage levels to reduce negative side effects or to induce better results. In addition to developing treatments for medical conditions, medical scientists attempt to discover ways to prevent health problems. For example, they may study the link between smoking and lung cancer or between alcoholism and liver disease.

Medical scientists who work in applied research or product development use knowledge discovered through basic research to develop new drugs and medical treatments. They usually have less autonomy than basic medical researchers do to choose the emphasis of their research. They spend more time working on marketable treatments to meet the business goals of their employers. Medical scientists doing applied research and product development in private industry may also be required to explain their research plans or results to nonscientists who are in a position to reject or approve their ideas. These scientists must consider the business effects of their work. Scientists increasingly work as part of teams, interacting with engineers, scientists of other disciplines, business managers, and technicians.

Swift advances in basic medical knowledge related to genetics and organic molecules have spurred growth in the field of biotechnology. Discovery of important drugs, including human insulin and growth hormone, is the result of research using biotechnology techniques, such as recombining DNA. Many other substances not previously available in large quantities are now produced by biotechnological means; some may one day be

Opportunities will be best for medical scientists with both a Ph.D. and M.D.

useful in treating diseases such as Parkinson's or Alzheimer's. Today, many medical scientists are involved in the science of genetic engineering—isolating, identifying, and sequencing human genes to determine their functions. This work continues to lead to the discovery of genes associated with specific diseases and inherited health risks, such as sickle cell anemia. These advances in biotechnology have opened up research opportunities in almost all areas of medical science.

Some medical scientists specialize in epidemiology. This branch of medical science investigates and describes the causes and spread of disease and develops the means for prevention or control. Epidemiologists may study many different illnesses, often focusing on major infectious diseases such as influenza or cholera. Epidemiologists can be separated into two groups—research and clinical.

Research epidemiologists conduct research in an effort to eradicate or control infectious diseases. Many work on illnesses that affect the entire body, such as AIDS or typhus, while others focus on localized infections such as those of the brain, lungs, or digestive tract. Research epidemiologists work at colleges and universities, schools of public health, medical schools, and independent research firms. For example, Federal Government agencies, such as the U.S. Department of Defense, may contract with a research firm to evaluate the incidence of malaria in certain parts of the world. Other research epidemiologists may work as college and university faculty and are counted as postsecondary teachers.

Clinical epidemiologists work primarily in consulting roles at hospitals, informing the medical staff of infectious outbreaks and providing containment solutions. These epidemiologists sometimes are referred to as infection control professionals, and some of them are also physicians. Clinical epidemiologists who are not also physicians often collaborate with physicians to find ways to contain outbreaks of diseases. In addition to traditional duties of studying and controlling diseases, clinical epidemiologists also may be required to develop standards and guidelines for the treatment and control of communicable diseases. Some clinical epidemiologists may work in outpatient settings.

Work environment. Many medical scientists work independently in private industry, university, or government laboratories, exploring new areas of research or expanding on specialized research that they began in graduate school. Medical scientists working in colleges and universities, hospitals, and nonprofit medical research organizations typically submit grant proposals to obtain funding for their projects. Colleges and universities, private industry, and Federal Government agencies—particularly the National Institutes of Health and the National Science Foundation—provide the primary support for researchers whose proposals are determined to be financially feasible and to have the potential to advance new ideas or processes. Medical scientists who rely on grant money may be under pressure to meet deadlines and to conform to rigid grant-writing specifications when preparing proposals to seek new or extended funding.

Medical scientists who conduct research usually work in laboratories and use a wide variety of equipment. Some may work directly with individual patients or larger groups as they administer drugs and monitor patients during clinical trials. Often, these medical scientists also spend time working in clinics and hospitals.

Medical scientists usually are not exposed to unsafe or unhealthy conditions; however, those scientists who work with dangerous organisms or toxic substances must follow strict safety procedures to avoid contamination.

Medical scientists typically work regular hours in offices or laboratories, but longer hours are not uncommon. Researchers may be required to work odd hours in laboratories or other locations, depending on the nature of their research. On occasion, epidemiologists may be required to travel to meetings and hearings for medical investigations.

Training, Other Qualifications, and Advancement

A Ph.D. in a biological science is the minimum education required for most prospective medical scientists, except epidemiologists. However, some medical scientists pursue medical degrees to perform clinical work. Epidemiologists typically need at least a master's degree in public health, but some work requires a Ph.D. or medical degree. A period of postdoctoral work in the laboratory of a senior researcher is becoming increasingly common for medical scientists.

Education and training. A Ph.D. typically qualifies people to research basic life processes or particular medical problems and to analyze the results of experiments. Some medical scientists obtain a medical degree instead of a Ph.D., but some do not become licensed physicians because they prefer research to clinical practice. It is particularly helpful for medical scientists to earn both a Ph.D. and a medical degree.

Students planning careers as medical scientists should have a bachelor's degree in a biological science. In addition to required courses in chemistry and biology, undergraduates should study allied disciplines, such as mathematics, engineering, physics, and computer science, or courses in their field of interest. Once they have completed undergraduate studies, they can then select a specialty for their advanced degree, such as cytology, bioinformatics, genomics, or pathology.

The minimum educational requirement for epidemiologists is a master's degree from a school of public health. Some jobs may require a Ph.D. or medical degree, depending on the work performed. Epidemiologists who work in hospitals and health care centers often must have a medical degree with specific training in infectious diseases. Some employees in research epidemiology positions are required to be licensed physicians because they must administer drugs in clinical trials.

Few students select epidemiology for undergraduate study. Undergraduates, nonetheless, should study biological sciences and should have a solid background in chemistry, mathematics, and computer science. Once a student is prepared for graduate studies, he or she can choose a specialty within epidemiology. For example, those interested in studying environmental epidemiology should focus on environmental coursework, such as water pollution, air pollution, pesticide use, toxicology, and molecular biology. Other specialties include occupational epidemiology, infection processes, infection control precautions, surveillance methodology, and outbreak investigation. Some epidemiologists begin their careers in other health care occupations, such as registered nurse or medical technologist.

In addition to formal education, medical scientists usually spend some time in a postdoctoral position before they apply for permanent jobs. Postdoctoral work provides valuable laboratory experience, including experience in specific processes and techniques such as gene splicing, which is transferable to other research projects. In some institutions, the postdoctoral position can lead to a permanent job.

Licensure. Medical scientists who administer drug or gene therapy to human patients, or who otherwise interact medically with patients—drawing blood, excising tissue, or performing other invasive procedures—must be licensed physicians. To be licensed, physicians must graduate from an accredited medical school, pass a licensing examination, and complete 1 to 7 years of graduate medical education. (See the statement on physicians and surgeons elsewhere in the *Handbook*.)

Epidemiologists who perform laboratory tests often require the knowledge and expertise of a licensed physician to administer drugs to patients in clinical trials. Epidemiologists who are not physicians frequently work closely with one.

Other qualifications. Medical scientists should be able to work independently or as part of a team and be able to communicate clearly and concisely, both orally and in writing. Those in private industry, especially those who aspire to consulting and administrative positions, should possess strong communication skills so that they can provide instruction and advice to physicians and other health care professionals.

Certification and advancement. The Association for Professionals in Infection Control and Epidemiology offers continuing education courses and certification programs in infection prevention and control and applied epidemiology. To become certified as an infection control professional, applicants must pass an examination. Certification can be an advantage for those seeking advancement in this rapidly evolving field.

Advancement among medical scientists usually takes the form of greater independence in their work, larger budgets, or tenure in university positions. Others choose to move into managerial positions and become natural science managers (see engineering and natural science managers elsewhere in the *Handbook*). Those who pursue management careers spend more time preparing budgets and schedules.

