AL- Mustaqpal University

Science College

Dep. Biochemistry

First Stage

Lec 1

General Concepts of Biophysics

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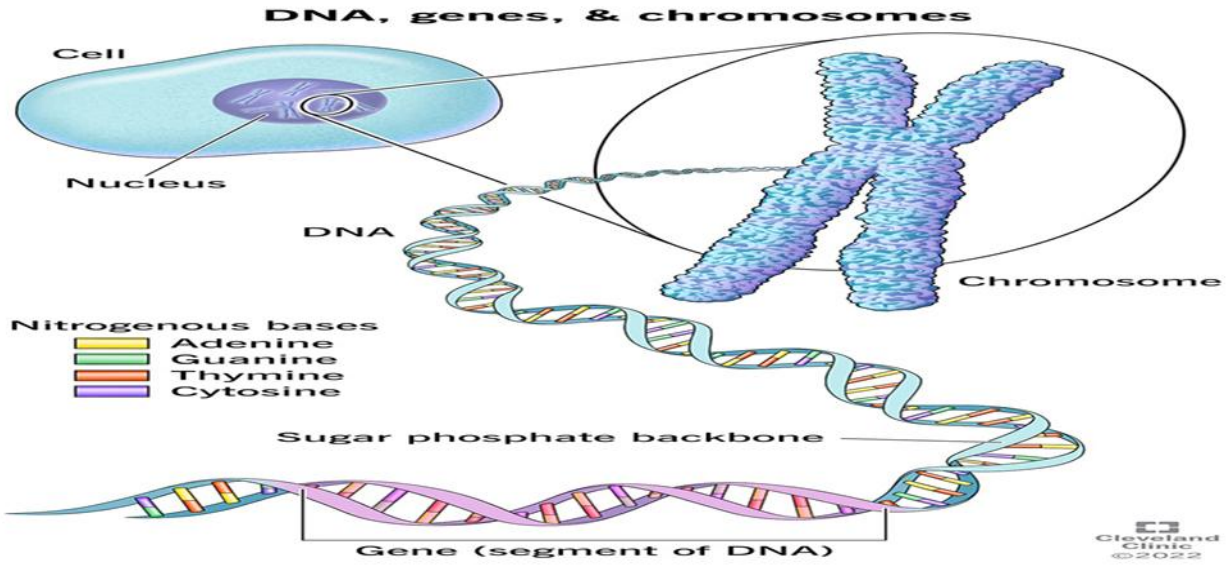
General concepts of biophysics

Biophysics interdisciplinary science that uses the methods of physics to study biological systems

And is that branch of knowledge that applies the principles of physics and chemistry and the methods of mathematical analysis and computer modeling to biological systems, with the ultimate goal of understanding at a fundamental level the structure, dynamics, interactions, and ultimately the function of biological systems. Biophysics seeks to explain biological function in terms of the physical properties of specific molecules.

The size of these molecules varies from small fatty acids and sugars (~1 nm = 10^{-9} m), to macromolecules like proteins (5–10 nm), starches (>1000 nm), and the enormously elongated DNA molecules (over 10,000,000 nm = 1 cm long but only 20 nm wide).



These 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.

Thus, 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; and proteins and DNA wind up into chromosomes, the carriers of the genetic code.

Much effort in biophysics is directed to determining the structure and dynamics of specific biological molecules and of the larger architecture into which they assemble. Some of this effort involves inventing new methods and building new instruments for viewing these dynamic structures in action.
In addition, biophysicists are increasingly concerned with the mechanical properties of biological systems, on length scales from nanometers to meters. Biophysics is relevant to medicine, and many biophysicists direct their investigations towards biomolecules that play a key role in disease.
For examples include Alzheimer's disease, HIV, diabetes, breast cancer, and multiple sclerosis. Consequently, although the central focus of Biophysics is on basic science rather than medical applications, many of biophysicists have close interactions with Faculty of Medicine, and many hold appointments in the Faculty of Medicine.

The biological questions of interest to biophysics 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 ?
- How does RNA fold into complex 3-D structures and carry out highly sophisticated transactions when it is composed of four chemically-similar nucleotides ?
- How are sound waves, or photons, or odors, or flavors, or touches, detected by a sensory 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 a highly interdisciplinary approach that combines chemical and biochemical analysis for identifying molecules and spectroscopic techniques and computational methods to examine relationships between their physical properties and biological function. In so doing, Biophysics explains biological functions in terms of molecular mechanisms: precise physical descriptions of how individual molecules work together like tiny “nanomachines” to produce specific biological functions.

In the context of biophysics, scientists work to analyze and understand the interactions and processes that occur at the molecular and cellular level within living organisms. Scientists in this field study the structures of biological molecules such as proteins and nucleic acids, and try to explain how this delicate biological system interacts. These molecular studies also include examining the physical properties of biological components and understanding the effects of changes in ambient conditions on these processes.

What is the specialty of biophysics ?

It is an interdisciplinary field that integrates physics and biology. It applies physical principles to understand biological systems, extending from molecular to organismal levels by using quantitative methods, scientists in this field explore topics such as biomolecular dynamics, cellular processes, and neurophysics.

Benefits of working in this field

1- **Making contributions to society**: Working in this specialty allows you to contribute to solving pressing issues such as disease and hunger by developing new and effective methods.
2- **Developing valuable skills**: Scientists in this field acquire valuable skills such as project management and data analysis, which enhances their capabilities in other fields in addition to biophysics.

