JOBS BIOT

APPLYING OLD

IN

THESE WORKERS MAKE A CAREER OF TWEAKING MOTHER NATURE. FIND OUT WHO DOES WHAT WHERE THE CHROMOSOMES ROAM.

ECHNOLOGY:

SCIENCES TO NEW DISCOVERIES

by Azure Reaser

You walk into the room, aware that they already know your identity. They know your face better than you do; the patterns of your fingerprints are no secret, either. Your past is an open book. There is nothing left to hide.

Sound like science fiction? Guess again: it's biotechnology, a field of science that fuses engineering and technology with the life sciences. Authentication systems, like the hypothetical one described above, are an example of biotechnology's emerging uses. They are one of many developments that have shone the spotlight on this field.

But what, exactly, is biotechnology? And, more importantly for your future career plans, what kinds of jobs are there in this field?

The answer to that first question isn't easy. Some think biotechnology refers only to the manipulation of genetic material, the use of recombinant DNA. But biotechnology processes date back thousands of years: humans learned to breed animals and produce foods, such as wine and cheese, long before they had any understanding of genetics or fermentation. Both the modern definition and the technology have expanded to cover many areas related to biology and medicine. For purposes of this article, biotechnology is broadly defined as the science of using molecular biology to create new products.

Regarding the second question, jobs related to biotechnology vary widely. Geneticists might alter the genetic codes of living organisms to create new foods or medicines. Animal research associates work with animals used for research and experiments. Assay analysts test and maintain tissue and cell cultures. These and other biotechnology-related occupations discussed on the following pages illustrate three types of work within biotechnology: medical research and development, agricultural research and development, and production. The occupational descriptions include job duties, working conditions, employment, earnings, and training requirements—from a high school diploma plus experience to a doctoral degree.

This article provides an overview of biotechnology as a career field and, consequently, does not cover every biotechnology-related occupation—such as the biometric engineers and scientists who develop authentication systems. In addition to presenting occupational descriptions, the following pages discuss nontechnical jobs within biotechnology, the pros and cons of working in this field, and resources to help you continue exploring the ever-changing world of biotechnology.

Medical research and development

Perhaps the best known area of modern biotechnology is its use in medical research and the development of pharmaceuticals and medical therapies. Biotechnology scientists and technicians working in medical research and development study the human body and the intricate way in which it functions. Occupations include geneticist, biomedical engineer, and clinical research coordinator and associate.

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Geneticist

Working in either medical or agricultural research, geneticists study genes from plants, animals, and humans to determine how genes interact with each other, evolve, and duplicate.

Developments in mapping the human genome—the set of all genes in human DNA—are taking biotechnology to a new level. Geneticists are gaining insight into ways of preventing a disease from even starting. "In the future," says Tim Lockie, director of business operations with a gene-transfer research firm in Madison, Wisconsin, "we hope that custom-tailored medicines specific to people's genetic backgrounds will be available."

Working conditions. Geneticists usually work in laboratories to study genetic material. They use both standard equipment, such as microscopes, and more advanced tools, such as DNA scanners. Some equipment is designed for gene therapy and gene manipulation procedures. Geneticits also pore over vast amounts of data with the help of computers and special software.

Often relying on grants for funding, geneticists work in industry, academia, and Federal and State governments.

Employment and earnings. In Bureau of Labor Statistics (BLS) data, geneticists are included within the larger occupation of biological scientists. Biological scientists held about 73,000 jobs in 2000, the most recent year for which data are available. Almost 25 percent of all biological scientists worked in the Federal Government, and another 22 percent worked in research and testing services.

Median annual earnings of biological scientists were $49,000 in 2000. According to a salary survey by the National Association of Colleges and Employers, starting offers for biological scientists in 2001 averaged $42,744 for doctoral degree recipients.

Workers in biotechnology are no strangers to technology. Geneticists, for example, use computers for tasks ranging from DNA mapping to data analysis.

