MBIO 4540 Biological Energy Transduction

Biological Energy Transduction is the subject of a specialized biochemical discipline – bioenergetics. In this course, the general topic is “Transformation of energy in biomembranes”. Specific topics include introduction into the chemiosmotic theory, relevant elements of thermodynamics, specific methods of membrane bioenergetics, molecular mechanisms of generation (e.g., respiration, photosynthesis, bacteriorhodopsin) and utilization of ion motive forces in ATP synthesis as well as in osmotic and mechanical work. Students are expected to be comfortable in elementary mathematics, physics and organic as well as inorganic chemistry. This course is based on a thermodynamic approach, and a certain amount of the relevant calculations will be included in both the mid-term and final examinations. Brief look into the Course Notes (UMLearn, the course site) will give a general idea about the expectations in math/physics/chemistry.

Marking: midterm (30%) and a final exam (70%).

Course outline:

Part I – GENERAL BIOENERGETICS

1. **Introduction**: cellular energy flow. ATP as the universal energy currency of all cells. Cellular energy metabolism. ATP–yielding pathways: substrate level phosphorylation, oxidative and photo-phosphorylation. ATP-consuming pathways: chemical, osmotic, and mechanical work in living systems.


Part II – QUANTITATIVE BIOENERGETICS: THERMODYNAMICAL APPROACH

3. **Relevant elements of equilibrium thermodynamics**. The free energy change (∆G). Gibbs energy and equilibrium. ∆G for the ATP hydrolysis and synthesis reactions. Oxidation-reduction (redox) potentials. Electron and hydrogen carriers. Redox potential (Eh) and pH.


Part III – SELECTED METHODS

Part IV – KEY MOLECULAR MECHANISMS IN BIOENERGETICS


7. Q-cycle and complexes III, IV. The bc$_1$ complex and Q-cycle. Cytochrome c oxidase. Reduction of oxygen as a "thermodynamic sink".

8. $H^+$ motive $F_0F_1$ ATPase: rotational catalysis. The central enzyme of membrane bioenergetics. Molecular anatomy of the $F_0F_1$ ATPase. Unusual enzymology of the ATPase: binding change mechanism. Rotation in $F_0F_1$.


Part V – DIVERSITY OF MOLECULAR MECHANISMS IN BIOENERGETICS


