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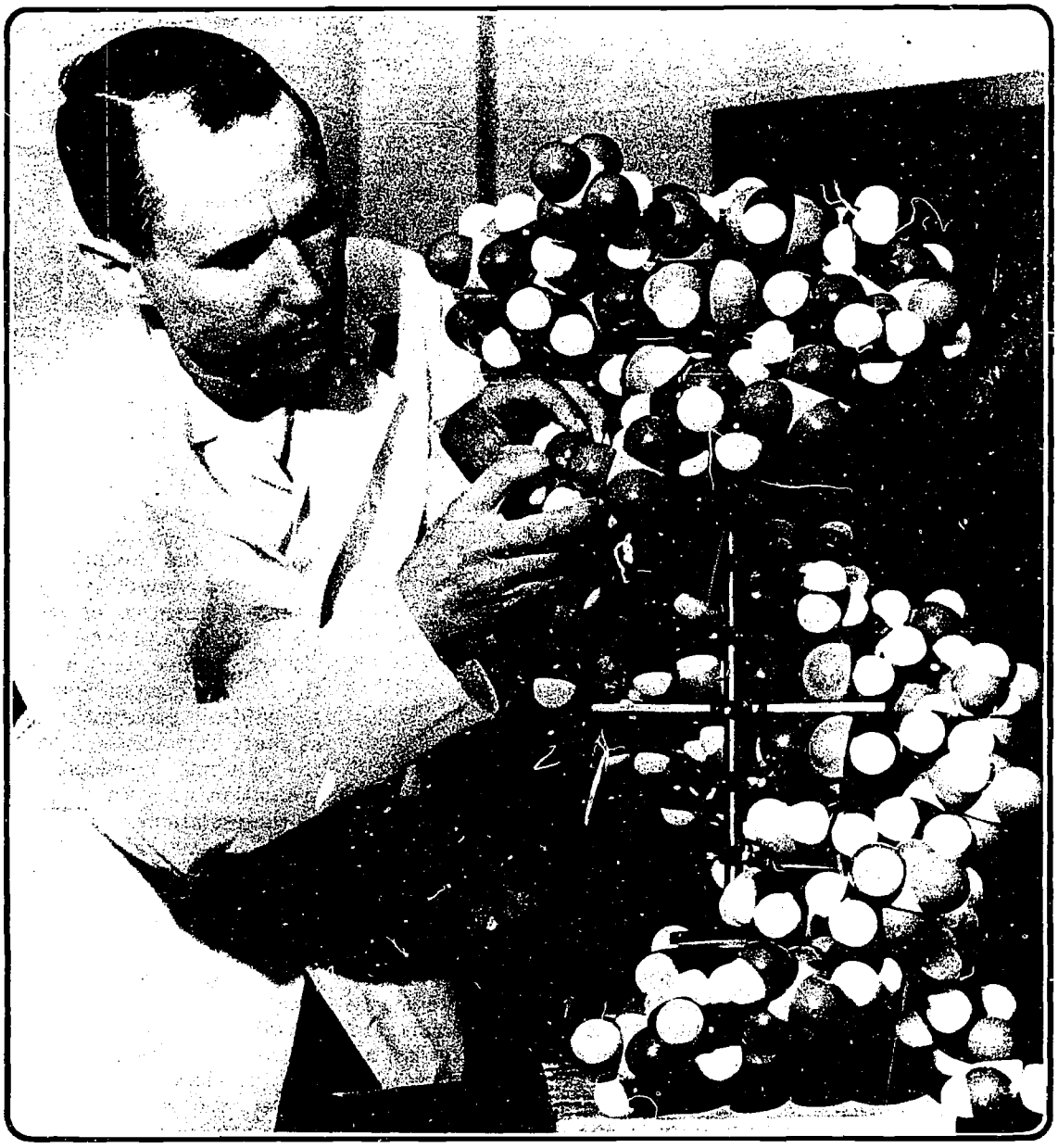
ABSTRACT

The nature of the work performed by biologists and biochemists is described in general terms, and for the subcategories such as agronomists, pharmacologists and entomologists. The types of employment opportunities, the necessary training the employment outlook and typical salaries and working conditions are described. Addresses for requesting additional information are given, and a list of other pamphlets describing other occupations is appended. (AL)

Employment Outlook

Life Science Occupations

- Life Scientists
- Biochemists



A Reprint from the Occupational Outlook Handbook, 1970-71 Edition

U.S. Department of Labor
Bureau of Labor Statistics
Bulletin 1650-25

Life sciences

The life sciences encompass the study of all living organisms and the processes that determine the nature of life. They are concerned with men and microbes, plants and animals, and health and disease, as well as how these organisms relate to their environment.