Training. A doctoral degree is usually necessary to work as a geneticist. Geneticists usually study biology or genetics as undergraduates, but a major in one of the physical sciences with a minor in biology is acceptable for many Ph.D. programs. Doctoral programs in genetics usually involve laboratory work, research projects, and genetics-related courses.

Biomedical engineer

Biomedical engineers are behind innovations such as artificial limbs, edible sensors, and sophisticated monitors used during surgery. These workers combine biology and medicine with engineering to develop machines and processes. Using their engineering knowledge, biomedical engineers develop devices and procedures to solve medical and health-related problems and to research the biological systems of humans and animals. For example, they may design laser systems for use in corrective eye surgery or develop artificial organs, imaging systems, and devices for regulating insulin.

Specialties within biomedical engineering include biomaterials, biomechanics, medical imaging, rehabilitation, and orthopedic engineering.

Working conditions. Biomedical engineers are employed in a variety of settings, from hospitals to research facilities to industry, depending on their specialization. In hospitals, they may design equipment for patients who have severe burns or who are paralyzed, developing systems to monitor their condition. In research facilities, biomedical engineers supervise or participate in projects to develop equipment, pharmaceuticals, or cures for disease. And in industry, they may be involved in performance testing of new products or may advise companies on proper safety standards for medical machinery.

Employment and earnings. Biomedical engineers held about 7,200 jobs in 2000, according to BLS. Manufacturing industries employed 30 percent of all biomedical engineers, primarily in the medical instruments and supplies industries. Some biomedical engineers worked for health services; others worked as contractors for government agencies or as independent consultants.

Median annual earnings of biomedical engineers were $57,480 in 2000. According to the National Association of Colleges and Employers, biomedical engineers with a bachelor's degree received average starting salary offers of $47,850 per year in 2001 and those with a master's degree were offered an average of $62,600.

Training. A bachelor's degree in either biomedical engineering or a closely related specialty, such as mechanical or electronic engineering, is required for almost all entry-level biomedical engineering jobs. Students take core engineering classes first, followed by coursework in the biomedical engineering specialty. Some programs offer many different concentrations; others offer a limited number. Prospective students should investigate curricula and accreditations before selecting a program.

Biotechnology scientists and technicians in medical research and development study the human body and its functions.

Graduate training is necessary for most biomedical engineering faculty positions and many research and development programs.

Clinical research coordinator and associate

Making sure that new medicines are safe is the work of these researchers. Clinical research coordinators and associates test new drugs and medical procedures by monitoring human responses to medical treatment. Clinical research coordinators recruit and screen patients who try new treatments and monitor and report on patient progress. Clinical research associates use automated equipment to evaluate test results, ensuring that the study is conducted properly and meets regulations. They also supervise others conducting the tests and may develop the methods used in the study and prepare final reports.

Working conditions. Clinical research coordinators and associates usually work in large hospitals or independent laboratories. Depending on the type of clinical studies they perform, clinical research coordinators and associates may have to work rotating shifts that include nights, weekends, and holidays.

Employment and earnings. Although BLS does not have data on clinical research coordinators and associates, medical and clinical laboratory technologists and technicians, some of whose duties are similar to those of coordinators and associates, held 295,000 jobs in 2000. Health services employed about 86 percent of all medical and clinical laboratory technologists and technicians, with hospitals accounting for 52 percent and medical and dental laboratories accounting for another 13 percent.

Median annual earnings in 2000 were $40,510 for medical and clinical laboratory technologists and $27,540 for medical and clinical laboratory technicians. In hospitals, median

Animal research associates work primarily with animals, such as rats and mice, that are used in experiments.

earnings were $40,840 for technologists and $28,860 for technicians; in offices and clinics of medical doctors, median earnings were $38,850 and $27,180, respectively; and in medical and dental laboratories, median earnings were $39,780 and $25,250, respectively.

Training. For entry-level jobs, both clinical research coordinators and clinical research associates usually need a bachelor of science degree or training as a registered nurse. Coordinators and associates also need some clinical experience, either in medical research, nursing, or pharmaceuticals. For some jobs, coordinators may need a master's degree in science or a related clinical field. Applicant experience is a significant factor for filling senior coordinator jobs. Individuals are sometimes considered for associate positions if they have a high school diploma or an associate degree and at least 3 years of experience.

