Elements of Biology

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Course Notes

Summary

The goal of the course is to investigate the foundations of modern biology. We try to identify the empirical data and theoretical concepts on which modern biology is built and to analyze its relationship with other branches of human knowledge.
History shows that biology has been built on four ideas elaborated during the nineteenth century: the theory of evolution, the theory of the cell, the theory of heredity and the theory of chirality of life. The twentieth century has witnessed the deepening of our knowledge for each of these for fundamental ideas, and has brought to us a detailed molecular understanding of biology. Life sciences have reached a stage where most classic biological concepts have a clear material basis. The problem of heredity for instance, was transformed by the discovery of the structure of the genetic material. The polymeric nature of DNA and other bio-macromolecules implies in turn that issues of genetics and biochemistry must also be understood from the point of view of polymer physics and polymer chemistry. This same conclusion applies to the theory of evolution and to natural selection, which must now be interpreted within a physico-chemical framework.
The goal of this course is to study the foundations of modern biology in this unifying perspective. We shall investigate the issues of chance and necessity in biology: we show that the structure of the genetic material is in a qualified manner necessary and not contingent, and that it can be built starting from simple considerations. The first lectures are devoted to this theoretical construction of the genetic material. Through this construction key concepts of biology are introduced in an intuitive manner. The remaining lectures are devoted to a more detailed study of these concepts.

Outline

September 18, 2008

1. Introduction: Evolution, cells, heredity and chirality
2. Theoretical construction of the genetic material (1)

September 25, 2008

3. Theoretical construction of the genetic material (2)
4. Symmetry and asymmetry: helices, icosahedra
5. Fitness and environment

October 2, 2008

6. Biological matter: Physical description of biopolymers (1)
7. Biological matter: Physical description of biopolymers (2)

October 9, 2008

8. Biological motion: kinetics of complementary recognition and dynamics of entangled biopolymers
9. Physical chemistry of natural selection