Biological Scientists

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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.

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.

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

(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 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 ba-

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016 Number	Change, 2006-2016 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*.

sic 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.