Employment

Medical scientists held about 92,000 jobs in 2006. Epidemiologists accounted for only 5 percent of that total. In addition, many medical scientists held faculty positions in colleges and universities, but they are classified as college or university faculty. (See teachers—postsecondary, elsewhere in the *Handbook*.)

About 34 percent of medical scientists, except epidemiologists, were employed in colleges and universities. About 28 percent were employed in scientific research and development services firms; 12 percent were employed in pharmaceutical and medicine manufacturing; 9 percent were employed in hospitals; and most of the remainder were employed in private educational services and ambulatory health care services.

Among epidemiologists, 57 percent were employed in government; 12 percent were employed in hospitals; 11 percent were employed in colleges and universities; and 9 percent were employed in scientific research and development services.

Job Outlook

Medical scientists can expect to face competition for most jobs, in part because of the attractiveness of the career. However, those with both a Ph.D. and M.D. are likely to experience very good opportunities.

Employment change. Employment of medical scientists is expected to increase 20 percent over the 2006-16 decade, faster than the average for all occupations. The Federal Government funds much basic research and development, including many areas of medical research. Although previous budget increases at the National Institutes of Health have led to large increases in the number of grants awarded to researchers, the increase in expenditures has slowed significantly, causing expected future employment growth to be more modest than in the past despite the faster than average projected growth.

Medical scientists enjoyed rapid gains in employment since the 1980s—reflecting, in part, the growth of biotechnology companies. Job growth should be dampened somewhat as fewer new biotechnology firms are founded and as existing firms merge or are absorbed by larger biotechnology or pharmaceutical firms. Some companies may conduct a portion of their research and development in other lower-wage countries, further limiting employment growth. However, much of the basic medical research done in recent years has resulted in new knowledge, including the isolation and identification of new genes. Medical scientists will be needed to take this knowledge to the next stage—understanding how certain genes function within an entire organism—so that medical treatments can be developed for various diseases. Even pharmaceutical and other firms not solely engaged in biotechnology have largely adopted biotechnology techniques, thus creating employment for medical scientists.

Employment growth should also occur as a result of the expected expansion in research related to illnesses such as AIDS, cancer, and avian influenza, along with growing treatment problems such as antibiotic resistance. Moreover, environmental conditions such as overcrowding and the increasing frequency

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Medical scientists	19-1040	92,000	110,000	18,000	20
Epidemiologists	19-1041	4,500	5,100	600	14
Medical scientists, except epidemiologists	19-1042	87,000	105,000	18,000	20

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

of international travel will tend to spread existing diseases and give rise to new ones. Medical scientists will continue to be needed because they greatly contribute to the development of treatments and medicines that improve human health.

An increasing focus on monitoring patients at hospitals and health care centers to ensure positive patient outcomes will contribute to job growth for epidemiologists. In addition, a heightened awareness of bioterrorism and rare, but infectious diseases such as West Nile Virus or severe acute respiratory syndrome (SARS) should spur demand for these workers. As hospitals enhance their infection control programs, many will seek to boost the quality and quantity of their staff.

Job prospects. Besides job openings due to employment growth, openings will arise as workers leave the labor force or transfer to other occupations. However, doctoral degree holders can expect to face considerable competition for basic research positions and for research grants. If the number of advanced degrees awarded continues to grow, applicants are likely to face even more competition.

Although medical scientists can expect competition for jobs, those with both doctoral and medical degrees are likely to experience very good opportunities. As funding for research becomes more difficult to obtain, those with both a biological and professional medical background will have a distinct advantage. Opportunities in epidemiology also should be highly competitive, as the number of available positions will continue to be limited.

Medical scientists and epidemiologists are less likely to lose their jobs during recessions than are those in many other occupations because they are employed on long-term research projects. However, a recession could influence the amount of money allocated to new research and development, particularly in areas of risky or innovative medical research. A recession also could limit extensions or renewals of existing projects.

Earnings

Median annual earnings of wage and salary medical scientists, except epidemiologists, were $61,680 in May 2006. The middle 50 percent of these workers earned between $44,830 and $88,130. The lowest 10 percent earned less than $35,490, and the highest 10 percent earned more than $117,520. Median annual earnings in the industries employing the largest numbers of medical scientists were:

Pharmaceutical and medicine manufacturing	$82,640
Research and development in the physical, engineering, and life sciences	71,490
Offices of physicians	70,000
General medical and surgical hospitals	64,700
Colleges, universities, and professional schools	44,600

Median annual earnings of wage and salary epidemiologists were $56,670 in May 2006. The middle 50 percent earned between $45,220 and $71,080. The lowest 10 percent earned less than $36,920, and the highest 10 percent earned more than $87,300.

Related Occupations

Many other occupations deal with living organisms and require a level of training similar to that of medical scientists. These occupations include biological scientists, agricultural and food scientists, pharmacists, engineering and natural sciences managers, and health occupations such as physicians and surgeons, dentists, and veterinarians.

Sources of Additional Information

For information on pharmaceutical scientists, contact:

➤ American Association of Pharmaceutical Scientists (AAPS), 2107 Wilson Blvd., Suite 700, Arlington, VA 22201. Internet: **http://www.aapspharmaceutica.org**

For information on careers in microbiology, contact:

➤ American Society for Microbiology, Career Information—Education Department, 1752 N St.NW., Washington, DC 20036. Internet: **http://www.asm.org**

For information on infectious diseases training programs, contact:

➤ Infectious Diseases Society of America, Guide to Training Programs, 66 Canal Center Plaza, Suite 600, Alexandria, VA 22314. Internet: **http://www.idsociety.org**

Information on obtaining a medical scientist position with the Federal Government is available from the Office of Personnel Management through USAJOBS, the Federal Government's official employment information system. This resource for locating and applying for job opportunities can be accessed through the Internet at **http://www.usajobs.opm.gov** or through an interactive voice response telephone system at (703) 724-1850 or TDD (978) 461-8404. These numbers are not toll free, and charges may result. For advice on how to find and apply for Federal jobs, see the Occupational Outlook Quarterly article "How to get a job in the Federal Government," online at: **http://www.bls.gov/opub/ooq/2004/summer/art01.pdf**.

Physicists and Astronomers

(O*NET 19-2011.00, 19-2012.00)

Significant Points

- Scientific research and development services firms and the Federal Government employ over half of all physicists and astronomers.
- Most jobs are in basic research, usually requiring a doctoral degree; master's degree holders qualify for some jobs in applied research and development; bachelor's degree holders often qualify as research assistants or for other physics-related occupations, such as technicians.
- Applicants may face competition for basic research positions due to limited funding; however, those with a background in physics or astronomy may have good opportunities in related occupations.

Nature of the Work

Physicists and astronomers conduct research to understand the nature of the universe and everything in it. These researchers observe, measure, interpret, and develop theories to explain celestial and physical phenomena using mathematics. From the vastness of space to the infinitesimal scale of subatomic particles, they study the fundamental properties of the natural world and apply the knowledge gained to design new technologies.

Physicists explore and identify basic principles and laws governing the motion, energy, structure, and interactions of matter. Some physicists study theoretical areas, such as the nature of time and the origin of the universe; others apply their knowledge of physics to practical areas, such as the development of advanced materials, electronic and optical devices, and medical equipment.

Physicists design and perform experiments with lasers, particle accelerators, electron microscopes, mass spectrometers, and other equipment. On the basis of their observations and analysis, they attempt to discover and explain laws describing the forces of nature, such as gravity, electromagnetism, and nuclear interactions. Experiments also help physicists find ways to apply physical laws and theories to problems in nuclear energy, electronics, optics, materials, communications, aerospace technology, and medical instrumentation.

Most jobs for physicists and astronomers are in research and usually require a doctoral degree.

