Chronicle Guidance Publications

Biotechnologists

Occupational Brief Title Codes:
- D.O.T.: 041.
- G.O.E.: 02.02
- S.O.C.: 19-10
- O*NET™ 3.1: 19-10
- N.A.I.C.S.: Any Industry
- H.O.C.: No Code

Occupational Subtitles:
- Biochemists
- Bioprocess Engineers
- Biotechnicians
- Food Scientists
- Geneticists
- Immunologists
- Microbiologists

Work Classification Based Related D.O.T. Occupations:
- Animal Breeders
- Biophysicists
- Botanists
- Entomologists

Interests Based Related G.O.E. Occupations:
- Food Chemists
- Mycologists
- Physiologists
- Zoologists

Skills Based Related O*NET Occupations:
- Conservation Scientists and Foresters
- Dentists
- Physicians and Surgeons
- Veterinarians

Noteworthy Quote:

"In this very cross-disciplinary field, people may be scientists, engineers, technicians, quality control managers, CEOs, entrepreneurs...and the list could go on. Moreover, among the scientists you have chemists, microbiologists, geneticists, agronomists, etc. Jobs are quite diverse depending on one's specialty and level of education. It's like trying to say what it's like to work in the oil business—the answer would be very different depending on whether you're a roughneck, an accountant, a geologist, or a tanker captain."

– Kathleen E. Kennedy, Ph.D., North Carolina Biotechnology Center, Research Triangle Park, NC

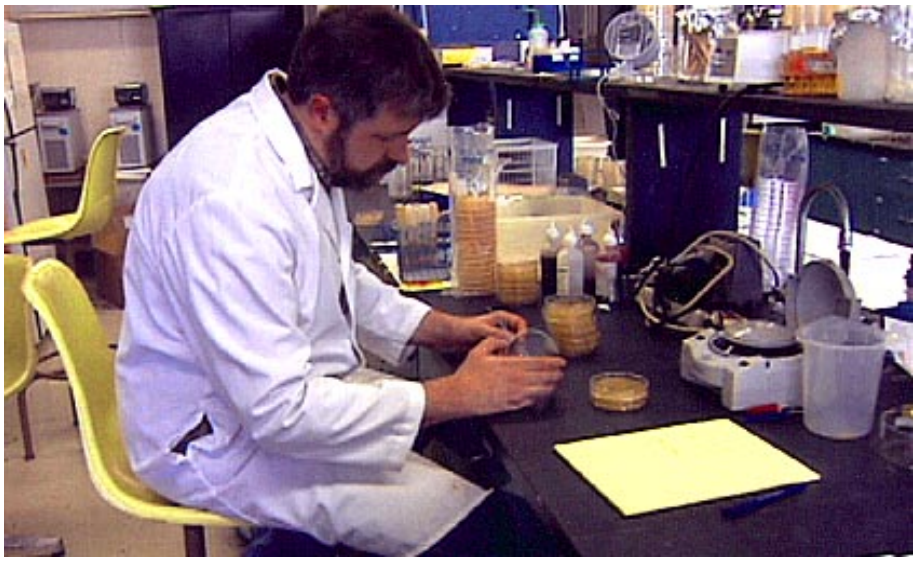
Biotechnologists (bio-tech-'nol-o-gists) work with genetic materials and biological agents or systems to modify or create new products or processes for specific uses in the fields of medicine, agriculture, food and beverage processing, specialty chemicals, and environmental science.

Many say the science of biotechnology is not really new. People in ancient times learned that tiny live organisms like yeast and bacteria would cause organic material to ferment. They used this knowledge to turn grapes into wine, grain into beer, and dough into bread. They turned milk into cheese or yogurt. By guiding the natural processes of rotting, souring, or molding, they were able to preserve foods for use later.

Farmers and ranchers have been using the best livestock for breeding since agriculture began. In that way they improved the breed. By saving the best seeds for planting, they improved the next crop. In the nineteenth century scientists learned how to cross two breeds of a plant or animal to get the best traits of both.

