How essential is biophysics to progress in biology?

Biophysics reveals 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.

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 knowledge for treating the disease of growth known as cancer.

Today we are learning about the biology and health of society and are deeply concerned about the health of our planet. Biophysical methods are increasingly used to serve everyday needs, from forensic science to bioremediation.

Variations in proteins make people respond to drugs differently. Understanding these differences opens up 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.

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 machines of life.

During the 1980s, biophysical inventions decoded all the genes in a human being. All of the genes of exactly 20 billion 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.

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

What are the applications?

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

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

Biophysicists invented instruments for detecting, identifying, 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.

Advancements in protein science can be understood as the technology to produce new possibilities in drug design, including thousands of genes in one experiment.

Molecules for photosynthesis (green) and for fuel are fluorescently labelled in this cross-section of a stalk.

What 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 sustain clean and plentiful water? These are questions 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.

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

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

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

Biophysics pushes back barriers that once seemed insurmountable.

Biophysics applies the power of physics, chemistry, and math to understanding health, preventing disease, and inventing cures.
What do biophysicists study?

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:

- 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 viruses invade cells? How do viruses pack DNA into viruses? How do viruses exit cells? How do viruses make new copies of themselves?
- How do proteins pack DNA into viruses? How do plants harness sunlight to make food?
- How do viruses invade cells? How do viruses make new copies of themselves?

What Is Biophysics?

Biophysics is a bridge between biology and physics.

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