Introduction to Biological Physics

Zhanchun Tu (涂展春)

Department of Physics, BNU

Email: tuzc@bnu.edu.cn

Homepage: caea.net.cn/tzc/index.html
Biology and Physics

- Biology
  - Definition: greek words bios (life) and logos (study); the science of life and living organisms
  - Objects of study: from molecules in cells, to species then to ecosystems
  - Method: experiment (more) & theory (fewer)
  - Branch: Physiology(生理学), Genetics(遗传学), Evolutionary Biology(进化生物学), Molecular Biology(分子生物学), Morphology(形态学), Systematics(系统生物学), Ecology(生态学), etc.
• Physics
  – Definition: the science to study the structure and movement of matter
  – Objects of study: from quark to universe (usually nonliving)
  – Method: experiment (~50%) & theory (~50%)

Branch: mechanics (力学), thermodynamics(热学), electrodynamics(电动力学), statistical mechanics(统计力学), quantum mechanics(量子力学), particle physics (粒子物理), field theory(场论), relativity(相对论), etc.
• Two cultures:
  – Biological scientists: have traditionally been more likely to emphasize what we see, not universal laws in the inherently complex living world. In such a world, often it's the details that really matter most
  – Physical scientists: tend to look for the forest, not the trees, to see that which is universal and simple in any system

Note: (1) Two views are complementary
    (2) Select proper approach in practice
    (3) Entertain that the other one is valuable too
What's Biological Physics?

- Biological Physics (Biophysics) is a branch of knowledge that applies the principles of physics and chemistry and the methods of mathematical analysis and computer modeling to understand how biological systems work. It seeks to explain biological function in terms of the molecular structures and properties of specific molecules. (----Amer. Biophys. Soc.)

生物物理学旨在运用物理学、化学的原理以及数学分析和计算机建模的方法理解生物系统的运作规律。它致力于以分子的结构以及特定分子的性质解释生物体展现的各种功能
Purpose

- To introduce the basic concepts of Biophysics
- Try to give answers to 3 questions
  - Is life determined by its material basis?
  - Do living organisms obey the physical law?
  - How molecular devices works in cells?
- Through studying this course, the students
  - can survey this interdisciplinary field comprehensively
  - are able to read the latest research papers
Main reference books

- 黎明，戴陆如 等 译，生物物理学：能量、信息、生命 (上海科学技术出版社，2006)
Schedule of the course

• Part I. Introduction
  – Lecture 1. Cells: the basic units of life
  – Lecture 2. Underlying principles behind life

• Part II. Diffusion, dissipation, drive
  – Lecture 4. Life in the low lane: the low Reynolds-number world
  – Lecture 5. Entropy, temperature and free energy
  – Lecture 6. Entropic forces
  – Lecture 7. Chemical forces and self-assembly
• **Part III.** Molecules, Machines, and Mechanisms
  - **Lecture 8.** Cooperative transitions in macromolecules
  - **Lecture 9.** Enzymes and molecular machines
  - **Lecture 10.** Molecular machines in membranes

• **Part IV.** Selected Advanced topics
  - **Lecture 11.** Bio-membranes
  - **Lecture 12.** Cell crawls and migrations
  - **Lecture 13.** Allometric Scaling Laws in Biology

• **Part V.** Final Exams (3X2 hours)
  - **Presentations** on the selected papers by the students (1 paper per student)
Acknowledgment

- Ming Li (黎明): Graduate school, CAS [ppt]
- Jie Yan (严杰): Department of physics, NUS [ppt]
- Zhanpeng Tu (涂展鹏): Shihui com. [tech.]