Some scientists in this field perform research to expand our understandings of living things. Others, who teach, pass this knowledge on to students. Many scientists pursue both activities. Still others apply these concepts and principles to the solution of practical problems, such as the development of new drugs or varieties of plants.

This chapter discusses life scientists as a group since they receive comparable basic training and have similar employment and earning prospects. Brief descriptions are provided about the nature of the work of a number of life scientists—including botanists, zoologists microbiologists, biophysicists, ecologists, pathologists, and pharmacologists. This chapter also contains a separate statement on biochemists. More detailed statements for other professional workers in the life sciences—soil scientists, soil conservationists, foresters, and range managers—are discussed elsewhere in the *Handbook*.

LIFE SCIENTISTS

(D.O.T. 040.081, 041.081, 070.081, and 077.128)

Nature of the Work

Life scientists study living organisms, their structure, evolutionary development, behavior, and life processes. They place emphasis on the relationship between these organisms and their environments. The number and variety of plants and animals are so vast and the life processes so varied and complex that life scientists must of necessity become specialists. Some learn as much as possible about a particular kind of animal, plant, or microorganism. Others, interested in how an animal or the human body functions, study such things as the nervous system, how food is digested, or how organisms are affected by disease. Some are interested in the evolution of living organisms, the mechanisms of heredity; or the ways environmental factors, such as light or heat, affect life processes. In general, life scientists specialize in one of three broad areas—agriculture, biology, medicine.

Two-fifths of all life scientists are engaged in research and development. Many conduct basic research, which is aimed at adding to our knowledge of living organisms with only secondary regard to its application. Nevertheless, the development of insecticides, disease-resistant crops, and antibiotics have resulted from basic research in the life sciences. Much of the basic medical knowledge of the treatment of disease has its origin in pure science.

Research in the life sciences may take many forms. A botanist exploring the volcanic Alaskan valleys to see what plants live in this strange environment and a zoologist searching the jungles of the Amazon valley for previously unknown kinds of animals are both doing research; likewise, an entomologist in a laboratory tests various chemical insecticides for effectiveness and possible hazards to human and animal life.

Regardless of the type of research in which they are engaged, life scientists must be familiar with fundamental research techniques and the use, not only of light and electron microscopes, but of other complex physical and electronic laboratory equipment. Advanced techniques and principles from chemistry and physics are applied widely. A knowledge of mathematical and statistical procedures, as well as of the operation of electronic computers, often is needed in experiments involving a large number of variable factors.

Teaching in a college or university is the major function of nearly one-fourth of all life scientists. Many teachers combine independent research with their regular teaching duties, and in some large educational institutions, use the major portion of their time on research.

More than one-fourth of all life scientists are engaged in management and administrative work, primarily the planning, supervision, and administration of programs of research or testing of foods, drugs, and other products. Others provide liaison between the Federal Government and the agricultural experiment stations at State universities, assisting in the planning, development, and evaluation of research programs at these stations.

The remaining life scientists are engaged in a variety of other types of work, such as consulting, writing, testing, and inspection. A few are employed in technical sales or field service work for industrial firms; such work may include, for example, teaching company salesmen and prospective purchasers the value and proper use of new chemicals. Some are engaged in research in