Astronomers use the principles of physics and mathematics to learn about the fundamental nature of the universe, including the sun, moon, planets, stars, and galaxies. As such, astronomy is sometimes considered a subfield of physics. They also apply their knowledge to solve problems in navigation, space flight, and satellite communications and to develop the instrumentation and techniques used to observe and collect astronomical data.

Most physicists work in research and development. Some do basic research to increase scientific knowledge. Others conduct applied research to build upon the discoveries made through basic research and work to develop new devices, products, and processes. For example, basic research in solid-state physics led to the development of transistors and, then, integrated circuits used in computers.

Physicists also design research equipment, which often has additional unanticipated uses. For example, lasers are used in surgery, microwave devices function in ovens, and measuring instruments can analyze blood or the chemical content of foods.

A small number of physicists work in inspection, testing, quality control, and other production-related jobs in industry.

Much physics research is done in small or medium-sized laboratories. However, experiments in plasma, nuclear, and high-energy physics, as well as in some other areas of physics, require extremely large, expensive equipment, such as particle accelerators. Physicists in these subfields often work in large teams. Although physics research may require extensive experimentation in laboratories, research physicists still spend much time in offices planning, recording, analyzing, and reporting on research.

Physicists generally specialize in one of many subfields: elementary particle physics, nuclear physics, atomic and molecular physics, condensed matter physics (solid-state physics), optics, acoustics, space physics, plasma physics, or the physics of fluids. Some specialize in a subdivision of one of these subfields. For example, within condensed-matter physics, specialties include superconductivity, crystallography, and semiconductors. However, all physics involves the same fundamental principles, so specialties may overlap, and physicists may switch from one subfield to another. Also, growing numbers of physicists work in interdisciplinary fields, such as biophysics, chemical physics, and geophysics.

Almost all astronomers do research. Some are theoreticians, working on the laws governing the structure and evolution of astronomical objects. Others analyze large quantities of data gathered by observatories and satellites and write scientific papers or reports on their findings. Some astronomers actually operate large space-based or ground-based telescopes, usually as part of a team. However, astronomers may spend only a few weeks each year making observations with optical telescopes, radio telescopes, and other instruments.

For many years, satellites and other space-based instruments, such as the Hubble space telescope, have provided prodigious amounts of astronomical data. New technology has lead to improvements in analytical techniques and instruments, such as computers and optical telescopes and mounts, and is creating a resurgence in ground-based research.

A small number of astronomers work in museums housing planetariums. These astronomers develop and revise programs presented to the public and may direct planetarium operations.

Work environment. Most physicists and astronomers do not encounter unusual hazards in their work. Some physicists temporarily work away from home at national or international facilities with unique equipment, such as particle accelerators. Astronomers who make observations with ground-based telescopes may spend many hours working in observatories; this work usually involves travel to remote locations and may require working at night. Physicists and astronomers whose work depends on grant money often are under pressure to write grant proposals to keep their work funded.

Physicists often work regular hours in laboratories and offices. At times, however, those who are deeply involved in research may work long or irregular hours. Astronomers may need to work at odd hours to observe celestial phenomena, particularly those working with ground-based telescopes.

Training, Other Qualifications, and Advancement

Because most jobs are in basic research and development, a doctoral degree is the usual educational requirement for physicists and astronomers. Master's degree holders qualify for some jobs in applied research and development, whereas bachelor's degree holders often qualify as research assistants or for other occupations related to physics.

Education and training. A Ph.D. degree in physics or closely related fiends is typically required for basic research positions, independent research in industry, faculty positions, and advancement to managerial positions. This prepares students for a career in research through rigorous training in theory, methodology, and mathematics. Most physicists specialize in a subfield during graduate school and continue working in that area afterwards.

Additional experience and training in a postdoctoral research appointment, although not required, is important for physicists and astronomers aspiring to permanent positions in basic research in universities and government laboratories. Many physics and astronomy Ph.D. holders ultimately teach at the college or university level.

Master's degree holders usually do not qualify for basic research positions, but may qualify for many kinds of jobs requiring a physics background, including positions in manufacturing and applied research and development. Increasingly, many master's degree programs are specifically preparing students for physics-related research and development that does not require a Ph.D. degree. These programs teach students specific research skills that can be used in private-industry jobs. In addition, a master's degree coupled with State certification usually qualifies one for teaching jobs in high schools or at 2-year colleges.

Those with bachelor's degrees in physics are rarely qualified to fill positions in research or in teaching at the college level. They are, however, usually qualified to work as technicians or research assistants in engineering-related areas, in software development and other scientific fields, or in setting up computer networks and sophisticated laboratory equipment. Increasingly, some may qualify for applied research jobs in private industry or take on nontraditional physics roles, often in computer science, such as systems analysts or database administrators. Some become science teachers in secondary schools.

Holders of a bachelor's or master's degree in astronomy often enter an unrelated field. However, they are also qualified to work in planetariums running science shows, to assist astronomers doing research, and to operate space-based and ground-based telescopes and other astronomical instrumentation. (See the statements on engineers, geoscientists, computer programmers, computer scientists and database administrators, computer software engineers, and computer systems analysts elsewhere in the *Handbook*.)

About 760 colleges and universities offer a bachelor's degree in physics. Undergraduate programs provide a broad background in the natural sciences and mathematics. Typical physics courses include electromagnetism, optics, thermodynamics, atomic physics, and quantum mechanics.

Approximately 185 colleges and universities have departments offering Ph.D. degrees in physics; about 70 additional colleges offer a master's as their highest degree in physics. Graduate students usually concentrate in a subfield of physics, such as elementary particles or condensed matter. Many begin studying for their doctorate immediately after receiving their bachelor's degree.

About 80 universities grant degrees in astronomy, either through an astronomy, physics, or combined physics-astronomy department. Currently, about 40 astronomy departments are combined with physics departments, and the same number are administered separately. With about 40 doctoral programs in astronomy, applicants face considerable competition for available slots. Those planning a career in the subject should have a strong physics background. In fact, an undergraduate degree in either physics or astronomy is excellent preparation, followed by a Ph.D. in astronomy.

Many physics and astronomy Ph.D. holders begin their careers in a postdoctoral research position, in which they may work with experienced physicists as they continue to learn about their specialties or develop a broader understanding of related areas of research. Initial work may be under the close supervision of senior scientists. As they gain experience, physicists perform increasingly complex tasks and achieve greater independence in their work. Experience, either in academic laboratories or through internships, fellowships, or work-study programs in industry, also is useful. Some employers of research physicists, particularly in the information technology industry, prefer to hire individuals with several years of postdoctoral experience.

Other qualifications. Mathematical ability, problem-solving and analytical skills, an inquisitive mind, imagination, and initiative are important traits for anyone planning a career in physics or astronomy. Prospective physicists who hope to work in industrial laboratories applying physics knowledge to practical problems should broaden their educational background to include courses outside of physics, such as economics, information technology, and business management. Good oral and written communication skills also are important because many physicists work as part of a team, write research papers or proposals, or have contact with clients or customers with nonphysics backgrounds.

Advancement. Advancement among physicists and astronomers usually takes the form of greater independence in their work, larger budgets, or tenure in university positions. Others choose to move into managerial positions and become natural science managers (listed elsewhere in the *Handbook*). Those who pursue management careers spend more time preparing budgets and schedules. Those who develop new products or processes sometimes form their own companies or join new firms to develop these ideas.

Employment

Physicists and astronomers held about 18,000 jobs in 2006. Physicists accounted for about 17,000 of these, while astronomers accounted for only about 1,700 jobs. Many physicists and astronomers held faculty positions in colleges and universities. Those classified as postsecondary teachers are not included in these employment numbers. (See the statement on teachers—postsecondary elsewhere in the *Handbook*.)

