Biophysics

A Biophysics applies the principles of mathematics, chemistry, biology and physics to study living cells and organisms, including structures and fine structures, bioelectric phenomena, radiation effects, molecular behaviour, photosynthesis, membranes and modelling.
Biophysics is the field that applies the theories and methods of physics to understand how biological systems work.

Biophysics has been critical to understanding the mechanics of how the molecules of life are made, how different parts of a cell move and function, and how complex systems in our bodies—the brain, circulation, immune system, and others - work. Biophysics is a vibrant scientific field where scientists from many fields including math, chemistry, physics, engineering, pharmacology, and materials sciences, use their skills to explore and develop new tools for understanding how biology - all life - works.

Physical scientists use mathematics to explain what happens in nature. Life scientists want to understand how biological systems work. These systems include molecules, cells, organisms, and ecosystems that are very complex. Biological research in the 21st century involves experiments that produce huge amounts of data. How can biologists even begin to understand this data or predict how these systems might work ?
This is where biophysicists come in. Biophysicists are uniquely trained in the quantitative how nerve cells communicate, to how plant cells capture light and transform it into energy, to how changes in the DNA of healthy cells can trigger their transformation into cancer cells, to so many other biological problemssciences of physics, math, and chemistry and they are able tackle a wide array of topics, ranging from.

Importance of Biophysicists

Biophysicists work to develop methods to overcome disease, eradicate global hunger, produce renewable energy sources, design cutting-edge technologies, and solve countless scientific mysteries. In short, biophysicists are at the forefront of solving age-old human problems as well as problems of the future.

1. Data Analysis and Structure

The structure of DNA was solved in 1953 using biophysics, and this discovery was critical to showing how DNA is like a blueprint for life.
Now we can read the sequences of DNA from thousands of humans and all varieties of living organisms. Biophysical techniques are also essential to the analysis of these vast quantities of data.

2. Computer Modelling

Biophysicists develop and use computer modelling methods to see and manipulate the shapes and structures of proteins, viruses, and other complex molecules, crucial information needed to develop new drug targets, or understand how proteins mutate and cause tumors to grow.

3. Molecules in Motion

Biophysicists study how hormones move around the cell, and how cells communicate with each other. Using fluorescent tags, biophysicists have been able to make cells glow like a firefly under a microscope and learn about the cell's sophisticated internal transit system.

4. Neuroscience

Biophysicists are building computer models called neural networks to model how the brain and nervous system work, leading to new understandings of how visual and auditory information is processed.

5. Bioengineering, Nanotechnologies, Biomaterials

Biophysics has also been critical to understanding biomechanics and applying this information to the design of better prosthetic limbs, and better nanomaterials for drug delivery.

6. Imaging

Biophysicists have developed sophisticated diagnostic imaging techniques including MRIs, CT scans, and PET scans. Biophysics continues to be essential to the development of even safer, faster, and more precise technology to improve medical imaging and teach us more about the body's inner workings.

7. Medical Applications

Biophysics has been essential to the development of many life-saving treatments and devices including kidney dialysis, radiation therapy, cardiac defibrillators, pacemakers, and artificial heart valves.

8. Ecosystems

Environmental biophysics measures and models all aspects of the environment from the stratosphere to deep ocean vents. Environmental biophysicists research the diverse microbial communities that inhabit every niche of this planet, they track pollutants across the atmosphere, and are finding ways to turn algae into biofuels.

Opportunities for Biophysicists

Biophysicists are teachers and researchers in biology, physics, engineering, and many other fields. They work in universities, hospitals, tech startups, and engineering companies developing new diagnostic tests, drug delivery systems, or potential biofuels. Biophysicists develop computer models to find out why a new flu strain eludes the immune system or they make 3D models of new protein structures to better understand how they work. They practice law in specialized fields like intellectual property, write about science for print and online publications, and work in government to advise legislatures. Those who are trained in biophysics have unlimited career possibilities.

Introduction

The plasma membranes enveloping living cells separate the exterior environment from the cytoplasm. It provides a selective diffusion barrier to molecules moving into, and out of, the cell and it contains energy driven transport mechanisms that maintain concentration differences of many substances between the external environment and the cytoplasm. Voltage gated ion channels in the plasma membrane generate 'action' potentials in neurones that are transmitted along the membrane of nerve axons. Cells sense the presence of specific molecules in the surrounding medium when these molecules bind to specific receptor molecules embedded in the membrane and this forms the basis of the immune signalling and response system. Almost all of the biochemical processes in a cell are associated with membrane bound enzymes and transport and transduction mechanisms.

The cell membrane is some two orders of magnitude smaller than the resolution of optical microscopes. The presence of a membrane was initially inferred from the rate of permeation of various substances into cells.

Historical Background

Before the turn of the 19^{th} century, it was observed that the rates of intracellular accumulation of substances were proportional to their solubility in lipids.

