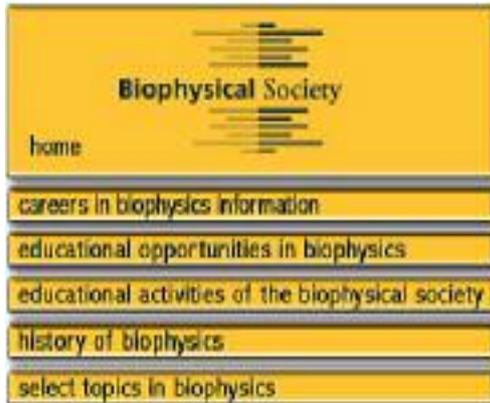


## educational resources



### What is Biophysics?

Biophysics is that branch of knowledge that applies the principles of physics and chemistry and the methods of mathematical analysis and computer modeling to understand how biological systems work.

Biophysics is a molecular science. It seeks to explain biological function in terms of the molecular structures and properties of specific molecules. The size of these molecules varies dramatically, from small fatty acids and sugars ( $\sim 1 \text{ nm} = 10^{-9} \text{ m}$ ), to macromolecules like proteins (5-10 nm), starches ( $>1000 \text{ nm}$ ), and the enormously elongated DNA molecules (over  $10,000,000 \text{ nm} = 1 \text{ cm}$  long but only 2 nm wide; imagine a piece of string 45 miles long!).

These molecules, the sole building blocks of living organisms, assemble into cells, tissues, and whole organisms by forming complex individual structures with dimensions of 10, 100, 1000, 10,000 nm and larger. Proteins assemble into the casein micelles of milk, which aggregate to form the curd of cheese; proteins and ribonucleic acids assemble into ribosomes, the machinery for building proteins; lipids and proteins assemble into cell membranes, the external barriers and internal surfaces of cells; proteins and DNA wind up into chromosomes, the carriers of the genetic code; and so on.

Consequently, much effort in biophysics is directed to determining the structure of specific biological molecules and of the larger structures into which they assemble. Some of this effort involves inventing new methods and in building new instruments for viewing these structures. Many of the exciting new developments in biological microscopy, described here under Resources in Biophysics, are part of this effort.

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### What Does Biophysics Study?

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The biological questions with which biophysics is concerned are as diverse as the organisms of biology:

- How do linear polymers of only 20 different amino acids fold into proteins with precise three-dimensional structures and specific biological functions?
- How does a single enormously long DNA molecule untwist and exactly replicate itself during cell division or direct the production of proteins?

- How are sound waves, or photons, or odors, or flavors, or touches, detected by a sense organ and converted into electrical impulses that provide the brain with information about the external world?
- How does a muscle cell convert the chemical energy of ATP hydrolysis into mechanical force and movement?
- How does the cell membrane, a lipid barrier impermeable to water-soluble molecules, selectively transport such molecules through its non-polar interior?

Biophysics seeks to answer these questions using an eclectic approach. The specific molecules involved in a biological process are identified using the techniques of chemical and biochemical analysis. Their molecular structures and interactions are determined using the spectroscopic techniques of physics and chemistry. And the relationship between biological function and molecular structure is investigated using highly precise and exquisitely sensitive physical instruments and techniques that are able to monitor the properties or the movement of specific groups of molecules, or in exciting new developments, are able to view and manipulate single molecules and to measure their behavior.

Biophysics explains biological functions in terms of molecular mechanisms: precise physical descriptions of how individual molecules work together like tiny machines to produce specific biological functions. Some of these biophysical mechanisms, many involving detailed molecular models, are described in detail under Resources in Biophysics.

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## Selected Topics in Biophysics

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Biophysics is a diverse and eclectic field, and consequently difficult to categorize. For the purposes of this summary of educational resources in biophysics, biophysics is divided into three parts or topic areas: molecular structures, biophysical techniques, and biological mechanisms. Each topic area is defined here and an attempt is made to indicate how these areas are interrelated within the field of biophysics. An annotated list of specific resources, available as text files or web sites, for each topic area is then provided on subsequent pages.

Every effort is made to ensure that links to sites maintained by other institutions or individuals are active, educational, and accurate. If you find otherwise, please contact the Society at [society@biophysics.org](mailto:society@biophysics.org) or at 301-634-7114.

### **Molecular Structures**

Biophysics explains the biological functions of cells, tissues, and organisms in terms of the structure and behavior of biological molecules. Genes, the basic elements of biological information, reflect the molecular structures of the enormously large, linear DNA (deoxyribonucleic acid) molecules of which they are made. The behavior of enzymes, hormones, and antibodies reflects the molecular structures of proteins and the organic chemistry of the functional groups of the amino acid side chains. The surface and barrier properties of biological membranes reflect the ability of lipids to aggregate into flexible two-dimensional bilayers with hydrophobic cores and polar surfaces.

Information about the molecular structures and biophysical properties of proteins, nucleic acids (DNA and RNA), lipids, and carbohydrates is available on the [Select Topics in Biophysics page](#).

### **Biophysical Techniques**

The characterization of molecular structure, the measurement of molecular properties, and the observation of molecular behavior presents an enormous challenge for biological scientists. A wide range of biophysical techniques have been developed to study molecules in crystals, in solution, in cells, and in organisms. These biophysical techniques provide information about the electronic structure, size, shape, dynamics, polarity, and modes of interaction of biological molecules. Some of the most exciting techniques provide images of cells, subcellular structures, and even individual molecules. It is now possible, for example, to directly observe the biological behavior and physical properties of single protein or DNA molecules within a living cell and determine how the behavior of the single molecule influences the biological function of the organism.

Information about the wide variety biophysical techniques available to study the structures, properties, and functions of molecules both in the test tube and in living biological systems is available on our [Select Topics in Biophysics page](#).

### **Biophysical Mechanisms**

Much of the scientific success of biophysics depends upon its ability to develop detailed physical mechanisms to explain specific biological processes. The double helical structure of DNA, for example, provides a framework for an explanation of how genetic material is replicated and of how genetic mutations arise: specific proteins mediate the unwinding of the DNA duplex and the assembly of a new strand based on complementary base pairing of the four

DNA bases, guanine with cytosine and adenine with thymine; mismatch of one of these base pairs generates a complementary strand with a single base substitution (a mutation). The value of this, and a variety of other biophysical mechanisms, is unlimited for human knowledge in general and for biomedical research in particular. Molecular descriptions of a variety biological functions are available on our [Select Topics in Biophysics page](#).

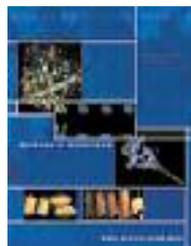
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## Graduate Programs in Biophysics

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Numerous colleges and universities throughout the USA and the world support graduate study in biophysics. Some offer specific graduate degrees in biophysics; others offer a specialization in biophysics as part of a degree in Chemistry, Biology, Physics, or other field. Our interactive database allows you to search for graduate study opportunities in biophysics by geographical location, by degree offered, and by specific area of research expertise.

- [Database of available programs in biophysics](#)



[Careers in Biophysics Booklet](#)