About 38 percent of physicists and astronomers worked for scientific research and development services firms. The Federal Government employed 21 percent, mostly in the U.S. Department of Defense, but also in the National Aeronautics and Space Administration (NASA) and in the U.S. Departments of Commerce, Health and Human Services, and Energy. Other physicists and astronomers worked in colleges and universities in nonfaculty, usually research, positions, or for State governments, information technology companies, pharmaceutical and medicine manufacturing companies, or electronic equipment manufacturers.

Although physicists and astronomers are employed in all parts of the country, most work in areas in which universities, large research laboratories, or observatories are located.

Job Outlook

Physicists and astronomers should experience average job growth but may face competition for basic research positions due to limited funding. However, those with a background in physics or astronomy may have good opportunities in related occupations.

Employment change. Employment of physicists and astronomers is expected to grow at 7 percent, about as fast as the average for all occupations during the 2006-16 decade. The need to replace physicists and astronomers who retire or otherwise leave the occupation permanently will account for many additional expected job openings.

Federal research expenditures are the major source of physics- and astronomy-related research funds, especially for basic research. Although these expenditures are expected to increase over the 2006-16 projection period, resulting in some growth in employment and opportunities, the limited science research funds available still will result in competition for basic research jobs among Ph.D. holders. However, research relating to biotechnology and nanotechnology should continue to see strong growth.

Although research and development expenditures in private industry will continue to grow, many research laboratories in private industry are expected to continue to reduce basic research, which includes much physics research, in favor of applied or manufacturing research and product and software development. Nevertheless, people with a physics background continue to be in demand in information technology, semiconductor technology, and other applied sciences. This trend is expected to continue; however, many of the new workers will have job titles such as computer software engineer, computer programmer, or systems analyst or developer, rather than physicist.

Job prospects. In recent years the number of doctorates granted in physics has been somewhat greater than the number of job openings for traditional physics research positions in colleges and universities and in research centers. Recent increases in undergraduate physics enrollments may also lead to growth in enrollments in graduate physics programs, so that there may be an increase in the number of doctoral degrees granted that could intensify the competition for basic research positions. However, demand has grown in other related occupations for those with advanced training in physics. Prospects should be favorable for physicists in applied research, development, and related technical fields.

Opportunities should also be numerous for those with a master's degree, particularly graduates from programs preparing students for related work in applied research and development, product design, and manufacturing positions in private industry. Many of these positions, however, will have titles other than physicist, such as engineer or computer scientist.

People with only a bachelor's degree in physics or astronomy are usually not qualified for physics or astronomy research jobs, but they may qualify for a wide range of positions related to engineering, mathematics, computer science, environmental science, and some nonscience fields, such as finance. Those who meet State certification requirements can become high school physics teachers, an occupation in strong demand in many school districts. Some States require new teachers to obtain a master's degree in education within a certain time. (See the statement on teachers—preschool, kindergarten, elementary, middle, and secondary elsewhere in the *Handbook*.) Despite competition for traditional physics and astronomy research jobs, graduates with a physics or astronomy degree at any level will find their knowledge of science and mathematics useful for entry into many other occupations.

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016 Number	Change, 2006-2016 Percent
Astronomers and physicists	19-2010	18,000	19,000	1,200	7
Astronomers	19-2011	1,700	1,700	100	6
Physicists	19-2012	17,000	18,000	1,100	7

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook.*

Despite their small numbers, astronomers can expect good job prospects in government and academia over the projection period. Since astronomers are particularly dependent upon government funding, Federal budgetary decisions will have a sizable influence on job prospects for astronomers.

Earnings

Median annual earnings of physicists were 94,240 in May 2006. The middle 50 percent earned between $72,910 and $117,080. The lowest 10 percent earned less than $52,070, and the highest 10 percent earned 143,570.

Median annual earnings of astronomers were $95,740 in 2006. The middle 50 percent earned between $62,050 and $125,420, the lowest 10 percent less than $44,590, and the highest 10 percent more than $145,600.

According to a 2007 National Association of Colleges and Employers survey, the average annual starting salary offer to physics doctoral degree candidates was $52,469.

The American Institute of Physics reported a median annual salary of $80,000 in 2006 for its members with Ph.D.'s (excluding those in postdoctoral positions) who were employed by a university on a 9-10 month salary; the median was $112,700 for those who held a Ph.D. and worked at a federally funded research and development center; and $110,000 for self-employed physicists who hold a Ph.D. Those working in temporary postdoctoral positions earned significantly less.

The average annual salary for physicists employed by the Federal Government was $111,769 in 2007; for astronomy and space scientists, it was $117,570.

Related Occupations

The work of physicists and astronomers relates closely to that of engineers, chemists and materials scientists, atmospheric scientists, environmental scientists and hydrologists, geoscientists, computer systems analysts, computer scientists and database administrators, computer programmers, mathematicians, and engineering and natural sciences managers.

Sources of Additional Information

Further information on career opportunities in physics is available from the following organizations:

➤ American Institute of Physics, Career Services Division and Education and Employment Division, One Physics EllipSE., College Park, MD 20740-3843. Internet: **http://www.aip.org**

➤ American Physical Society, One Physics EllipSE., College Park, MD 20740-3844. Internet: **http://www.aps.org**

Science Technicians

(O*NET 19-4011.00, 19-4011.01, 19-4011.02, 19-4021.00, 19-4031.00, 19-4041.00, 19-4041.01, 19-4041.02, 19-4051.00, 19-4051.01, 19-4051.02, 19-4091.00, 19-4092.00, 19-4093.00, 19-4099.99)

Significant Points

- Science technicians in production jobs can be employed on day, evening, or night shifts; other technicians work outdoors, sometimes in remote locations.
- Most science technicians need an associate degree or a certificate in applied science or science-related technology; biological and forensic science technicians usually need a bachelor's degree.
- Projected job growth varies among occupational specialties; for example, forensic science technicians will grow much faster than average, while chemical technicians will grow more slowly than average.
- Job opportunities are expected to be best for graduates of applied science technology programs who are well trained on equipment used in laboratories or production facilities.

Nature of the Work

Science technicians use the principles and theories of science and mathematics to solve problems in research and development and to help invent and improve products and processes. However, their jobs are more practically oriented than those of scientists. Technicians set up, operate, and maintain laboratory instruments, monitor experiments, make observations, calculate and record results, and often develop conclusions. They must keep detailed logs of all of their work. Those who perform production work monitor manufacturing processes and may ensure quality by testing products for proper proportions of ingredients, for purity, or for strength and durability.

As laboratory instrumentation and procedures have become more complex, the role of science technicians in research and development has expanded. In addition to performing routine tasks, many technicians, under the direction of scientists, now develop and adapt laboratory procedures to achieve the best results, interpret data, and devise solutions to problems. Technicians must develop expert knowledge of laboratory equipment so that they can adjust settings when necessary and recognize when equipment is malfunctioning.

Most science technicians specialize, learning their skills and working in the same disciplines in which scientists work. Occupational titles, therefore, tend to follow the same structure as those for scientists.

Agricultural and food science technicians work with related scientists to conduct research, development, and testing on food and other agricultural products. Agricultural technicians are involved in food, fiber, and animal research, production, and processing. Some conduct tests and experiments to improve the yield and quality of crops or to increase the resistance of plants and animals to disease, insects, or other

Job opportunities will be best for graduates who are trained on equipment used in labratories or production facilities.

hazards. Other agricultural technicians breed animals for the purpose of investigating nutrition. Food science technicians assist food scientists and technologists in research and development, production technology, and quality control. For example, food science technicians may conduct tests on food additives and preservatives to ensure compliance with Food and Drug Administration regulations regarding color, texture, and nutrients. These technicians analyze, record, and compile test results; order supplies to maintain laboratory inventory; and clean and sterilize laboratory equipment.

