

GENERIC ELECTIVE (GE – 7): BIOLOGICAL PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
BIOLOGICAL PHYSICS GE – 7	4	3	1	0	Passed 12 th Class	NIL

LEARNING OBJECTIVES

This course familiarizes the students with the basic facts and ideas of biology from a quantitative perspective. It shows them how ideas and methods of physics enrich our understanding of biological systems at diverse length and time scales. The course also gives them a flavour of the interface between biology, chemistry, physics and mathematics.

LEARNING OUTCOMES

After completing this course, students will

- Know basic facts about biological systems, including single cells, multicellular organisms and ecosystems from a quantitative perspective.
- Gain familiarity with various biological processes at different length and time scales, including molecular processes, organism level processes and evolution.
- Appreciate how fundamental principles of physics can be applied to gain an understanding of biological systems.
- Get exposure to complexity of life at i) the level of cell, ii) level of multi cellular organism and iii) at macroscopic system – ecosystem and biosphere.
- Gain a systems level perspective on organisms and appreciate how networks of interactions of many components give rise to complex behaviour.
- Perform mathematical modelling of certain aspects of living systems.
- Get exposure to models of evolution.

SYLLABUS OF GE 7

THEORY COMPONENT

Unit – I

(4 Hours)

Overview: The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales.

Unit - II

(12 Hours)

Molecules of life: Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling. Typical populations of molecules of various

types present in cells, their rates of production and turnover. Energy required to make a bacterial cell. Simplified mathematical models of transcription and translation.

Unit - III

(12 Hours)

Molecular motion in cells: Random walks and applications to biology: Diffusion; models of macromolecules. Molecular motors: Transport along microtubules. Flagellar motion: bacterial chemotaxis.

Unit - IV

(12 Hours)

The complexity of life: At the level of a cell: Intracellular biochemical networks. Dynamics of metabolic networks; the stoichiometric matrix. The implausibility of life based on a simplified probability estimate, and the origin of life problem. At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cellular differentiation and development. Brain structure: neurons and neural networks. At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self-sustaining ecosystems. Allometric scaling laws.

Unit - V

(5 Hours)

Evolution: The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution.

References:

Essential Readings:

- 1) Biological Physics: Energy, Information, Life, P. Nelson, W H Freeman & Co, NY, 2004
- 2) Cell Biology by the Numbers, R. Milo and R. Phillips, Garland Science, Taylor & Francis Group, NY USA and Abingdon UK, 2016
- 3) Physical Biology of the Cell, R. Phillips et al, 2nd edition, Garland Science, Taylor & Francis Group, NY USA and Abingdon UK, 2013
- 4) Evolution, M. Ridley, Blackwell Publishers, 2009, 3rd edition

Additional Readings:

- 1) Physics in Molecular Biology, K. Sneppen and G. Zocchi, Cambridge University Press, Cambridge UK, 2005
- 2) Biophysics: Searching for Principles, W. Bialek, Princeton University Press, Princeton USA, 2012