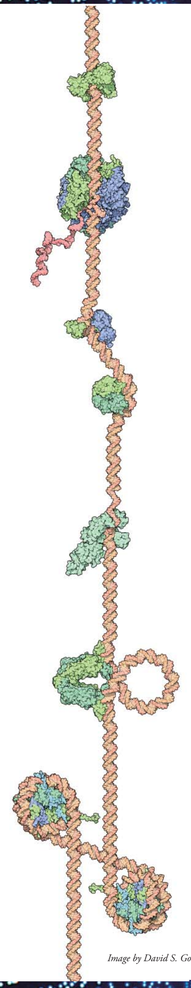


Image by David S. Goodsell, RCSB Protein Data Bank.

How essential is biophysics to progress in biology?

Biophysics discovers how atoms are arranged to work in DNA and proteins.
Protein molecules perform the body's chemical reactions. They push and pull in the muscles that move your limbs. Proteins make the parts of your eyes, ears, nose, and skin that sense your environment. They turn food into energy and light into vision. They provide immunity to illness. Proteins repair what is broken inside of cells, and regulate growth. They fire the electrical signals in your brain. They read the DNA blueprints in your body and copy the DNA for future generations.

Biophysicists are discovering how proteins work. These mysteries are solved part by part. To learn how a car works, you first need to know how the parts fit together. Now, thanks to biophysics, we know exactly where the thousands of atoms are located in more than 50,000 different proteins. Each year, over a million scientists and students from all over the world, from physicists to medical practitioners, use these protein structures for discovering how biological machines work, in health and also in diseases.

Variations in proteins make people respond to drugs differently. Understanding these differences opens new possibilities in drug design, diagnosis, and disease control. Soon, medicines will be tailored to each individual patient's propensity for side effects.

Biophysics revealed the structure of DNA

Experiments in the 1940s showed that genes are made of a simple chemical: DNA. How such a simple chemical could be the molecule of inheritance remained a mystery until biophysicists discovered the DNA double helix in 1953.

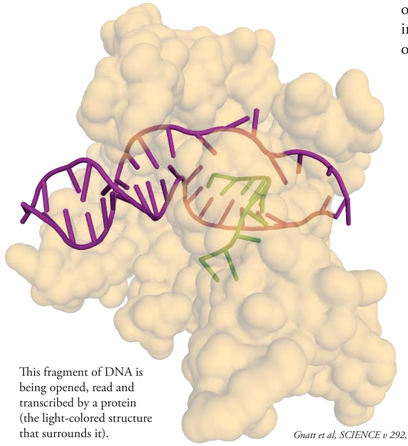
Biophysicists Maurice Wilkins (not pictured), James Watson, Francis Crick (above) and Rosalind Franklin (right) discovered the structure of DNA.

Photos courtesy of Cold Spring Harbor Laboratory Archives.

The structure of DNA was a great watershed. It showed how simple variations on a single chemical could generate unique individuals and perpetuate their species.

Biophysics showed how DNA serves as the book of life. Inside of cells, genes are opened, closed, read, translated, and copied, just like books. The translation leads from DNA to proteins, the molecular machinery of life.

During the 2000s, biophysical inventions decoded all the genes in a human being. All the genes of nearly 200 different species, and some genes from more than 100,000 other species have been determined. Biophysicists analyze those genes to learn how organisms are related, how individuals differ, and how organisms evolved.



This fragment of DNA is being opened, read and transcribed by a protein (the light-colored structure that surrounds it).

Gnatt et al, SCIENCE v 292, 1876, 2001.

Discoveries about DNA and proteins fuel progress in preventing and curing disease.

What are the applications?

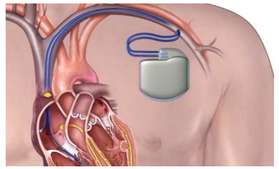
Biophysics is a wellspring of innovation for our high-tech economy. The applications of biophysics depend on society's needs. In the 20th century, great progress was made in treating disease. Biophysics helped create powerful vaccines against infectious diseases. It provided new insights into diseases of metabolism, such as diabetes. And biophysics provided both the tools and the understanding for treating the diseases of growth known as cancers. Today we are learning more about the biology of health and society is deeply concerned about the health of our planet. Biophysical methods are increasingly used to serve everyday needs, from forensic science to bioremediation.

Biophysics gives us medical imaging technologies including MRI, CAT scans, PET scans, and sonograms for diagnosing diseases.