Although not required, certification is available from the Association of Clinical Research Professionals for clinical research coordinators and associates. Certification allows coordinators and associates to demonstrate that they have met eligibility requirements and have at least a minimal level of job-related knowledge and skills. Recertification is required every 2 years.

Agricultural research and development

Increasingly, biotechnology is being applied by workers in agriculture to modify and improve crops and animals. Some scientists working with plants transfer genes between dissimilar plants to produce crops that are able to resist disease or thrive in harsh environments. Scientists working with animals might develop tests and antibodies to diagnose, treat, and prevent ailments in farm animals. The occupations discussed in this section—plant breeder and animal research associate—are involved with these facets of agricultural research and development.

Plant breeder

Plant breeders develop hybrids: they cross-breed plants that have desirable characteristics with other plants to produce plants and seeds with superior traits. Although this has been a common practice for centuries, biotechnology allows plant breeders to modify a plant's genes more precisely.

> **In agriculture, workers apply biotechnology to modify and improve crops and animals.**

Plant breeders working in biotechnology manipulate the genetic material of some plants to incorporate genetic material from other, sometimes unrelated, organisms. For example, breeders have discovered proteins in some plants that provide natural self-protection from insects—and have successfully transferred into crop plants the genetic material producing these proteins. However, the use of genetically modified plants is controversial and is heavily regulated.

In addition to planning and conducting research, a plant breeder's responsibilities may range from public relations to advising management.

Working conditions. Plant breeders usually work in offices or laboratories, although they may do new-product trials offsite. Some travel may be required to meet with other breeders. Because they often depend on grant money to support their research, plant breeders may be under pressure to meet deadlines and to conform to rigid specifications in preparing funding proposals.

Employment and earnings. In BLS data, plant breeders are included within the occupation of agricultural and food scientists. Agricultural and food scientists held about 17,000 jobs in 2000. About 32 percent of all salaried, nonfaculty agricultural and food scientists worked for Federal, State, or local governments. Nearly two-thirds worked for the Federal Government, primarily in the U.S. Department of Agriculture. In addition, large numbers worked for State agricultural colleges or agricultural research stations. About 23 percent were self-employed, chiefly as consultants. Almost 9 percent worked in the research and testing services industry, most of them in commerical research and development laboratories. The rest were distributed throughout different industries.

Scientists and technicians in biotechnology, like those in other fields, usually perform job duties in laboratories and offices.

Median annual earnings of agricultural and food scientists were $52,160 in 2000. Average salaries for Federal workers in some agricultural science specialties in 2001 were as follows: agronomy, $62,311; soil science, $58,878; horticulture, $59,472; and entomology, $70,133.

Training. Plant breeders must have at least a bachelor's degree and 2 years of plant breeding or agronomical experience, along with training in plant breeding or plant science. Most plant breeders have a master's or doctoral degree. Breeders who develop and use biotechnical techniques for genetic manipulation usually have a Ph.D.

Animal research associate

Animal research associates work primarily with animals used in experiments. Some research associates modify the genetic makeup of laboratory animals, such as rats and mice. Others use biotechnology-based diagnostic tests on livestock herds for early and more accurate diagnosis of disease. Current research projects include creating edible vaccines for livestock and investigating the feasibility of producing disease-resistant livestock. Animal research associates' other job duties include feeding animals and cleaning their living quarters, assessing animal health, harvesting tissues, and maintaining research documentation.

Working conditions. Animal research associates work in research facilities, private clinics, animal hospitals, and farms. Some tasks may require physical strength for lifting and moving animals. Because animals need constant care, animal research associates often work weekends, nights, and holidays. Most full-time associates work about 40 hours per week, but some work 50 or more hours per week.