Biological technicians work with biologists studying living organisms. Many assist scientists who conduct medical research—helping to find a cure for cancer or AIDS, for example. Those who work in pharmaceutical companies help develop and manufacture medicine. Those working in the field of microbiology generally work as laboratory assistants, studying living organisms and infectious agents. Biological technicians also analyze organic substances, such as blood, food, and drugs. Biological technicians working in biotechnology apply knowledge and techniques gained from basic research, including gene splicing and recombinant DNA, and apply them to product development.

Chemical technicians work with chemists and chemical engineers, developing and using chemicals and related products and equipment. Generally, there are two types of chemical technicians: research technicians who work in experimental laboratories and process control technicians who work in manufacturing or other industrial plants. Many chemical technicians working in research and development conduct a variety of laboratory procedures, from routine process control to complex research projects. For example, they may collect and analyze samples of air and water to monitor pollution levels, or they may produce compounds through complex organic synthesis. Most *process technicians* work in manufacturing, testing packaging for design, integrity of materials, and environmental acceptability. Often, process technicians who work in plants focus on quality assurance, monitoring product quality or production processes and developing new production techniques. A few work in shipping to provide technical support and expertise.

Environmental science and protection technicians perform laboratory and field tests to monitor environmental resources and determine the contaminants and sources of pollution in the environment. They may collect samples for testing or be involved in abating and controlling sources of environmental pollution. Some are responsible for waste management operations, control and management of hazardous materials inventory, or general activities involving regulatory compliance. Many environmental science technicians employed at private consulting firms work directly under the supervision of an environmental scientist.

Forensic science technicians investigate crimes by collecting and analyzing physical evidence. Often, they specialize in areas such as DNA analysis or firearm examination, performing tests on weapons or on substances such as fiber, glass, hair, tissue, and body fluids to determine their significance to the investigation. Proper collection and storage methods are important to protect the evidence. Forensic science technicians also prepare reports to document their findings and the laboratory techniques used, and they may provide information and expert opinions to investigators. When criminal cases come to trial, forensic science technicians often give testimony as expert witnesses on laboratory findings by identifying and classifying substances, materials, and other evidence collected at the scene of a crime. Some forensic science technicians work closely with other experts or technicians. For example, a forensic science technician may consult either a medical expert about the exact time and cause of a death or another technician who specializes in DNA typing in hopes of matching a DNA type to a suspect.

Forest and conservation technicians compile data on the size, content, and condition of forest land. These workers usually work in a forest under the supervision of a forester, doing specific tasks such as measuring timber, supervising harvesting operations, assisting in road building operations, and locating property lines and features. They also may gather basic information, such as data on populations of trees, disease and insect damage, tree seedling mortality, and conditions that may pose a fire hazard. In addition, forest and conservation technicians train and lead forest and conservation workers in seasonal activities, such as planting tree seedlings, and maintaining recreational facilities. Increasing numbers of forest and conservation technicians work in urban forestry—the study of individual trees in cities—and other nontraditional specialties, rather than in forests or rural areas.

Geological and petroleum technicians measure and record physical and geologic conditions in oil or gas wells, using advanced instruments lowered into the wells or analyzing the mud from the wells. In oil and gas exploration, technicians collect and examine geological data or test geological samples to determine their petroleum content and their mineral and element composition. Some petroleum technicians, called scouts, collect information about oil well and gas well drilling operations, geological and geophysical prospecting, and land or lease contracts.

Nuclear technicians operate nuclear test and research equipment, monitor radiation, and assist nuclear engineers and physicists in research. Some also operate remote controlled equipment to manipulate radioactive materials or materials exposed to radioactivity. Workers who control nuclear reactors are classified as *nuclear power reactor operators*, and are not included in this statement. (See the statement on power plant operators, distributors, and dispatchers elsewhere in the *Handbook*.)

Other science technicians perform a wide range of activities. Some collect weather information or assist oceanographers; others work as laser technicians or radiographers.

Work environment. Science technicians work under a wide variety of conditions. Most work indoors, usually in laboratories, and have regular hours. Some occasionally work irregular hours to monitor experiments that cannot be completed during regular working hours. Production technicians often work in 8-hour shifts around the clock. Others, such as agricultural, forest and conservation, geological and petroleum, and environmental science and protection technicians, perform much of their work outdoors, sometimes in remote locations.

Advances in automation and information technology require technicians to operate more sophisticated laboratory equipment. Science technicians make extensive use of computers, electronic measuring equipment, and traditional experimental apparatus.

Some science technicians may be exposed to hazards from equipment, chemicals, or toxic materials. Chemical technicians sometimes work with toxic chemicals or radioactive isotopes; nuclear technicians may be exposed to radiation, and biological technicians sometimes work with disease-causing organisms or radioactive agents. Forensic science technicians often are exposed to human body fluids and firearms. However, these working conditions pose little risk if proper safety procedures are followed. For forensic science technicians, collecting evidence from crime scenes can be distressing and unpleasant.

Training, Other Qualifications, and Advancement

Most science technicians need an associate degree or a certificate in applied science or science-related technology. Biological and forensic science technicians usually need a bachelor's degree. Science technicians with a high school diploma and no college degree typically begin work as trainees under the direct supervision of a more experienced technician, and eventually earn a 2-year degree in science technology.

Education and training. There are several ways to qualify for a job as a science technician. Many employers prefer applicants who have at least 2 years of specialized training or an associate degree in applied science or science-related technology. Because employers' preferences vary, however, some science technicians have a bachelor's degree in chemistry, biology, or forensic science or have completed several science and math courses at a 4-year college.

Most biological technician jobs, for example, require a bachelor's degree in biology or a closely related field. Forensic science positions also typically require a bachelor's degree to work in the field. Knowledge and understanding of legal procedures also can be helpful. Chemical technician positions in research and development also often have a bachelor's degree, but most chemical process technicians have a 2-year degree instead, usually an associate degree in process technology. In some cases, a high school diploma is sufficient. These workers usually receive additional on-the-job training. Entry-level workers whose college training encompasses extensive hands-on experience with a variety of diagnostic laboratory equipment generally require less on-the-job training.

Whatever their degree, science technicians usually need hands-on training either in school or on the job. Most can get good career preparation through 2-year formal training programs that combine the teaching of scientific principles and theory with practical hands-on application in a laboratory setting with up-to-date equipment. Graduates of bachelor's degree programs in science who have considerable experience in laboratory-based courses, have completed internships, or have held summer jobs in laboratories also are well qualified for science technician positions and are preferred by some employers.

Job candidates, who have extensive hands-on experience with a variety of laboratory equipment, including computers and related equipment, usually require a short period of on-the-job training. Those with a high school diploma and no college degree typically begin work as trainees under the direct supervision of a more experienced technician. Many with a high school diploma eventually earn a 2-year degree in science technology, often paid for by their employer.

Many technical and community colleges offer associate degrees in a specific technology or more general education in science and mathematics. A number of associate degree programs are designed to provide easy transfer to bachelor's degree programs at colleges or universities. Technical institutes usually offer technician training, but they provide less theory and general education than do community colleges. The length of programs at technical institutes varies, although 1-year certificate programs and 2-year associate degree programs are common. Prospective forestry and conservation technicians can choose from more than 20 associate degree programs in forest technology accredited by the Society of American Foresters.

Approximately 30 colleges and universities offer a bachelor's degree program in forensic science; about another 25 schools offer a bachelor's degree in a natural science with an emphasis on forensic science or criminology; a few additional schools offer a bachelor's degree with an emphasis in a specialty area, such as criminology, pathology, jurisprudence, investigation, odontology, toxicology, or forensic accounting.

Some schools offer cooperative-education or internship programs, allowing students the opportunity to work at a local company or some other workplace while attending classes during alternate terms. Participation in such programs can significantly enhance a student's employment prospects.