In (1935) Danielli and Davsonput forward a model of the cell membrane in which a lipoidal layer is sandwiched between two proteinaceous layers. This was consistent with an earlier measurement by Gorter and Grendel in 1925 who had spread the lipids extracted from red blood cells as a monolayer

and determined that the area occupied by the lipids was equal to twice the total surface areas of the erythrocytes.
In that same year Fricke and Morse had estimated the thickness of the cell membrane from measurements of the electrical impedance of a suspension of cells. Their estimate of 20–30 nm was only a factor of ~3 too large. The first direct measurement of the thickness obtained from electron-micrographs by Robertson were not made until 1959. It showed that the lipoidal layer was probably only as thick as two molecules of common biological lipids. He introduced the idea of the 'unit membrane'.

This concept of the presence of a bimolecular layer of lipids in cell membranes was further strengthened when in 1962 Mueller, Rudin, Tien and Wescott produced the first artificial, planar, lipid bilayer membrane from lipids extracted from bovine brain. We now know that the cell membrane consists of a bimolecular layer of lipid molecules in which are imbedded various functional proteins. The bimolecular lipid membrane, or lipid bilayer, provides a fluid matrix in which the membrane proteins assume specific orientations and form functional aggregates.

In 1892 Karl Pearson: The Grammar of biophysical Science.
In 1943: Erwin Schrodinger (Nobel Prize), lecture series: What is Life.
In 1946: Biophysics Research Unit, King's College, London, hire physicists to work on questions of biological significance.
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Maurice Wilkins, Rosalind Franklin: X-ray diffraction of DNA.
In 1953: Francis Crick particle (physicist turned into biophysicist at Cambridge) and James Watson (biologist):double helix structure of DNA.
In 1957:The Biophysical Society was founded.

Classification Biophysical subjects based on relative size of subject.

Biophysics can be classified depending on the relative size of biological subject (e.g., molecules, cells, or whole organism), or which technique and application is employed. Biophysical subjects based on relative size of subject. and sub cellular biophysics Physiological and anatomical biophysics Environmental biophysics Biophysical techniques and application General biophysical techniques Imaging biophysics Medical biophysics

1. Molecular and Subcellular Biophysics

Most common branches of biophysics deals with molecules and subcellular function. This division of biophysics is sometimes also called biochemical physics, physical biochemistry, or biophysical chemistry. All three terms mean the same thing - what we will call molecular and subcellular biophysics. It is the place where biology, chemistry and physics all meet. The structure and conformation of biological molecules. Structure function relationship• Conformational transitions.• Ligand binding and intermolecular binding. Diffusion and molecular transport Membrane biophysics DNA and nucleic acid biophysics Energy flow and bioenergetics Statistical mechanics Kinetics Molecular Machines.

2. Physiological and Anatomical Biophysics

Biomechanics Biomechanics is the branch of biophysics that deals with the application of forces to biological objects. Notice that biomechanics is studied at all levels: subcellular, physiological, and environmental. Electrophysiology Electrophysiology is the study of electrical aspects of living things. Its main focus is the study of nerves. It is concerned with excitable tissue, that create conduct, or use electrical impulses. Excitable tissues include nerves, muscles, sensory cells, and electroreceptive cells.
Sensory Biophysics Electrophysiology
Sensory biophysics explores the electrophysiology and mechanism of the senses: seeing, hearing, touch, balance, smell, and taste. Sensory biophysics explores questions such as how proteins in the eye respond to different energies of light, how electrical signals from retina are transmitted to the

brain, and how the eye muscles move the eye, focus the eye, and adjust the amount of light entering the eye.

3. Environmental Biophysics

Environmental biophysics focuses on the physical aspects of the relationship between the organisms and their environment. The primary source of energy in the environment is solar energy, which is captured through the process of photosynthesis and converted by plants into food. There are other areas of focus within environmental biophysics as well. Heat and temperature environmental biophysics Resource and mass exchange environmental biophysics Radiation biophysics Environmental bioengineering

4. Biophysical Techniques & Applications

Ultracentrifugation to separate molecules of different sizes based on the sedimentation principle. Electrophoresis to separate molecules of different molecular mass/size based on the sedimentation principle; electric field acts on the charged molecules; gel electrophoresis Spectroscopy mostly with EM radiation and measuring the intensity/direction/polarization of the emitted radiation (originally only the visible spectrum nm was used; now also UV and IR); in addition to EM also electron and mass spectroscopy; Mass Spectrometry to measure mass or molecular weight of molecules; molecules are ionized in a vacuum, then passed through a magnetic field.

X-Ray Crystallography to determine the relative positions of atoms within a crystal by using diffraction on a 3D crystal lattice; high resolution of structural details but the molecules need to be in a crystalline phase. Nuclear Magnetic Resonance Spectroscopy (NMR) to obtain structural information about molecules of the highest resolution using EM of a radio frequency, which interacts with nuclear spins of atoms in a large magnetic field. Electron Microscopy to view objects 1,000-2,500 times smaller than those seen by light microscopes.