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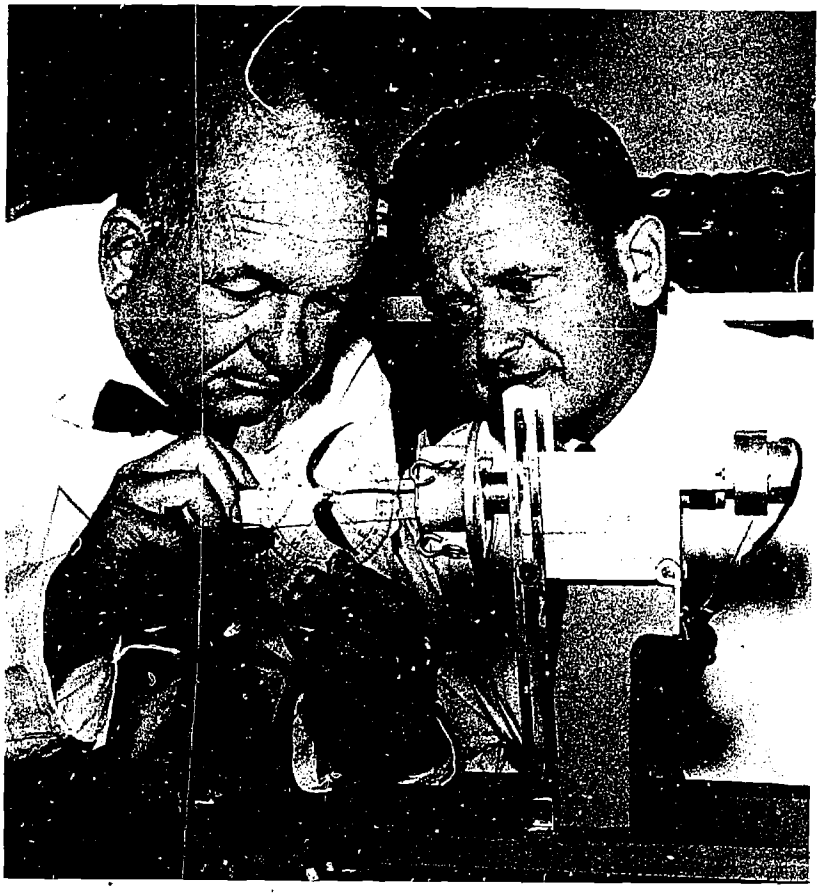


Botanists study leaves of pepper plant to be launched into earth orbit.

natural history museums, zoos, and botanical gardens.

Life scientists may be classified into three broad groups characterized by the general type of organism with which they work: Botanists, who study plants; zoologists, who are concerned with animals; and microbiologists, who work with micro-organisms.

Botanists study all aspects of plant life. Plant taxonomists identify and classify plants. Plant ecologists study the interrelationships between environmental elements and plant life and distribution. Other botanists include plant morphologists, concerned with the structure of plants and plant cells; plant physiologists, interested in the life processes of plants; and plant pathologists, engaged in determining the cause and control of plant diseases.

Zoologists study animal life—its origin, classification, behavior, life processes, diseases, and parasites—and the ways in which animals influence and are influenced by their environment. Zoologists who specialize in the study of certain classes of animals may use titles that indicate the kind of animal studied, such as ornithologists (birds), herpetologists (reptiles and amphibians), ichthyologists (fishes), and mammalogists (mammals).

Microbiologists investigate the growth, structure, and general characteristics of bacteria, viruses, molds, and other organisms of microscopic or submicroscopic size. Although the terms bacteriology and microbiology are sometimes used interchangeably, microbiology, the broader term, is preferable when referring to the study of all microscopic organisms. Microbiologists isolate and make cultures of these organisms in order to examine them with a variety of highly specialized equipment. Some microbiologists pursue medical problems, such as the relationship between bacteria and infectious disease, or the effect of antibiotics on bacteria. Others specialize in soil bacteriology (the study of soil microorganisms and their relation to soil fertility), virology (the study of viruses), immunology (the study of the mechanisms that fight infection), or serology (the study of animal and plant fluids, including blood serums).

Life scientists also may be classified according to the type of approach used—some of which are wholly within 1 of the 3 major groupings, and others which may be found in all 3 groups. Some life scientists are classified according to the specific type of organism studied. Some life scientists whose work cuts across more than one of these major groupings, as often in the case of college and university teachers, simply may call themselves biologists. A description of the work of some life scientists follows.

Agronomists are concerned with field-crop problems. They develop new methods of growing crops for improved quality, higher yield, and more efficient production. They seek new, hardier varieties of crops and better methods of controlling disease, pests, and weeds. Agronomists may specialize in the problems of a geographical region, a particular crop, or a technical area, such as crop-

breeding or production methods.

Anatomists study the form and structure of organisms. Those who specialize in the structure of cells are known as cytologists, whereas those who specialize in the structure of tissues and organs are known as histologists. Anatomists may examine structures visible to the naked eye or of microscopic size, or those of submicroscopic size, visible only through the use of the electron microscope. Many anatomists specialize in human anatomy.

Biochemists, who are trained in both chemistry and biology, study the chemical processes of living things. A more detailed description of their work is contained in a separate statement elsewhere in this chapter.

