Biophysics lecture notes

Presented by

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First-year students

Lecture 1

Introduction to Biophysics

Biophysics is the field that applies the theories and methods of physics to understand how biological systems work. Many scientific fields combine physics, chemistry and biology but each has a different focus compared to others.

To clarify, we have:

Subject	Main field	Focus
Biochemistry	Biology and chemistry	Chemical processes related to living organisms
Molecular biology	Biology	Molecular basis of biological processes
Physical chemistry	Physics & chemistry	Studying chemical systems using physical concepts
Physiology	Chemistry, physics & biology	Functions and mechanisms in a living system
Bioengineering & biotechnology	Biology & engineering	Combining biology & engineering to design products.

In other words, biophysics uses physics to study biological processes & to understand the mechanics of how the molecules of life are made.

A physicist who applies the methods of physics to biology is known as a biophysicist.

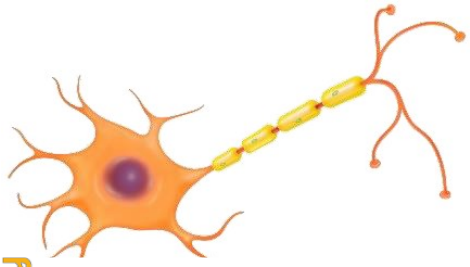
Biophysics has been critical to:

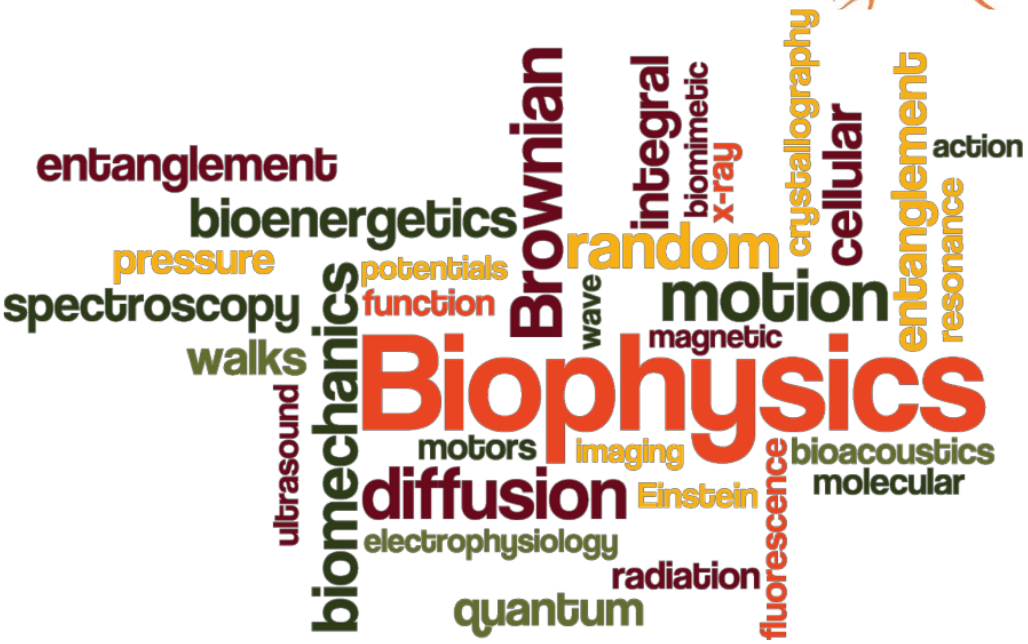
- Understanding the mechanics of how the molecules of life are made,
- How different parts of a cell move and function,
- What complex systems in our bodies—the brain, circulation, immune system, and others— work.

Course outline

This course will focus on the following subjects:

1. Defining the molecular structure and how molecules bond to each other to form biological organisms.
2. List the four main molecules of life
3. The energy forms that are common in biology and their applications.
4. Motion through diffusion and directed transport.
5. Load bearing in biology
6. Cellular membranes and their electrical excitability.
7. Self-assembly as a critical process for biology
8. An express introduction to neuroscience





Why biophysics is important?

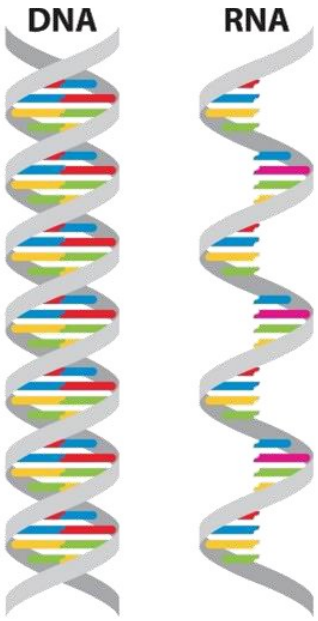
Biophysics is an interdisciplinary scientific field where scientists from many fields including math, chemistry, physics, engineering, pharmacology, and materials sciences, use their skills to explore and develop new tools for understanding how biology—all life—works.

