I. Membrane Structure and Function
   A. Lipid structures
      1. Phospholipids
      2. Sterols
      3. Proteins

   The physical concept of hydrophobicity was explored by example, including predictive models and experimental descriptions of protein structure in membranes

   B. Fluidity

   The interplay between temperature and fludity was explored from experimental examples.

II. Molecular Motion
   A. Diffusion
      1. Einstein's explanantion of Brownian motion
      2. Membrane partitioning

   Einstein's explanation was the starting point of a mathematical description of the flux of neutral solutes, in solution (Fick's equations) and across membranes.

III. Gramicidin Channel
   A. Historical
      1. Antibiotic
      2. Bioenergetics
   B. Channel properties
      1. Current-voltage relations
      2. Ionic motion
      3. Ion properties, permeability and conductance

   We explored the underlying causes of the flux of charged ions, in solution and across membranes (Goldman equation), including a physical explanation of Stoke's radius, and the consequences of electroneutrality in the context of cellular capacitance, all important to the understanding of ion flux through channels.

IV. Potassium Channel
   A. Channel structure and the mechanism of selectivity

   The concepts of ion selectivity rely heavily on an understanding of the remarkable energetics and steric nature of ionic hydration.

V. Arsenate transport
   A. Historical and environmental overview of arsenicals
      1. Chemistry and redox properties
      2. Toxicology
   B. ATPase and channel mediated arsenic extrusion
      1. ars operon of *E. coli*
      2. other transport mechanisms

   We explored the bioenergetics of oxidative phosphorylation, using the bacterial system as an experimental tool to assess the driving forces for arsenic extrusion.

VI. ATP synthase

A. Historical evolution of mechanism

1. From chemical intermediate to electrochemical gradient – mediated synthesis to a rotatory machine.

B. Rotatory engines at a low Reynolds number

Bioenergetic consequences of coupling ion gradients and ATP chemical synthesis were explored in the context of standard Gibb's free energy descriptions.

VII. Light-activated channels

A. Introduction to algal vision

1. Phototactic responses
2. Ultrastructure and photobiological properties

B. Bacteriorhodopsin

1. Identification of putative channels and heterologous expression and analysis in *Xenopus laevis*

C. A working model of vision and signal transduction in a protist

The integration of ion transport to create a system of vision and response.

VII. Short Case Studies

A. Manganese: uptake and extrusion

1. Yeast as a heterologous system for experimental studies

B. Voltage dependent Cl^- channels: their role in action potentials

1. Ion channel mutations and organismal phenotype