Biotechnology today, however, is more advanced, faster, and more reliable. In living cells, genes hold information that controls the characteristics of an organism. By molecular manipulation or engineering, biotechnologists can alter the genes and change the makeup or behavior of organisms. Biotechnologists can then turn these altered organisms into industrial or technical products for use as fuel, medicine, or food.

Today, some biotechnologists work on the Human Genome project, isolating, identifying, and sequencing human genes. This work continues to lead to the discovery of the genes associated with specific diseases and inherited traits, such as certain types of cancer or obesity. These advances in biotechnology have opened up research opportunities in almost all areas of biology, including commercial applications in agriculture, environmental remediation, and the food and chemical industries.



Biotechnologists work with genetic materials to modify or create new products for specific uses.
Photo by COEI

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Work Performed

Biotechnologists in research look into the possibilities of developing a new product from known scientific principles and theories. They design and develop processes to make and purify the product. They may direct large teams who conduct research on the product. About one third of the researchers in biotechnology are ***molecular biologists*** and ***immunologists***. They may also be ***geneticists***, ***biochemists***, ***microbiologists***, ***food scientists***, or ***bioprocess engineers***.

Most molecular biologists focus on animal and bacterial systems because this research is related to human health. Immunologists develop cells produced by the fusing of two cells of different origins. These resulting cells, called hybridomas, produce monoclonal (single-cell) antibodies. In animals or humans, the immune system produces antibodies to combat disease. They can also be used to detect diseases and other abnormal substances in the blood. Research with antibodies makes vaccines possible.

To artificially produce or improve elements found in nature, geneticists often use a technique known as genetic engineering. They alter the basic building blocks of life—genes and cells—to change the makeup or behavior of living things.

Microbiologists study bacteria, yeast, and other microorganisms. They identify microbes with certain characteristics for industrial processes. In other efforts they work with microorganisms to extract and detoxify chemicals. In the environmental field, for instance, microbiologists have discovered certain microbes that can devour oil spills.

Bioprocess engineers design systems to produce in large commercial quantities the products developed by researchers in the laboratories. They design equipment for the recovery, purification, and quality control of biological products. Bioprocess engineers design temperature-controlled vats for fermenting organisms to give them exactly the right conditions for growth. They also collect the products when they are ready, purify them, and work to refine the whole process so that it will yield consistently good results.

Biotechnologists in medicine, such as biochemists, do research to find treatments for AIDS, arthritis, heart disease, cancer, some blood diseases, diabetes, and the common cold. Current research into diabetes centers on a hormone, amylin, which may help control blood glucose levels better than insulin alone.

In agriculture, biotechnologists are using gene transfer techniques to develop crops that can survive without water for weeks, resist disease, and produce abundant yields. Gene transfers may make crops more resistant to pests, and make them adaptable to soils that cannot normally support crops, or cause them to produce their own algae-based fertilizer.

In animal husbandry (farming), biotechnologists have developed embryo splitting to produce twins in superior cows. Embryos from supercows can be implanted in inferior animals for gestation. The use of growth hormones has been widely researched. Milk cows injected with bovine somatotropin (BST) produce from 15 to 20 per-cent more milk while requiring less feed. The hormone porcine somatotropin stimulates muscle growth instead of fat in hogs.

Biotechnologists in food science and food analysis select bacteria to produce foods such as cheese, yogurt, bread, and sausage with consistently high quality. Food scientists apply biotechnology to improving food safety and quality. For example, they have developed improved strains of fermenting micro-organisms for use in making cheese and sausage. They have also produced tomatoes with improved texture. Those in the beverage industry produce beer, wine, and other fermented beverages. Biotechnologists in regulation study the rulings and guidelines of the U.S. Food and Drug Administration (FDA) to be sure the products meet FDA standards.

Biotechnologists in research often direct the work of ***biotechnicians*** (***laboratory assistants*** and ***research associates***). Like biotechnologists, the specific duties of biotechnicians vary for each of the different disciplines. Laboratory assistants may combine bacteria and nutrients in petri dishes, test and photograph them at intervals, spin them, separate DNA (the bearer of genetic traits) from cell nuclei, or do simple digestions. Research associates do more precise work, like putting cloned DNA fragments into filters. Under the supervision of a biotechnologist and with the help of a computer they also analyze data.