Employment and earnings. BLS does not have data on animal research associates. But BLS data show that veterinarians, who have some job responsibilities similar to those of animal research associates, held about 59,000 jobs in 2000. And according to the National Association of Colleges and Employers, beginning salary offers in 2001 for jobseekers with a bachelor's degree in animal science averaged $28,031 per year.

Veterinarians had median annual earnings of $60,910 in 2000. Veterinary medical college graduates entering the Federal Government earned at least $35,808 in 2001.

Training. Animal research associates must have a bachelor's degree in biology or a related subject. They should have 2 to 8 years of experience working with animals in a veterinary or research setting.

Production

Biotechnology production workers move the results of biotechnology research from the laboratory to the marketplace. These workers develop safe and efficient methods for mass producing biotechnology-developed products, such as

Assay analysts work with scientists and technicians, preparing slides and other equipment for tests of tissue and cell cultures.

drugs. In some ways, the jobs of these workers are similar to those of production workers in other fields. However, production workers in biotechnology, including process development associates and assay analysts, usually need additional skills and training.

Process development associate

Most of the job duties of process development associates revolve around optimizing and improving manufacturing processes. These associates develop processes that improve product yield and reduce costs in various areas, including fermentation and purification, and research and implement new methods and technologies to enhance production.

Working conditions. Most process development associates work 40 hours per week in offices or manufacturing plants but may have to work more, depending on the project they are assigned. Travel to other plants sometimes is needed to observe different production processes and to meet with management.

Employment and earnings. In BLS data, process development associates are included among industrial engineers. In 2000, industrial engineers held about 154,000 jobs, more than 75 percent of which were in manufacturing industries. But because of the diverse nature of their skills, industrial engineers were also employed in other industries, including engineering and management services and business services.

Median annual earnings of industrial engineers were $58,580 in 2000.

Training. Process development associates need a bachelor's degree in a scientific or engineering discipline and at least 2 years of experience in manufacturing. Associates working in biotechnology also benefit from training in biology, chemistry, and chemical production.

Assay analyst

Assay analysts prepare, maintain, and test tissue and cell cultures—groups of these materials growing in scientifically controlled environments. Analysts prepare required equipment and tools, which include Petri dishes and slides. In testing cell and tissue samples, they use chemicals following instructions from scientists and science technicians. Assay analysts monitor cultures' reactions and record results of their tests.

Working conditions. Most assay analysts work indoors, usually in laboratories. Although most have regular hours, some may occasionally work irregular hours to monitor experiments that cannot be completed during their regular shifts. Some technicians may be exposed to hazards from equipment, chemicals, or toxic materials.

Employment and earnings. BLS does not collect information about assay analysts, but it does have information about chemical technicians, whose work is similar. Chemical technicians held about 73,000 jobs in 2000, according to BLS. More than 68 percent of the jobs were in the manufacturing sector, specifically chemicals and allied products, where chemical technicians held more than 30,000 jobs. Research and testing services employed more than 12,000.

Chemical technicians, most of whom have a bachelor's degree, had median hourly earnings in 2000 of $17.05. Assay analysts usually make less than that amount, in part because the tasks they perform are less complicated than those of chemical technicians. Earnings for chemical technicians varied by industry: in research and testing services, earnings ranged from $8.64 for the lowest 10 percent to $20.28 for the highest 10 percent; in drug manufacturing, earnings ranged from $11.47 for the lowest 10 percent to $26.93 for the highest 10 percent.

> **Production workers in biotechnology develop safe methods for mass producing biotechnology-developed goods.**

Training. Assay analysts need a high school diploma or equivalent. Some laboratory experience is recommended.

Biotechnology jobs for nonscientists

In addition to the many scientific jobs involving biotechnology, there are many nonscientific jobs that usually do not require training in biology. However, some science knowledge often is recommended. "There are jobs available no matter what background or education you have, because biotechnology is such a diverse field," says Nat Page, a molecular breeding coordinator with a research firm in Arlington, Wisconsin.

Jobs relating to biotechnology are diverse. Occupations include writers and editors, who describe developments in biotechnology for trade journals or other media; public relations or marketing specialists, who coordinate the flow of information to and from biotechnology companies; and genetic counselors, who work with those adversely affected by genetic disorders as well as with families who may be at risk of inheriting genetic diseases.