It is important because:

1. It helps inventing new methods and building new instruments for viewing biological structures in action.
2. It helps the understanding of the mechanical properties of biological systems, on length scales from nanometers to meters.
3. Biophysics is relevant to medicine, and many biophysicists direct their investigations towards biomolecules that play a key role in disease. Examples include Alzheimer's disease, ALS ("Lou Gehrig's disease"), HIV, diabetes, breast cancer, and multiple sclerosis. The knowledge provided by biophysics helps developing diagnosis, prevention and cure for life threatening illnesses.

History of biophysics

- 17th-century: Athanasius Kircher (German priest) devoted two chapters of his book 'Ars Magna Lucis et Umbrae' to bioluminescence.
- 1687: Sir Isaac Newton in the 'Principia' wrote on the relation between electricity and biology.
- 1773: John Walsh wrote the details of his discovery of the electrical nature of the discharge from the torpedo or electric ray in a letter to the American inventor and statesman Benjamin Franklin.
- 1856: Adolf Fick published the first biophysics text 'Die medizinische Physik' ("Medical Physics"), which discussed the fundamental laws governing diffusion.
- 1937: Max Perutz and John Kendrew used X rays to analyze two proteins fundamental to life, myoglobin and hemoglobin.
- 1944: The book 'What Is Life?' by Erwin Schrödinger was published.
- 1951: Hodgkin and Huxley presented their explanation of the mechanism of nervous conduction in five scientific papers between October 1951 and March 1952.
- 1962: Watson, Crick, and Wilkins established the structure of DNA using x-ray.



Atomic Structure

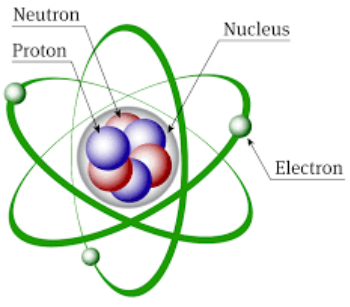
All matter is composed of aggregates of atoms with the exception of radiochemistry and radioactivity.

Atoms are neither created nor destroyed during physical or chemical changes.

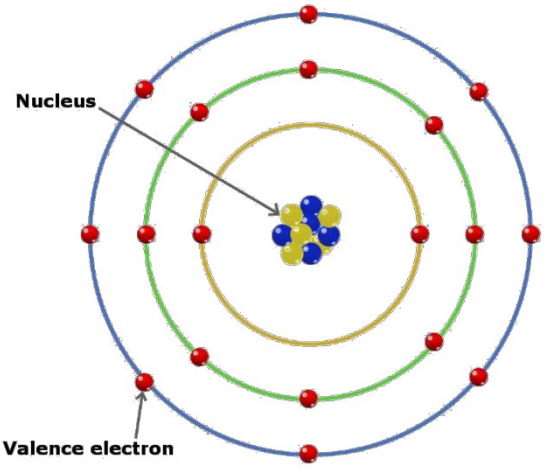
It has been determined that 90 chemically different atoms, the chemical elements, are naturally present on the Earth, and others have been prepared by radioactive transmutations. Chemical elements are frequently represented by symbols, which are abbreviations of the name of the element.

An atom of any element is made up of a small massive nucleus, in which almost all of the mass resides, surrounded by an electron cloud. The nucleus is positively charged and in a neutral atom this charge is exactly balanced by an equivalent number of electrons, each of which carries one unit of negative charge.

The electron is considered to exhibit both wavelike and particle-like characteristics. Electrons surround the nucleus at shells with defined capacity for electrons and hence, a defined energy level. Each shell contains sub-shells. An electron position is considered to be the probability of an electron's being at various locations around the nucleus.



Of course, not all possible states in an atom are filled with electrons. For most atoms, the electrons fill up the lowest possible energy states in the electron shells and subshells, two electrons (having opposite spins) per state. The valence electrons are those that occupy the outermost filled shell. These electrons are extremely important; as will be seen, they participate in the bonding between atoms to form atomic and molecular aggregates. Furthermore, many of the physical and chemical properties of solids are based on these valence electrons.



Questions

Q1: What is biophysics? Why it's important?

Q2: Can we create atoms? Can we destroy them?

Q3: Are all matter is made of atoms?

Q4: Describe the structure of an atom.

Q5: What are the characteristics of electron?

Q6: Are all shells filled with atoms? Which ones are filled?

Q7: Define valence electrons? Why they are important?