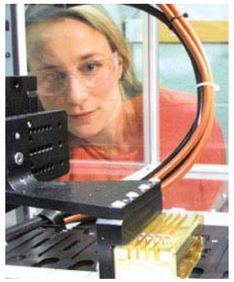
It provides the life-saving treatment methods of kidney dialysis, radiation therapy, cardiac defibrillators, and pacemakers.

Biophysicists invented instruments for detecting, purifying, imaging, and manipulating chemicals and materials.

Advanced biophysical research instruments are the daily workhorses of drug development in the world's pharmaceutical and biotechnology industries. Since the 1970s, more than 1500 biotechnology companies, employing 200,000 people, have earned more than $60 billion per year.



© medmovie.
The implantable cardiac defibrillator saves lives.



Oak Ridge National Laboratory.
Gene-chips are made to test the functions of thousands of genes in one experiment.

Courtesy of FONAR Corporation.
MRI scans help diagnose disease without surgery.

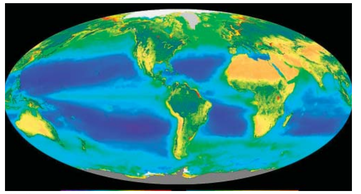
Biophysics applies the power of physics, chemistry, and math to understanding health, preventing disease, and inventing cures.

Why is biophysics important right now?

Society is facing physical and biological problems of global proportions. How will we continue to get sufficient energy? How can we feed the world's population? How do we remediate global warming? How do we preserve biological diversity? How do we secure clean and plentiful water? These are crises that require scientific insight and innovation. Biophysics provides that insight and technologies for meeting these challenges, based on the principles of physics and the mechanisms of biology.

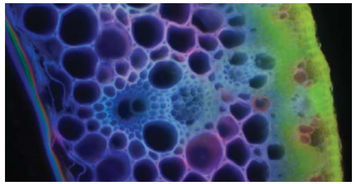
U.S. Department of Energy Genome Programs, http://genomics.energy.gov.
Batches of biofuel microbes are being tested.

Biophysics discovers how to modify microorganisms for biofuel (replacing gasoline and diesel fuel) and bioelectricity (replacing petroleum products and coal for producing electricity).



U.S. Department of Energy Genome Programs, http://genomics.energy.gov.
Biophysics determines the abundance of photosynthetic microbes and plants in the global biosphere.

Biophysics discovers the biological cycles of heat, light, water, carbon, nitrogen, oxygen, heat, and organisms throughout our planet.



U.S. Department of Energy Genome Programs, http://genomics.energy.gov.
Molecules for photosynthesis (green) and for fuel are fluorescently labelled in this cross-section of a stalk.

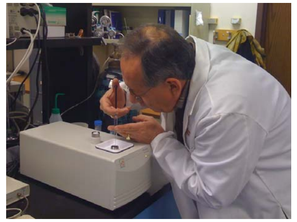
Biophysics harnesses microorganisms to clean our water and to produce lifesaving drugs.

Biophysics pushes back barriers that once seemed insurmountable.

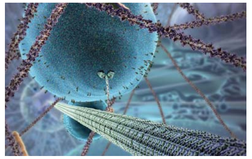
What do biophysicists study?

All of biology is fair game.

Biophysicists study life at every level, from atoms and molecules to cells, organisms, and environments. As innovations come out of physics and biology labs, biophysicists find new areas to explore where they can apply their expertise, create new tools, and learn new things. The work always aims to find out how biological systems work. Biophysicists ask questions, such as:



Biophysicist Luis Marky loads his differential scanning calorimetry instrument.



Robert Lee and Alain Viel, Harvard University, John Liebler, XVIVO, LCC.

Kinesin protein (center) walking along a protein track (bottom diagonal) carrying a load (large blue sphere).

How do protein machines work? Even though they are millions of times smaller than everyday machines, molecular machines work on the same principles. They use energy to do work. The kinesin machine shown here is carrying a load as it walks along a track. Biophysics reveals how each step is powered forward.

How do systems of nerve cells communicate? Biophysicists invented colored protein tags for the chemicals used by cells. Each cell takes on a different color as it uses the tagged chemicals, making it possible to trace its many pathways.

How do proteins pack DNA into viruses? How do viruses invade cells? How do plants harness sunlight to make food?