Biological oceanographers, or marine biologists, study the plant and animal life in the oceans and the environmental conditions affecting them. See separate statement on Oceanographers elsewhere in the *Handbook*.

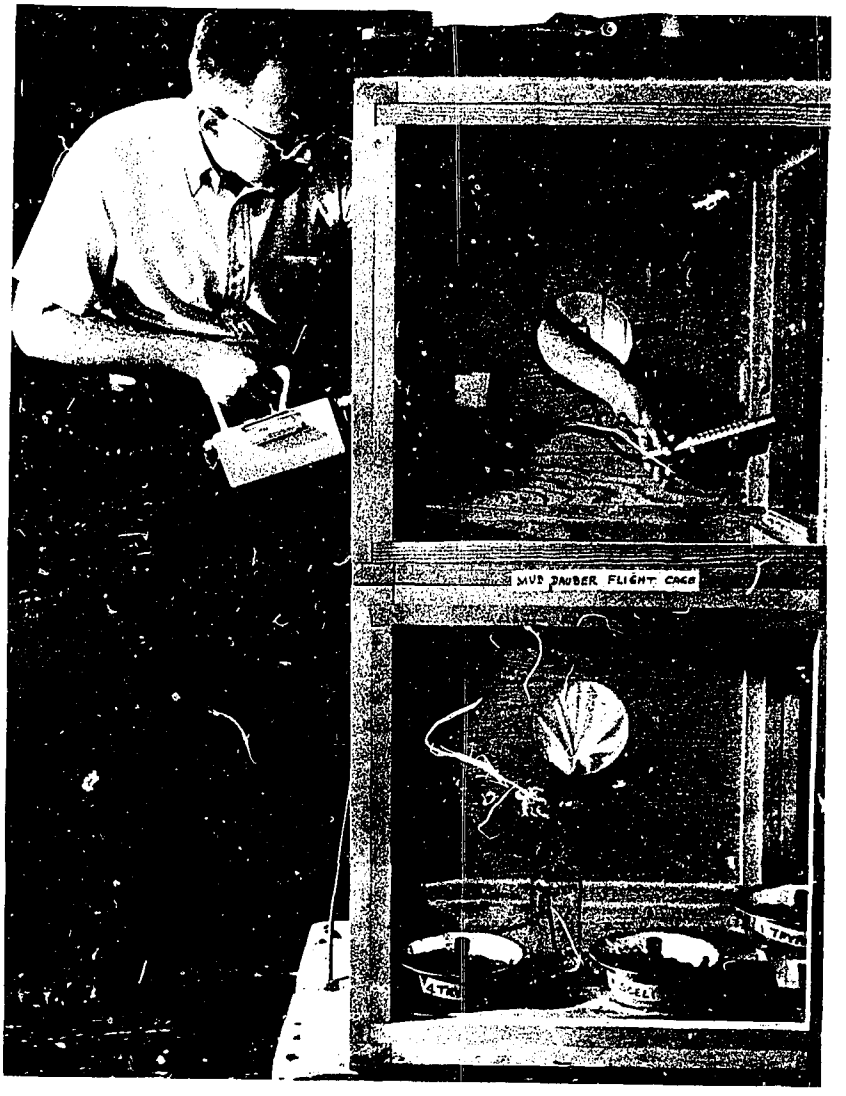
Biophysicists who are trained in both physics and biology, investigate the physical principles of living cells and organisms, and their responses to physical forces, such as heat, light, radiation, sound, and electricity. They may use the electron microscope to make tissues visible down to the smallest units and they may use nuclear reactors to study the effect of radiation on cells and tissues.

Ecologists study the mutual relationship among organisms and between them and their environment. They are interested in the effects of environmental influences such as rainfall, temperature, altitude, and kind and quality of food.

Embryologists study the development of an organism from fertilization of the egg through the hatching process or gestation period. They investigate the physiological, biochemical, and genetic mechanisms that control and direct the processes of development, how and why this control is accomplished, and the causes of abnormalities in development.

Entomologists are concerned with insects and their relation to plant and animal life. They identify and classify the enormous number of different kinds of insects. Some entomologists seek methods of controlling harmful insects that carry disease and spoil food supplies. Others develop ways to encourage the growth and spread of beneficial insects, such as honeybees.