Along with laboratory work, biotechnologists in research study the work of their peers in books and journals to keep up with new findings they may want to use. They write up their own work, which they present at professional conferences and publish in science journals.

Working Conditions

Biotechnologists in research work in laboratories and at computer terminals. Since they are part of a research team, they deal with others. As a rule, the higher the position, the less time that person spends in laboratory work and the more time he or she spends in administrative or supervisory work. These individuals may work in office settings.

Laboratory work is not physically strenuous. Test tubes and petri dishes containing live cultures require careful handling. Biotechnologists working with disease cultures or degrading toxic waste take routine precautions. Biotechnologists who depend on grant money to support their research may be under pressure to meet deadlines and conform to rigid grant-writing specifications when preparing proposals to seek new or extended funding.

Hours and Earnings

Many biotechnologists work on projects that do not allow set hours. They may work extra hours to meet a deadline or to see a process through to the end. They may check a project on different shifts. A normal workweek may consist of forty to sixty hours.

Separate employment figures for biotechnologists are not available, but they are often considered comparable to the larger group of biological scientists. In 2000, overall median annual earnings for biological scientists were about $49,200. Average earnings among the various industries and disciplines ranged from $44,970 a year to $63,430 a year.

According to the National Association of Colleges and Employers, beginning salary offers in private industry averaged $29,235 a year for bachelor's degree recipients in biological science; around $35,600 for master's degree recipients; and about $42,700 for doctoral degree recipients.

In the Federal Government, in 2001, general biological scientists in nonsupervisory, supervisory, and managerial positions earned an average salary of $61,236 a year; microbiologists, $67,835 a year; ecologists, $61,936 a year; physiologists, $78,366 a year; and geneticists, $72,510 a year.

In 2000, biotechnicians saw overall median earnings around $15.16 an hour. In the Federal Government, in 2001, biotechnicians started at around $19-20,000 a year. The average salary was $32,753 a year.

Fringe benefits for biotechnologists and technicians generally include paid vacations, sick leave, pension plans, and health insurance. Large firms (more than twenty employees) tend to give more and better benefits.

Education and Training

High school students should do well in biology, chemistry, mathematics, and physics. Biotechnologists should be well-educated in traditional disciplines. A bachelor's degree may qualify graduates for work as laboratory assistants. They should plan to earn at least a master's degree in order to advance. With a master's degree graduates may become research associates. Studies should include biology, microbiology, genetics, biochemistry, and engineering. Students may also take courses in molecular biology, immunology, fermentation, and separation technology. A comprehensive education in biotechnology will cover intensive laboratory work in recombinant DNA, protein chemistry, integrated bioreactors, microbial kinetics, and enzyme reactions.

A number of colleges and universities offer a bachelor's or a master's degree in biotechnology or in a biotechnological field such as recombinant gene technology, applied molecular technology, applied biological sciences, food science, microbial engineering, and chemical or biochemical engineering. Graduate work for a doctoral degree in genetic engineering, molecular and cellular biology, and biochemical engineering is also available in many colleges and universities. Doctoral degrees are mandatory for biotechnologists who wish to achieve top research and management positions.

The rapid development of new biotechniques requires biotechnologists to continue their studies and retraining throughout their careers. Short courses, seminars, departmental cross-training, and retraining at university laboratories help keep them up-to-date in new developments.

Licensing and Professional Societies

Biotechnologists are not individually licensed. However, in working with and producing biotechnology products, everyone in the biotechnology industry must follow stringent regulations of several federal agencies such as the Food and Drug Administration, the Environmental Protection Agency, the National Institutes of Health, and the Department of Agriculture, as well as international agreements. This is to help safeguard the public because, for example, biotechnologists in genetic engineering alter life forms. Others work with viruses, microbes, and other potentially dangerous substances.

Many other organizations support the biotechnology industry including biotechnologists and their research and production efforts. The Biotechnology Industry Organization (BIO), for instance, is an international nonprofit trade association of firms involved in the use of recombinant DNA, hybridoma, and immunological technologies in a broad range of applications in health care, animal husbandry, agriculture, and specialty chemical production. Most states also have an affiliated state-level organization.