People interested in careers as science technicians should take as many high school science and math courses as possible. Science courses taken beyond high school, in an associate or bachelor's degree program, should be laboratory oriented, with an emphasis on bench skills. A solid background in applied chemistry, physics, and math is vital.

Other qualifications. Communication skills are important because technicians are often required to report their findings both orally and in writing. In addition, technicians should be able to work well with others. Because computers often are used in research and development laboratories, technicians should also have strong computer skills, especially in computer modeling. Organizational ability, an eye for detail, and skill in interpreting scientific results are important as well, as are a high mechanical aptitude, attention to detail, and analytical thinking.

Advancement. Technicians usually begin work as trainees in routine positions under the direct supervision of a scientist or a more experienced technician. As they gain experience, technicians take on more responsibility and carry out assignments under only general supervision, and some eventually become supervisors. However, technicians employed at universities often have job prospects tied to those of particular professors; when those professors retire or leave, these technicians face uncertain employment prospects.

Employment

Science technicians held about 267,000 jobs in 2006. As indicated by the following tabulation, chemical and biological technicians accounted for 52 percent of all jobs:

Biological technicians	79,000
Chemical technicians	61,000
Environmental science and protection technicians, including health	37,000
Forest and conservation technicians	34,000
Agricultural and food science technicians	26,000
Forensic science technicians	13,000
Geological and petroleum technicians	12,000
Nuclear technicians	6,500

About 30 percent of biological technicians worked in professional, scientific, or technical services firms; most other biological technicians worked in educational services, Federal, State, and local governments, or pharmaceutical and medicine manufacturing. Chemical technicians held jobs in a wide range of manufacturing and service-providing industries. About 39 percent worked in chemical manufacturing and another 30 percent worked in professional, scientific, or technical services firms. Most environmental science and protection technicians worked for State and local governments and professional, scientific, and technical services firms. About 76 percent of forest and conservation technicians held jobs in the Federal Government, mostly in the Forest Service; another 17 percent worked for State governments. Around 32 percent of agricultural and food science technicians worked in educational services and 20 percent worked for food processing companies; most of the rest were employed in agriculture. Forensic science technicians worked primarily for State and local governments. Approximately 37 percent of all geological and petroleum technicians worked for oil and gas extraction companies and 49 percent of nuclear technicians worked for utilities.

Job Outlook

Employment of science technicians is projected to grow about as fast as the average, although employment change will vary by specialty. Job opportunities are expected to be best for graduates of applied science technology programs who are well trained on equipment used in laboratories or production facilities.

Employment change. Overall employment of science technicians is expected to grow 12 percent during the 2006-16 decade, about as fast as the average for all occupations. The continued growth of scientific and medical research—particularly research related to biotechnology—will be the primary driver of employment growth, but the development and production of technical products should also stimulate demand for science technicians in many industries.

Employment of biological technicians should increase faster than the average, as the growing number of agricultural and medicinal products developed with the use of biotechnology techniques boosts demand for these workers. Also, an aging population and stronger competition among pharmaceutical companies are expected to contribute to the need for innovative and improved drugs, further spurring demand. Most growth in employment will be in professional, scientific, and technical services and in educational services.

Job growth for chemical technicians is projected to grow more slowly than the average. The chemical manufacturing industry, except pharmaceutical and medicine manufacturing, is anticipated to experience a decline in overall employment as companies downsize and turn to outside contractors to provide specialized services. Some of these contractors will be in other countries with lower average wages, further limiting

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Science technicians	—	267,000	300,000	33,000	12
Agricultural and food science technicians	19-4011	26,000	28,000	1,700	7
Biological technicians	19-4021	79,000	91,000	13,000	16
Chemical technicians	19-4031	61,000	65,000	3,600	6
Geological and petroleum technicians	19-4041	12,000	13,000	1,000	9
Nuclear technicians	19-4051	6,500	6,900	400	7
Environmental science and protection technicians, including health	19-4091	37,000	47,000	10,000	28
Forensic science technicians	19-4092	13,000	17,000	4,000	31
Forest and conservation technicians	19-4093	34,000	33,000	-700	-2

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

employment growth. An increasing focus on quality assurance will require a greater number of process technicians, however, stimulating demand for these workers.

Employment of environmental science and protection technicians is expected to grow much faster than the average; these workers will be needed to help regulate waste products; to collect air, water, and soil samples for measuring levels of pollutants; to monitor compliance with environmental regulations; and to clean up contaminated sites. Over 80 percent of this growth is expected to be in professional, scientific, and technical services as environmental monitoring, management, and regulatory compliance increase.

An expected decline in employment of forest and conservation technicians within the Federal Government will lead to little or no change in employment in this specialty, due to budgetary constraints and continued reductions in demand for timber management on Federal lands. However, opportunities at State and local governments within specialties such as urban forestry may provide some new jobs. In addition, an increased emphasis on specific conservation issues, such as environmental protection, preservation of water resources, and control of exotic and invasive pests, may provide some employment opportunities.

Employment of agricultural and food science technicians is projected to grow about as fast as the average. Research in biotechnology and other areas of agricultural science will increase as it becomes more important to balance greater agricultural output with protection and preservation of soil, water, and the ecosystem. In particular, research will be needed to combat insects and diseases as they adapt to pesticides and as soil fertility and water quality continue to need improvement.

Jobs for forensic science technicians are expected to increase much faster than the average. Employment growth in State and local government should be driven by the increasing application of forensic science to examine, solve, and prevent crime. Crime scene technicians who work for State and county crime labs should experience favorable employment prospects resulting from strong job growth.

Average employment growth is expected for geological and petroleum technicians. Job growth should be strongest in professional, scientific, and technical services firms because geological and petroleum technicians will be needed to assist environmental scientists and geoscientists as they provide consultation services for companies regarding environmental policy and Federal Government mandates, such as those requiring lower sulfur emissions.

Nuclear technicians should grow about as fast as the average as more are needed to monitor the Nation's aging fleet of nuclear reactors and research future advances in nuclear power. Although no new nuclear powerplants have been built for decades in the United States, energy demand has recently renewed interest in this form of electricity generation and may lead to future construction. Technicians also will be needed to work in defense-related areas, to develop nuclear medical technology, and to improve and enforce waste management and safety standards.

Job prospects. In addition to job openings created by growth, many openings should arise from the need to replace technicians who retire or leave the labor force for other reasons. Job opportunities are expected to be best for graduates of applied science technology programs who are well trained on equipment used in laboratories or production facilities. As the instrumentation and techniques used in industrial research, development, and production become increasingly more complex, employers will seek individuals with highly developed technical skills. Good communication skills are also increasingly sought by employers.

Job opportunities vary by specialty. The best opportunities for agricultural and food science technicians will be in agricultural biotechnology, specifically in research and development on biofuels. Geological and petroleum technicians should experience little competition for positions because of the relatively small number of new entrants. Forensic science technicians with a bachelor's degree in a forensic science will enjoy much better opportunities than those with an associate degree. During periods of economic recession, science technicians may be laid off.

Earnings

Median hourly earnings of science technicians in May 2006 were as follows:

Nuclear technicians	$31.49
Geological and petroleum technicians	22.19
Forensic science technicians	21.79
Chemical technicians	18.87
Environmental science and protection technicians, including health	18.31
Biological technicians	17.17
Agricultural and food science technicians	15.26
Forest and conservation technicians	14.84

In 2007, the average annual salary in the Federal Government was $40,629 for biological science technicians; $53,026 for physical science technicians; $40,534 for forestry technicians; $54,081 for geodetic technicians; $50,337 for hydrologic technicians; and $63,396 for meteorological technicians.

Related Occupations

Other technicians who apply scientific principles and who usually have a 2-year associate degree include engineering technicians, broadcast and sound engineering technicians and radio operators, drafters, and health technologists and technicians—especially clinical laboratory technologists and technicians, diagnostic medical sonographers, and radiologic technologists and technicians.