Geneticists explore the origin, transmission, and development of hereditary characteristics. Geneticists engaged primarily in improving plant and animal breeds of economic importance—such as cereal and tobacco crops or dairy cattle and poultry—may be



Ecologist inspects wasp's nests made of radioactive mud.

classified as plant or animal breeders, agronomists, or animal science specialists. Theoretical geneticists search for the mechanisms that determine inherited traits in plants, animals, or humans.

Horticulturists work with orchard and garden plants, such as fruits, nuts, vegetables, flowers and ornamental plants, and other nursery stocks. They develop new or improved plant varieties and better methods of growing, harvesting, storing, and transporting horticultural crops. Horticulturists usually specialize in either a specific plant or a particular technical problem, such as plant breeding.

Husbandry specialists (animal) conduct research on the breeding, feeding, management, and diseases of domestic farm animals to improve the health and yield of these animals.

Nutritionists examine the processes through which food is utilized, the kinds and quantities of food elements—such as minerals, fats, sugars, vitamins, and proteins—that are essential to build and repair body tissues and maintain health, and how these food elements are transformed into body substances and energy. Nutritionists also analyze food to determine its composition in terms of essential ingredients or nutrients.

Pathologists study the nature, cause, and development of disease, degeneration, and abnormal functioning in humans, in animals, or in plants. Many specialize in the study of the effects of diseases, parasites, and insect pests on cells, tissues, and organs. Others investigate genetic variations and other abnormal effects caused by drugs. The term "pathologist" is normally reserved for specialists in human pathology (medical pathology). Specialists in animal pathology are usually

Pathologists usually work in laboratories.

veterinarians. (See statement on Veterinarians.) Those who study plant diseases may be called plant pathologists or phytopathologists; their work is discussed under the section on botanists.

Pharmacologists conduct tests to determine the effects of drugs, gases, poisons, dusts, and other substances on the functioning of tissues and organs, and relate their findings with medical data. They may develop new or improved chemical compounds for use in drugs and medicines.

Physiologists study the structure and functions of cells, tissues, and organs and the effects of environmental factors on life processes. They may specialize in cellular activities or in one of the organ systems, such as the digestive, nervous, circulatory, or reproductive systems. The knowledge gained in such research often provides the basis for the work of many other specialists, such as biochemists, pathologists, pharmacologists, or nutritionists.

Places of Employment

An estimated 170,000 persons were employed in the life sciences in 1968. About 10 percent were women. Of this total, nearly 48,000 worked in agricultural science, more than 66,000 worked in biological science, and about 54,000 worked on problems related to medical science.

More than half of the total were employed by colleges and universities in teaching and research positions. Medical schools and their associated hospitals employed particularly large numbers of life scientists in the medical field. State agricultural colleges and agricultural experiment stations operated by universities in cooperation with Federal and State Governments employed sizable numbers of agronomists, horticulturists, animal husbandry specialists, entomologists, and other agriculture-related specialists.

The Federal Government in 1968 employed about 28,000 life scientists, two-thirds of whom were employed in the Department of Agriculture. The Department of the Interior employed nearly all the fish and wildlife biologists in the Federal Government. Other large numbers of life scientists were employed by the Department of the Army and the National Institutes of Health. State and local governments, combined, employed about 19,000 biologists—mostly fish and wildlife specialists, microbiologists, and entomologists —for work in conservation, detection and control of diseases, and plant breeding.

Approximately 26,000 life scientists worked for private industry in 1968. Among the major industrial employers were manufacturers of pharmaceuticals, industrial chemicals, and food

products. A few were self-employed. Nearly 6,000 life scientists worked for privately financed research organizations and other nonprofit foundations.

Although life scientists were employed in all States, nearly two-fifths were located in five States—California, New York, Pennsylvania, Illinois, and Maryland. More than one-tenth of all life scientists were located in only two Metropolitan areas—Washington, D.C., and New York, N.Y.

Training, Other Qualifications, and Advancement

Young people seeking professional careers in the life sciences should plan to obtain an advanced degree—preferably a Ph. D.—in their field of interest. The bachelor's degree with a major in one of the life sciences is adequate preparation for many beginning jobs, but promotional opportunities for those without graduate training may be limited to intermediate level positions.

The Ph. D. degree generally is required for higher level college teaching positions and for independent research. It is also necessary for an increasing number of other positions involving the administration of research programs.

New graduates having a master's degree may qualify for most entry positions in applied research and for some types of positions in college teaching and basic research.