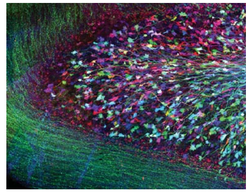
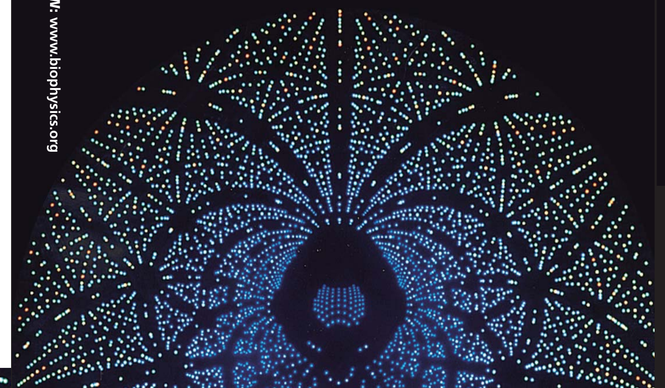


Image by Tamily Weissman, Harvard University. The Brainbow mouse was produced by Livet J, Weissman TA, Kang H, Draft RW, Lu J, Bennis RA, Sanes JR, Lichtman JW. Nature (2007) 450:56-62.

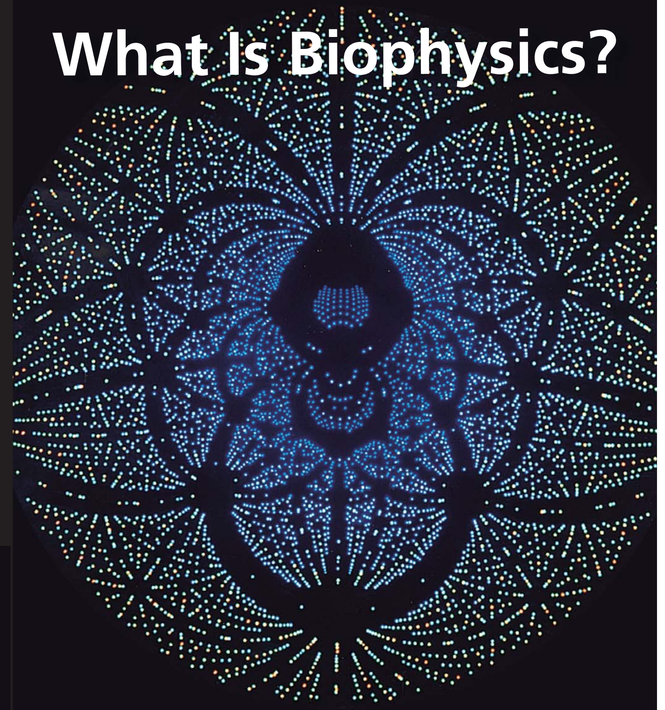
Each nerve cell takes on an individual color, depending on its response to engineered biomolecules, allowing individual nerve pathways of communications to be traced.

Biophysics studies life at every level, from atoms and molecules to cells, organisms, and environments.

11400 Rockville Pike, Suite 800, Rockville, Maryland 20852 E: society@biophysics.org W: www.biophysics.org



What Is Biophysics?

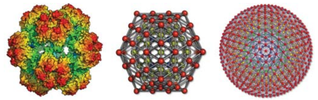


Biophysical Society

Biophysics is a bridge between biology and physics.

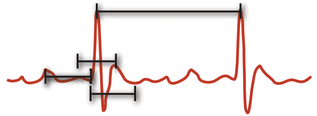
Biology studies life in its variety and complexity. It describes how organisms go about getting food, communicating, sensing the environment, and reproducing. On the other hand, physics looks for mathematical laws of nature and makes detailed predictions about the forces that drive physical systems. Spanning the distance between the complexity of life and the simplicity of physical laws is the challenge of biophysics. Looking for the patterns in life and analyzing them with math and physics is a powerful way to gain insights.

Biophysics looks for principles that describe patterns. If the principles are powerful, they make detailed predictions that can be tested.

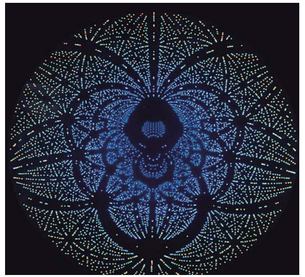


Yang, A., Bahar, I. and Widom, M., Biophysical Journal, Volume 96, Issue 11, 4438-4448, 3 June 2000.

The natural symmetries of viral shell molecules contribute to their strength and flexibility. These properties are vital to their life cycles, and also provide principles for devising strong, flexible materials for manufacture.



The patterns and quantities in an electrocardiogram describe the functioning of the human heart.



Shining X-rays on protein creates a diffraction pattern revealing its structure (cover image). This false-color pattern of a protein from peas was created using data from the world's first dedicated high energy synchrotron, the Synchrotron Radiation Source. Biophysicists analyze diffraction patterns to determine the positions of the atoms in proteins, DNA and other important molecules. Understanding the atomic structures is an important step toward understanding how molecules work together to sustain life.

Daresbury Laboratory, UK. © STFC.