Sources of Additional Information

For information about a career as a chemical technician, contact:

➤ American Chemical Society, Education Division, Career Publications, 1155 16th St.NW., Washington, DC 20036. Internet: **http://www.acs.org**

For career information and a list of undergraduate, graduate, and doctoral programs in forensic sciences, contact:

➤ American Academy of Forensic Sciences, P.O. Box 669, Colorado Springs, CO, 80901. Internet: **http://www.aafs.org**

For general information on forestry technicians and a list of schools offering education in forestry, send a self-addressed, stamped business envelope to:

➤ Society of American Foresters, 5400 Grosvenor Ln., Bethesda, MD 20814. Internet: **http://www.safnet.org**

Surveyors, Cartographers, Photogrammetrists, and Surveying and Mapping Technicians

(O*NET 17-1021.00, 17-1022.00, 17-3031.00, 17-3031.01, 17-3031.02)

Significant Points

- About 7 out of 10 jobs were in architectural, engineering, and related services.
- Opportunities will be best for surveyors, cartographers, and photogrammetrists who have a bachelor's degree and strong technical skills.
- Overall employment of surveyors, cartographers, photogrammetrists, and surveying technicians is expected to grow much faster than the average for all occupations through the year 2016.

Nature of the Work

Surveyors, cartographers, and photogrammetrists are responsible for measuring and mapping the Earth's surface. *Surveyors* establish official land, airspace, and water boundaries. They write descriptions of land for deeds, leases, and other legal documents; define airspace for airports; and take measurements of construction and mineral sites. Other surveyors provide data about the shape, contour, location, elevation, or dimension of land or land features. *Cartographers and photogrammetrists* collect, analyze, interpret, and map geographic information from surveys and from data and photographs collected using airplanes and satellites. *Surveying and mapping technicians* assist these professionals by collecting data in the field, making calculations, and helping with computer-aided drafting. Collectively, these occupations play key roles in the field of geospatial information.

Surveyors measure distances, directions, and angles between points and elevations of points, lines, and contours on, above, and below the Earth's surface. In the field, they select known survey reference points and determine the precise location of important features in the survey area using specialized equipment. Surveyors also research legal records, look for evidence of previous boundaries, and analyze data to determine the location of boundary lines. They are sometimes called to provide expert testimony in court about their work. Surveyors also record their results, verify the accuracy of data, and prepare plots, maps, and reports.

Some surveyors perform specialized functions closer to those of cartographers and photogrammetrists than to those of traditional surveyors. For example, *geodetic surveyors* use high-accuracy techniques, including satellite observations, to measure large areas of the earth's surface. *Geophysical prospecting surveyors* mark sites for subsurface exploration, usually to look for petroleum. *Marine or hydrographic surveyors* survey harbors, rivers, and other bodies of water to determine shorelines, the topography of the bottom, water depth, and other features.

Surveyors use the Global Positioning System (GPS) to locate reference points with a high degree of precision. To use this system, a surveyor places a satellite signal receiver—a small instrument mounted on a tripod—on a desired point, and another receiver on a point for which the geographic position is known. The receiver simultaneously collects information from several satellites to establish a precise position. The receiver also can be placed in a vehicle for tracing out road systems. Because receivers now come in different sizes and shapes, and because the cost of receivers has fallen, much more surveying work can be done with GPS. Surveyors then interpret and check the results produced by the new technology.

Field measurements are often taken by a survey party that gathers the information needed by the surveyor. A typical survey party consists of a party chief and one or more surveying technicians and helpers. The party chief, who may be either a surveyor or a senior surveying technician, leads day-to-day work activities. Surveying technicians assist the party chief by adjusting and operating surveying instruments, such as the total

Surveyors use sophisticated equipment to take measure-

station, which measures and records angles and distances simultaneously. Surveying technicians or assistants position and hold the vertical rods, or targets, that the operator sights on to measure angles, distances, or elevations. They may hold measuring tapes if electronic distance-measuring equipment is not used. Surveying technicians compile notes, make sketches, and enter the data obtained from surveying instruments into computers either in the field or at the office. Survey parties also may include laborers or helpers who perform less-skilled duties, such as clearing brush from sight lines, driving stakes, or carrying equipment.

Photogrammetrists and cartographers measure, map, and chart the Earth's surface. Their work involves everything from performing geographical research and compiling data to producing maps. They collect, analyze, and interpret both spatial data—such as latitude, longitude, elevation, and distance—and nonspatial data—for example, population density, land-use patterns, annual precipitation levels, and demographic characteristics. Their maps may give both physical and social characteristics of the land. They prepare maps in either digital or graphic form, using information provided by geodetic surveys and remote sensing systems including aerial cameras, satellites, and LIDAR.

LIDAR—light-imaging detection and ranging—uses lasers attached to planes and other equipment to digitally map the topography of the Earth. It is often more accurate than traditional surveying methods and also can be used to collect other forms of data, such as the location and density of forests. Data developed by LIDAR can be used by surveyors, cartographers, and photogrammetrists to provide spatial information to specialists in geology, seismology, forestry, and construction, and other fields.

Geographic Information Systems (GIS) have become an integral tool for surveyors, cartographers and photogrammetrists, and surveying and mapping technicians. Workers use GIS to assemble, integrate, analyze, and display data about location in a digital format. They also use GIS to compile information from a variety of sources. GIS typically are used to make maps which combine information useful for environmental studies, geology, engineering, planning, business marketing, and other disciplines. As more of these systems are developed, many mapping specialists are being called *geographic information specialists*.

Work environment. Surveyors and surveying technicians usually work an 8-hour day, 5 days a week and may spend a lot of time outdoors. Sometimes, they work longer hours during the summer, when weather and light conditions are most suitable for fieldwork. Construction-related work may be limited during times of inclement weather.

Surveyors and technicians engage in active, sometimes strenuous, work. They often stand for long periods, walk considerable distances, and climb hills with heavy packs of instruments and other equipment. They also can be exposed to all types of weather. Traveling is sometimes part of the job, and land surveyors and technicians may commute long distances, stay away from home overnight, or temporarily relocate near a survey site. Surveyors also work indoors while planning surveys, searching court records for deed information, analyzing data, and preparing reports and maps.

Cartographers and photogrammetrists spend most of their time in offices using computers. However, certain jobs may require extensive field work to verify results and acquire data.

Training, Other Qualifications, and Advancement

Most surveyors, cartographers, and photogrammetrists have a bachelor's degree in surveying or a related field. Every State requires that surveyors be licensed.

Education and training. In the past, many people with little formal training started as members of survey crews and worked their way up to become licensed surveyors, but this has become increasingly difficult to do. Now, most surveyors need a bachelor's degree. A number of universities offer bachelor's degree programs in surveying, and many community colleges, technical institutes, and vocational schools offer 1-, 2-, and 3-year programs in surveying or surveying technology.

Cartographers and photogrammetrists usually have a bachelor's degree in cartography, geography, surveying, engineering, forestry, computer science, or a physical science, although a few enter these positions after working as technicians. With the development of GIS, cartographers and photogrammetrists need more education and stronger technical skills—including more experience with computers—than in the past.

Most cartographic and photogrammetric technicians also have specialized postsecondary education. High school students interested in surveying and cartography should take courses in algebra, geometry, trigonometry, drafting, mechanical drawing, and computer science.

Licensure. All 50 States and all U.S. territories license surveyors. For licensure, most State licensing boards require that individuals pass a written examination given by the National Council of Examiners for Engineering and Surveying (NCEES). Most States also require surveyors to pass a written examination prepared by the State licensing board.