Those having a bachelor's degree may qualify for positions involving testing, production and operation work, technical sales and service, and duties connected with the enforcement of government regulations. They also may obtain positions as advanced technicians, particularly in the medical area. Those who graduate near the top of their class may qualify for some research positions, but these positions are mostly of a routine nature or are performed under close supervision. Some graduates having a bachelor's degree may take courses in education and choose a career as a high school teacher of biology rather than one as a life scientist. (See statement on Secondary School Teachers.)

Training leading to a bachelor's degree with a major in one of the life science specialties is offered by nearly all colleges and universities. Courses differ greatly from one college to another, and it is important that a student determine which college program best fits his interests and needs. In general, liberal arts colleges and universities emphasize training in the biological scences and in the medical aspects of life science. State universities and land-grant colleges offer special advantages to those interested in agricultural sciences because their agricultural experiment stations provide many opportunities for practical training and research work.

Prospective life scientists should obtain the broadest undergraduate training possible in all branches of biology and in related sciences, particularly biochemistry, organic and inorganic chemistry, physics, and mathematics. Courses in statistics, calculus, biometrics and computer programming analysis are becoming increasingly essential. Training and practice in laboratory techniques, in the use of laboratory equipment, and in fieldwork are also important.

Advanced degrees in the life sciences also are conferred by a large number of colleges and universities. Requirements for advanced degrees usually include fieldwork and laboratory research, as well as classroom studies and preparation of a thesis.

Employment Outlook

Employment opportunities for life scientists having graduate degrees are expected to be very good throughout the 1970's. Demand will be strong for those having doctorates to do research on problems important to medicine, health, and environmental quality control. Employment opportunities are likely to be favorable for persons having bachelor's degrees who graduate near the top of their class. New graduates holding the bachelor's degree will find many opportunities to work as research assistants or in technician jobs while continuing their graduate education.

Employment in the life sciences is expected to grow very rapidly throughout the 1970's. In addition to employment opportunities resulting from growth, nearly 9,600 life scientists will be needed each year to replace those who transfer to other fields, retire, or die.

One of the major factors which will tend to increase the employment of life scientists is the anticipated continued growth in research and development, particularly in medical research programs sponsored by the Federal Government and voluntary health agencies, including those promoting studies of heart disease, cancer, and birth defects. Research in such relatively new areas as space biology, radiation biology, environmental health, biological oceanography, and hereditary regulation also will probably increase.

Industry also is expected to increase its spending for research and development in the biological sciences. Furthermore, the stringent health standards of the Federal regulatory agencies are likely

to result in a heightened demand for additional life scientists in industry to perform research and testing before new drugs, chemicals, and processing methods are made available to the public.

Another factor which should increase employment of life scientists is the substantially larger college and university enrollments expected during the 1970's. Although the resulting rise in demand for teachers will be to a large extent for Ph. D.'s, there will be many openings for qualified people holding master's degrees.

Earnings and Working Conditions

In the Federal Government in late 1968, life scientists having a bachelor's degree could begin at $5,732 or $6,981 a year, depending on their college records. Beginning life scientists having a bachelor's degree and some graduate study could start at $6,981, $8,462, or $10,203, depending upon academic records and previous experience. Those having the Ph. D. degree could begin at $10,203 or $12,174. Pharmacologists had somewhat higher starting salaries than other life scientists.

Life scientists having the Ph. D. degree and employed as college and university teachers typically received starting salaries between $7,000 and $8,500 a year in 1968, according to the limited information available. (For further information, see statement on College and University Teachers.) Life scientists in educational institutions sometimes supplement their regular salaries with income from writing, consulting, and special research projects.

According to the National Science Foundation's Register of Scientific and Technical Personnel, agricultural scientists earned about $11,000 a year in 1968. The average (median) annual salary for biological scientists was $13,000 in 1968, according to the Register; only 10 percent earned less than $7,500 a year, and about 10 percent earned $23,000 or more. In general, life scientists in private industry tend to have higher salaries than those in either colleges and unversities or Government employment.

Sources of Additional Information

General information on careers in the life sciences may be obtained from:

American Institute of Biological Sciences, 3900 Wisconsin Ave. NW., Washington, D.C. 20016.

Specific information on Federal Government careers may be obtained from:

Interagency Board of U.S. Civil Service Examiners for Washington, D.C., 1900 E St. NW., Washington, D.C. 20415.