Personal Qualifications

Biotechnologists must have a creative mentality and an inquiring mind to devise techniques for research. They need patience, energy, and enthusiasm to carry out tests, cope with frustrations, face failures, and persevere until they get usable results. Biotechnologists must be good communicators in order to explain processes and the meaning of results to lay persons such as employers, product users, the government, and the public. Since biotechnologists often work as a team, they must work well with others.

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

Where Employed

In 2000, employment in the United States for biological scientists was around 69,000. Approximately 4 out of every 10 biological scientists were employed by federal, state, and local governments. Federal biological scientists worked mainly in the U.S. Departments of Agriculture, the Interior, and Defense, and in the National Institutes of Health. Most of the rest worked in the drug industry, which includes pharmaceutical and biotechnology establishments; hospitals; or research and testing laboratories.

There are hundreds of firms conducting biotechnology research in the United States, and several hundred more overseas. There are also a hundred or so major laboratories that either conduct biotechnology research or invest in biotechnology research in the United States. Most of these companies produce bacterial and virus vaccines, serums, plasmas, and other blood derivatives for human or animal use. Both small and large companies, such as pharmaceutical firms operate nationwide. Many biotechnology firms are allied with research foundations and departments in major universities.

Employment Outlook

The U.S. Department of Labor, projects faster-than-average employment growth for biological scientists through the year 2010, and average growth for biological technicians. Thousands of additional openings for biological scientists will also become available due to employee turnover due mainly to

the large number of established scientists who will retire over the next several years.

Despite prospects of faster-than-average job growth over the 2000-2010 period, biotechnologists can expect considerable competition for coveted basic research positions. Much research and development, including many areas of medical research, is funded by the federal government. Recent budget tightening has led to smaller increases in research and development expenditures, further limiting the dollar amount of each grant and slowing the growth of the number of grants awarded to researchers.

Opportunities for applied research positions in private industry should be more plentiful. However, the biological products industry is affected by stringent regulations that tend to increase production costs and delay release of products for sale. The best employment opportunities will be with large established biotechnology and pharmaceutical companies.

Entry Methods

Those planning to become biotechnologists should plan to serve as technicians or research associates in order to get the experience they must have to become biotechnologists. Graduates with a bachelor's degree might apply to firms in pharmaceuticals, biomedical engineering, or to any firm that conducts biotechnological activities.

School placement offices can offer help to job seekers. Industry often sends recruiters to colleges looking for job candidates. Professional societies maintain registers of employers and job openings for its members—several state BIO affiliates offer online job-placement services.

Another avenue of approach is to apply for a research grant or fellowship for completion during the graduate or postgraduate years. Many organizations dealing in biotechnology products or in biotechnological research offer grants, stipends, or fellowships to graduate students. Successful completion of assigned projects may lead to employment with pharmaceutical laboratories, government research laboratories, or universities.

Advancement

Graduates with a doctoral degree may enter industry as research scientists, or engineers. They may or may not have had experience as laboratory assistants or research associates. As researchers, biotechnologists devise projects and manage research teams. They usually publish their work in science or engineering journals. These research scientists or engineers guide and coordinate research projects that may take six to eight years to achieve major results. As directors biotechnologists manage, employ, promote, and discharge researchers. They control a budget and, along with other directors, help set company policies.

Opportunities for those with a bachelor's or master's degree in biological science are expected to be better. The number of science-related jobs in sales, marketing, and research management, for which non-Ph.D.'s generally qualify, are expected to be more plentiful than independent research positions. They may also fill positions as science or engineering technicians or health technologists and technicians. Some become high school biology teachers, while those with a doctorate in biological science may become college and university faculty members.

For Further Research

The Biotechnology Industry Organization (BIO), 1625 K Street, N.W., Suite 1100, Washington, D.C. 20006-1604. Web Site: www.bio.org

National Center for Biotechnology, Bio-Link, City College of San Francisco, 50 Phelan Avenue, Box S-12, San Francisco, CA 94112. Web Site: www.bio-link.org

Acknowledgments

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