Licensing happens in stages. After passing a first exam, the Fundamentals of Surveying, most candidates work under the supervision of an experienced surveyor for 4 years and then for licensure take a second exam, the Principles and Practice of Surveyors.

Specific requirements for training and education vary among the States. An increasing number of States require a bachelor's degree in surveying or in a closely related field, such as civil engineering or forestry, regardless of the number of years of experience. Some States require the degree to be from a school accredited by the Accreditation Board for Engineering and Technology. Many States also have a continuing education requirement.

Additionally a number of States require cartographers and photogrammetrists to be licensed as surveyors, and some States have specific licenses for photogrammetrists.

Other qualifications. Surveyors, cartographers, and photogrammetrists should be able to visualize objects, distances, sizes, and abstract forms. They must work with precision and accuracy because mistakes can be costly.

Members of a survey party must be in good physical condition because they work outdoors and often carry equipment over difficult terrain. They need good eyesight, coordination, and hearing to communicate verbally and using hand signals. Surveying is a cooperative operation, so good interpersonal skills and the ability to work as part of a team is important. Good office skills also are essential because surveyors must be able to research old deeds and other legal papers and prepare reports that document their work.

Certification and advancement. High school graduates with no formal training in surveying usually start as apprentices. Beginners with postsecondary school training in surveying usually can start as technicians or assistants. With on-the-job experience and formal training in surveying—either in an institutional program or from a correspondence school—workers may advance to senior survey technician, then to party chief. Depending on State licensing requirements, in some cases they may advance to licensed surveyor.

The National Society of Professional Surveyors, a member organization of the American Congress on Surveying and Mapping, has a voluntary certification program for surveying technicians. Technicians are certified at four levels requiring progressive amounts of experience and the passing of written examinations. Although not required for State licensure, many employers require certification for promotion to positions with greater responsibilities.

The American Society for Photogrammetry and Remote Sensing has voluntary certification programs for technicians and professionals in photogrammetry, remote sensing, and GIS. To qualify for these professional distinctions, individuals must meet work experience and training standards and pass a written examination. The professional recognition these certifications can help workers gain promotions.

Employment

Surveyors, cartographers, photogrammetrists, and surveying technicians held about 148,000 jobs in 2006. Employment was distributed by occupational specialty as follows:

Surveying and mapping technicians	76,000
Surveyors	60,000
Cartographers and photogrammetrists	12,000

The architectural, engineering, and related services industry—including firms that provided surveying and mapping services to other industries on a contract basis—provided 7 out of 10 jobs for these workers. Federal, State, and local governmental agencies provided about 14 percent of these jobs. Major Federal Government employers are the U.S. Geological Survey (USGS), the Bureau of Land Management (BLM), the National Geodetic Survey, the National Geospatial Intelligence Agency, and the Army Corps of Engineers. Most surveyors in State and local government work for highway departments or urban planning and redevelopment agencies. Construction, mining and utility companies also employ surveyors, cartographers, photogrammetrists, and surveying technicians.

Job Outlook

Surveyors, cartographers, photogrammetrists, and surveying and mapping technicians should have favorable job prospects. These occupations should experience much faster than average employment growth.

Employment change. Overall employment of surveyors, cartographers, photogrammetrists, and surveying and mapping technicians is expected to increase by 21 percent from 2006 to 2016, which is much faster than the average for all occupations. Increasing demand for fast, accurate, and complete geographic information will be the main source of growth for these occupations.

An increasing number of firms are interested in geographic information and its applications. For example, GIS can be used to create maps and information used in emergency planning, security, marketing, urban planning, natural resource exploration, construction, and other applications. Also, the increased popularity of online mapping systems has created a higher demand for and awareness of geographic information among consumers.

Job prospects. In addition to openings from growth, job openings will continue to arise from the need to replace workers who transfer to other occupations or who leave the labor force altogether. Many of the workers in these occupations are approaching retirement age.

Opportunities for surveyors, cartographers, and photogrammetrists should remain concentrated in engineering, surveying, mapping, building inspection, and drafting services firms. However, employment may fluctuate from year to year with construction activity or with mapping needs for land and resource management.

Opportunities should be stronger for professional surveyors than for surveying and mapping technicians. Advancements in technology, such as total stations and GPS, have made surveying parties smaller than they once were. Additionally, cartographers, photogrammetrists, and technicians who produce more basic GIS data may face competition for jobs from offshore firms and contractors.

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016 Number	Change, 2006-2016 Percent
Surveyors, cartographers, photogrammetrists, and surveying technicians	—	148,000	179,000	31,000	21
Cartographers and photogrammetrists	17-1021	12,000	15,000	2,500	20
Surveyors	17-1022	60,000	74,000	14,000	24
Surveying and mapping technicians	17-3031	76,000	90,000	15,000	19

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

As technologies become more complex, opportunities will be best for surveyors, cartographers, and photogrammetrists who have a bachelor's degree and strong technical skills. Increasing demand for geographic data, as opposed to traditional surveying services, will mean better opportunities for cartographers and photogrammetrists who are involved in the development and use of geographic and land information systems.

Earnings

Median annual earnings of cartographers and photogrammetrists were $48,240 in May 2006. The middle 50 percent earned between $37,480 and $65,240. The lowest 10 percent earned less than $30,910 and the highest 10 percent earned more than $80,520.

Median annual earnings of surveyors were $48,290 in May 2006. The middle 50 percent earned between $35,720 and $63,990. The lowest 10 percent earned less than $26,690 and the highest 10 percent earned more than $79,910. Median annual earnings of surveyors employed in architectural, engineering, and related services were $47,570 in May 2006.

Median annual earnings of surveying and mapping technicians were $32,340 in May 2006. The middle 50 percent earned between $25,070 and $42,230. The lowest 10 percent earned less than $20,020, and the highest 10 percent earned more than $53,310. Median annual earnings of surveying and mapping technicians employed in architectural, engineering, and related services were $30,670 in May 2006, while those employed by local governments had median annual earnings of $37,550.

Related Occupations

Surveying is related to the work of civil engineers, architects, and landscape architects because an accurate survey is the first step in land development and construction projects. Cartographic and geodetic surveying are related to the work of environmental scientists and geoscientists, who study the earth's internal composition, surface, and atmosphere. Cartography also is related to the work of geographers and urban and regional planners, who study and decide how the earth's surface is being and may be used.

Sources of Additional Information

For career information on surveyors, cartographers, photogrammetrists, and surveying technicians, contact:

➤ American Congress on Surveying and Mapping, Suite 403, 6 Montgomery Village Ave., Gaithersburg, MD 20879. Internet: **http://www.acsm.net**

Information about career opportunities, licensure requirements, and the surveying technician certification program is available from:

➤ National Society of Professional Surveyors, Suite 403, 6 Montgomery Village Ave., Gaithersburg, MD 20879.

For information on a career as a geodetic surveyor, contact:

➤ American Association of Geodetic Surveying (AAGS), Suite 403, 6 Montgomery Village Ave., Gaithersburg, MD 20879.

For career information on photogrammetrists, photogrammetric technicians, remote sensing scientists and image-based cartographers or geographic information system specialists, contact:

➤ ASPRS: Imaging and Geospatial Information Society, 5410 Grosvenor Lane., Suite 210, Bethesda, MD 20814-2160. Internet: **http://www.asprs.org**

General information on careers in photogrammetry, mapping, and surveying is available from:

➤ MAPPS: Management Association for Private Photogrammetric Surveyors, 1760 Reston Parkway, Suite 515, Reston, VA 20190. Internet: **http://www.mapps.org**

Information on about careers in remote sensing, photogrammetry, surveying, GIS, and other geography-related disciplines also is available from the Spring 2005 Occupational Outlook Quarterly article, "Geography Jobs", available online at: **http://www.bls.gov/opub/ooq/2005/spring/art01.pdf**