

720: INTRODUCTION TO PHYSICAL BIOLOGY

SYLLABUS

- Chapter 1: Introduction

Orders of magnitude

Cells: the atoms of the biological world. Internal and external structures. Examples. Some cell features. Viruses.

A list of parts.

- Chapter 2: Macromolecules: generalities

DNA: bases, hydrogen bonds, the double helix

Some physical properties. Secondary structures. X ray crystallography.

RNA

Proteins (a first look)

The flow of genetic information in molecular biology. Genes, chromosomes etc.

[Homework 1: X ray structure of DNA]

- Chapter 3: Some mathematical aspects of DNA

Sequence alignment. Needleman Wunsch and Waterman Smith algorithms

Correlations in DNA and evolution mechanisms

DNA computers

[Homework 2: some exercises with alignment.]

- Chapter 4: Some physical properties of DNA

DNA supercoiling, knots, topoisomerases. Gel electrophoresis.

Models of random chains

Optical tweezers

Stretching DNA. Denaturing DNA.

[Homework 3: models for DNA stretching.]

- Chapter 5: Proteins

Protein structures. A review of primary, secondary, tertiary structures with examples.

Interactions in proteins. The hydrophobic effect.

Quaternary structures. Structural classification of proteins.

Protein folding. Generalities. The Levinthal paradox. Simple models. Free energy landscape theories.

Ab initio modelling.

Experimental determination of protein structures. X ray crystallography.

[Homework 4: reading homework about the Rosetta and other protein folding algorithms.]

- Chapter 6: Molecular motors

Structure of muscles. Muscle contraction.

ATP

Myosin walk: mechanisms

Motility assay experiments. Kinesin.

Motors. Energy landscapes

Microscopic machines. Brownian ratchets. Fokker Planck equation. Flashing ratchets.

Enzymes. Michaelis Menten mechanism.

The constraints of life at low Reynolds numbers. Motors and propulsion.

[Homework 5: Fokker Planck equation and motors.]

- Chapter 7: Aspects of the physics of membranes

Cells and their membranes

Lipids. Amphiphilic molecules, micelles and membranes

Osmosis. Depletion forces. Passive transport in cells.

Diffusion in cells.

Nernst potentials. the sodium anomaly.

Machines in membranes: the sodium potassium pump.

[Homework 6: reading homework on the cytoskeleton.]

- Chapter 8: Aspects of the physics neurons

The structure of neurons; dendrites, axons.

The action potential

Neural networks: the Hopfield model.

- Chapter 9: Wrapping it up.

Another look at the cell. External and internal anatomy.

Thermodynamics of life

Physics issues in biology: diffusion, osmosis, viscosity