BIOCHEMISTS

(D.O.T. 041.081)

Nature of the Work

The biochemist has an important role in modern science's research for the basis of life and the factors that sustain life. His professional interests range from what determines heredity to how living things react to space travel.

Biochemists study the chemical composition of living organisms. They identify and analyze the chemical processes related to biological functions, such as muscular contraction, reproduction, and metabolism. Bichemists investigate the effects on organisms of such chemical substances as foods, hormones, and drugs. They study the chemical changes in living tissue caused by genetic and environmental factors.

Biochemists study a wide variety of substances, ranging from very small molecules to giant macromolecules. They analyze chemical compounds such as minerals, sugars, amino acids, proteins polysaccharides, nucleic acids, fats, and steriods. Biochemists deal with problems in genetics, enzymology, hormone action, bioenergetics, and the phenomena of biochemical control.

Foremost among the areas of application of biochemistry are medicine, biomedicine, nutrition, and agriculture. In the medical field, biochemists may investigate the causes and cures of disease or develop diagnostic procedures. In the biomedical area, they contribute to our understanding of genetics, heredity, brain function, and physiological adaption. In the nutritional field, they may identify the nutrients necessary to maintain good health and the effects of specific deficiencies on various kinds of performance, including the ability to learn. In agriculture, biochemists investigate soils, fertilizers, and plants, and undertake studies to discover more efficient methods of crop cultivation, storage, and utilization, and the design and use of pest-control agents.

Biochemists apply the principles and procedures of chemical and physical analysis to their research problems. They use a variety of scientific instruments and devices, including electron microscopes and radioactive isotope counters, and devise new instruments and analytical techniques as needed. Biochemists usually report the results of their research in scientific journals and sometimes lecture before scientific groups.

Biochemist constructs molecular model.

About seven out of ten biochemists are engaged in research. The vast majority pursue basic research designed to increase scientific knowledge. The small group of biochemists working in applied research use the discoveries of basic research to solve practical problems or develop useful products. For example, through basic research, biochemists discover how a living organism forms a hormone. This knowledge is put to use by synthesizing the hormone in the laboratory and then producing it on a mass scale to enrich hormone-deficient organisms. The distinction between basic and applied research, however, is often one of degree; biochemists may engage in both types of work.

Some biochemists teach in colleges and universities, often combining research with teaching. Small proportions are engaged in production and testing activities or private consulting.

Places of Employment

Approximately 11,000 biochemists were employed in the United States in 1968; about 15 percent were women. Biochemists were employed in both large and small cities, and in all States.

About half of all biochemists were employed by colleges and universities in 1968. Many of these scientists were teaching and performing research in university-operated laboratories and hospitals. Another 700 biochemists worked for nonprofit organizations, such as research institutes and foundations.

Private industry employed several thousand biochemists. The largest group of these worked in the chemical industry, primarily for manufacturers of drugs, insecticides, and cosmetics.

About one-fifth of all biochemists worked for Federal, State, and local government agencies. Most of these scientists were employed by Federal agencies concerned with health or agriculture.

Training, Other Qualifications, and Advancement

The minimum educational requirement for beginning positions in biochemistry is the bachelor's degree with a major in biochemistry or chemistry, or with a major in biology and a minor in chemistry. For most entrance positions in research and teaching, graduate training in biochemistry is required. Graduate work also is needed for advancement to most high-level positions in all types of work.

Fewer than 40 schools award the bachelor's degree in biochemistry. However, all colleges and universities offer a major in biology or chemistry. The prospective biochemist should take undergraduate courses in chemistry, biology, biochemistry, mathematics, and physics.

More than 100 colleges and universities offer graduate degrees in biochemistry. For entrance into a graduate program in biochemistry, schools usually require

the student to have a bachelor's degree in biochemistry, biology, or chemistry. However, students who have the bachelor's degree in another basic science but who have had several undergraduate courses in chemistry usually are admitted.

In graduate school, the student builds upon the basic knowledge obtained in the undergraduate curriculum. He takes advanced courses and may conduct research in many areas of biochemistry. In completing work for the doctoral degree, he usually specializes in a particular field of biochemistry by doing intensive research and writing a thesis.