Nonscientific training or skills may be useful in many biotechnology jobs. For example, sales ability is important in

Meaningful, independently directed work may draw people to careers in biotechnology.

jobs that involve selling biotechnology processes or products. Knowledge of federal licensing requirements is a must when working toward getting a biotechnology product licensed. And an auditing background is helpful for ensuring that business operates effectively on a tight budget.

In addition, jobseekers in biotechnology, like job applicants in most career fields, should develop the core skills employers usually seek. These include communication and interpersonal skills and organizational ability. Other sought-after applicant traits often cited by biotechnology employers are recordkeeping skills, management ability, and willingness to travel. Jobseekers also should convey an interest in biotechnology as a career field.

Information about most nonscience biotechnology jobs is accessible through the same channels used for science ones: Internet searches, employer inquiries, and job postings. The best way to learn about qualifications for a specific job is to contact the biotechnology employer directly.

Pros and cons of biotech work

Working in biotechnology has many advantages, but, like all career fields, it also has some drawbacks.

Meaningful work is one of the most commonly cited benefits of these jobs. The products workers create improve the health and nutrition of the world's population.

Jobseekers in biotechnology should develop core skills that employers seek.

Some principal scientists also say that worker independence is one of the best aspects of their jobs. Interesting work is another plus: biotechnology workers regularly learn new techniques and make discoveries.

Biotechnology is a vast field with much potential. But because it is not a specific industry or occupation, biotechnology employment projections are not produced by BLS. Still, BLS projections for some industries involved with biotechnology—including agricultural services, drug manufacturing, and health services—give some indication of its prospects. And these industries are projected to grow faster than the average throughout the 2000-10 decade.

For example, agricultural services, which includes veterinary and animal services, is projected to grow 39 percent, more than twice the average for all industries. Drug manufacturing is projected to grow 24 percent, and health services is expected to grow 25 percent. Combined, these industries are projected to add more than 3 million new jobs to the economy between 2000 and 2010.

New jobs are not employment guarantees, however, and jobs in biotechnology may be harder to find because projects in biotechnology are subject to fluctuations in funding. And the work can be frustrating. Laboratory workers need patience because they often must repeat the same tasks and experiments many times, waiting months for a breakthrough. Even after the laboratory work is complete, many of the products biotechnology workers develop never make it to the public. Regulations and financial considerations mean that some discoveries are shelved.

On the other hand, most scientists understand these restrictions and enjoy the challenges of their work despite its limitations. As one biotechnology scientist notes, keeping up with new technologies may not be easy, but the potential rewards are worth the effort.

Other sources of information

Reading this article is a good way to start learning about careers in biotechnology. To find out more, visit your local library or your school's career counseling center. Look for resources about biotechnology, biotechnology-related occupations, or other science occupations. Among the resources available in most libraries and career centers is the *Occupational Outlook Handbook, 2002-03 Edition*, which has more than 270 occupational statements describing the nature of the work, working conditions, employment, training requirements, earnings, and outlook for about 90 percent of the jobs in the economy. The *Handbook* also is available online at **www.bls.gov/oco**.

As the occupational examples in this article illustrate, experience is part of the entry-level training requirement for many biotechnology occupations. Many biotechnology employers offer internships for high school and college students who are interested in learning more about biotechnology companies. Whether in the laboratory or in the field, job experience can help you begin a career in biotechnology.

Information is available through most State biotechnology associations. These associations usually have general facts about biotechnology as well as statewide information about jobs, education, and current events. They also may be able to assist you in making contacts by providing employer directories. For links to State organizations, contact:

National Center for Biotechnology
Bio-Link
City College of San Francisco
50 Phelan Ave., Box S-12
San Francisco, CA 94112
(415) 487-2472
www.bio-link.org

To learn more about biotechnology, contact the following organizations:

Biotechnology Industry Organization
1225 Eye St. NW., Suite 400
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Council for Biotechnology Information
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