In the end, it can only be said that biophysics is an exciting field of great importance in our time as it allows the individual to explore a wide range of professional fields, while providing sustainable opportunities for scientific advancement and innovation and contributing to the progress and well-being of humanity.

Discussion

1. **What is the main focus of biophysics?**

   A) The study of space phenomena

   B) The application of physical principles to biological systems

   C) The analysis of human psychology

   D) The classification of animal species

   E) The study of geological formations

   Correct answer: B

2. **What size range do biological molecules typically fall into?**

   A) 1 mm - 10 mm
   B) 1 nm - 10,000,000 nm
   C) 1 pm - 100 pm
   D) 1 cm - 1 m
   E) 10 m - 100 m
   Correct answer: B

3. **Which of the following is NOT a primary biological molecule?**

   A) Proteins

   B) Starches

   C) DNA

   D) Silicon dioxide

   E) Fatty acids

   Correct answer: D

4. **What role do ribosomes play in biological systems?**

   A) Storing genetic information

   B) Breaking down waste materials

   C) Building proteins

   D) Transporting oxygen in the blood

   E) Detecting sensory signals

   Correct answer: C

5. **Why is biophysics important in medicine?**

   A) It focuses solely on animal behavior

   B) It ignores molecular structures

   C) It helps understand biomolecules related to diseases

   D) It replaces traditional medical practices

   E) It only studies environmental science

   Correct answer: C

6. **Which of the following diseases is NOT mentioned in the lecture as a research focus in biophysics?**

   A) Alzheimer's disease

   B) HIV

   C) Tuberculosis

   D) Breast cancer

   E) Multiple sclerosis

   Correct answer: C

7. **What is the function of the cell membrane?**

   A) Storing genetic information

   B) Synthesizing proteins

   C) Selectively transporting molecules

   D) Producing ATP energy

   E) Conducting nerve impulses

   Correct answer: C

8. **How does a muscle cell generate movement?**

   A) By using ribosomes

   B) Through the hydrolysis of ATP

   C) By absorbing sunlight

   D) Through osmosis

   E) By storing lipids

   Correct answer: B

9. **What determines the three-dimensional structure of proteins?**

   A) The sequence of amino acids

   B) The presence of DNA

   C) The level of ATP in the cell

   D) The amount of water in the environment

   E) The external temperature

   Correct answer: A

10. **What method do biophysicists use to study biological molecules?**

   A) Mathematical modeling

   B) Spectroscopy

   C) Biochemical analysis

   D) Computer simulations

   E) All of the above

   Correct answer: E

11. **Which of the following is NOT a fundamental aspect of biophysics?**

   A) Structure of biomolecules

   B) Quantum mechanics of stars

   C) Interactions between biological molecules

   D) Dynamics of biological systems

   E) Mechanical properties of cells

   Correct answer: B

12. **Which biological structure contains DNA?**

   A) Ribosome

   B) Mitochondria

   C) Endoplasmic reticulum

   D) Golgi apparatus

   E) Lysosome

   Correct answer: B

13. **What is the function of chromosomes?**

A) Producing ATP

B) Transporting oxygen

C) Carrying genetic information

D) Digesting food

E) Detecting light

Correct answer: C

14. **Which of the following techniques is commonly used in biophysics?**

A) X-ray crystallography

B) Electrophoresis

C) Magnetic resonance imaging (MRI)

D) Spectroscopy

E) All of the above

Correct answer: E

15. **What type of biological molecules form cell membranes?**

A) Carbohydrates

B) Proteins and lipids

C) DNA and RNA

D) Starches

E) Enzymes

Correct answer: B

16. **How do neurons communicate information?**

A) By producing ATP

B) By releasing neurotransmitters

C) By converting proteins into energy

D) By absorbing carbon dioxide

E) By storing glycogen

Correct answer: B

17. **What property allows sensory organs to detect external stimuli?**

A) Enzyme activity

B) Energy storage

C) Electrical impulse conversion

D) Lipid membrane formation

E) DNA replication

Correct answer: C

18. **Which of the following is an example of a macromolecule?**

A) Water

B) Oxygen

C) Protein

D) Sodium chloride

E) Glucose

Correct answer: C

19. **What does biophysics contribute to scientific advancement?**

A) Understanding fundamental biological processes

B) Replacing medical practices

C) Eliminating biological research

D) Studying only plants

E) Ignoring molecular interactions

Correct answer: A

20. **What kind of interdisciplinary approaches does biophysics involve?**

A) Only chemistry

B) Only biology

C) Only mathematics

D) A combination of physics, chemistry, and biology

E) Only environmental science

Correct answer: D

21. **Why is computational modeling important in biophysics?**

A) It helps predict molecular behavior

B) It replaces biological experiments

C) It ignores physical principles

D) It is only useful for chemistry

E) It has no real applications

Correct answer: A

22. **What is the role of ATP in cellular processes?**

A) Storing genetic information

B) Providing energy for reactions

C) Forming cell walls

D) Carrying oxygen

E) Transporting proteins

Correct answer: B

23. **Which of the following best defines biophysics?**

A) The study of human psychology

B) The application of physics to biological problems

C) The classification of species

D) The analysis of space phenomena

E) The study of fossils

Correct answer: B

24. **Which molecules assemble into chromosomes?**

A) Proteins and DNA

B) Lipids and starches

C) Amino acids and glucose

D) Enzymes and water

E) RNA and fats

Correct answer: A

25. **What is a major benefit of working in biophysics?**

A) Contributing to medical advancements

B) Developing new scientific techniques

C) Solving global problems

D) Advancing knowledge in interdisciplinary science

E) All of the above

Correct answer: E