Some graduate schools having extensive research facilities or a staff highly accomplished in a special field have gained a reputation for training students in that particular field of biochemistry. For example, a university affiliated with a medical school or hospital often has the facilities and equipment available for studying the biochemisty of disease. Therefore, a student who desires to specialize in a particular field of biochemistry should investigate the specialties of the various schools and make his selection carefully.

New graduates having the bachelor's degree usually begin work in industry or government as research assistants. These positions involve testing and analysis. In the drug manufacturing industry, for example, research assistants may analyze the ingredients of a product to verify and maintain its purity or quality. Some graduate students become research or teaching assistants in colleges and universities.

Beginning biochemists having advanced degrees usually qualify for research or teaching positions. Some experienced biochemists who have Ph. D. degrees advance to high-level administrative positions and supervise research programs. Other highly qualified biochemists, who prefer to devote their time to research, often become leaders in a particular field of biochemistry.

Employment Outlook

The employment outlook is likely to be very good for biochemists through the 1970's. In addition to new opportunities resulting from the very rapid growth expected in this field, about 450 new biochemists will be needed each year to replace workers who transfer to other fields of work, retire, or die.

The greatest demand will be for the biochemist who has the Ph. D. degree, to conduct independent research or to teach.

The major factor underlying the anticipated growth is the continued increase in expenditures for research and development in life sciences. These expenditures, which have risen rapidly in recent years, are expected to continue to rise, although at a somewhat slower rate.

The greatest growth in employment of biochemists is expected in medical research as research is expanded on health problems such as cancer, heart disease, muscular dystrophy, and mental illness. Additional biochemists will be needed to implement the more stringent drug standards that have been established by Congress and the Federal regulatory agencies. Biochemistry also is becoming important in other fields, such as environmental studies.

Growing college enrollments, especially of students majoring in chemistry and the life sciences, will strengthen the demand for biochemists qualified to teach in colleges and universities.

Although biochemistry is a relatively small profession and job openings will not be numerous in any one year, the number of graduates who have degrees in this science also is fairly small and is expected to remain small. Thus, the employment outlook should continue to be favorable for biochemistry graduates.

Earnings

Starting salaries paid to biochemists employed by colleges and universities are comparable to those for other professional faculty members. Biochemists in educational institutions often supplement their income by engaging in outside research or consulting work.

In 1968, the average (median) earnings for all biochemists who had a bachelor's degree was $8,600; for those having a master's degree, $9,900; and for those having a Ph. D., $14,000.

Sources of Additional Information

General information on careers in biochemistry may be obtained from:

American Society of Biological Chemists, 9650 Rockville Pike, Bethesda, Md. 20014.

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1650–77	Plumbers and Pipefitters	15
1650–78	Roofers, Sheet-Metal Workers	15
	Mechanics and Repairmen	
1650–79	Automobile Service Occupations Automobile Body Repairmen, Automobile Mechanics, Truck Mechanics and Bus Mechanics, Automobile Painters, Automobile Trimmers and Installation Men (Automobile Upholsterers), Automombile Parts Countermen, Automobile Service Advisors, Gasoline Service Station Attendants	20
1650–80	Air-Conditioning, Refrigeration, and Heating Mechanics	10
1650–81	Appliance Servicemen	10
1650–82	Bowling-Pin-Machine Mechanics	10
1650–83	Business Machine Servicemen	15
1650–84	Diesel Mechanics, Farm Equipment Mechanics	10
1650–85	Electric Sign Servicemen	10
1650–86	Maintenance Electricians, Industrial Machinery Repairmen, Millwrights	15
1650–87	Instrument Repairmen	10
1650–88	Jewelers and Jewelry Repairmen, Watch Repairmen	15
1650–89	Television and Radio Service Technicians	10
1650–90	Vending Machine Mechanics	10
	Other Manual Occupations	
1650–91	Blacksmiths	10
1650–92	Boilermaking Occupations	10
1650–93	Dispensing Opticians, Optical Mechanics	10
1650–94	Driving Occupations Over-the-road Truckdrivers, Local Truckdrivers, Routemen, Intercity Busdrivers, Local Transit Busdrivers, Taxi Drivers	20
1650–95	Factory Operatives Assemblers, Electroplaters, Inspectors, Power Truck Operators, Production Painters	15
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1650–97	Furniture Upholsterers	10
1650–98	Machining Occupations All-round Machinists, Machine Tool Operators, Tool and Die Makers, Instrument Makers (Mechanical), Setup Men (Machine Tools), Layout Men	15
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