# Biochemistry

MCDB S 300 01, MB&B S 200 01

## Description

An introduction to the biochemistry of animals, plants, and microorganisms, emphasizing the relations of chemical principles and structure to the evolution and regulation of living systems. This course will be taught in an active learning format, whereby the typical lecture and homework elements of a course are reversed. Narrated PowerPoint video lectures are viewed by students at home before the class session, while in-class time is devoted to problem-solving exercises, collaborative projects and discussions.

## Student's Learning Objectives

Students will know the chemical structures and chemistry of biological polymers (proteins, carbohydrates, lipids and nucleic acids) and their monomers (amino acids, sugars, fatty acids and other lipid monomers, and nucleotides) as well as the roles of these biological molecules in living cells. Students will be able to solve amino acid sequences of protein, nucleotide sequences of nucleic acids from experimental data and how to determine structures of carbohydrates and lipids. Students will be able analyze enzyme kinetic data as well as the bioenergetics/thermodynamics of biochemical reactions. Students will know the reactions of major metabolic pathways and be able to analyze the regulation of these pathways: Central Metabolism (Glycolysis-Gluconeogenesis, Pentose phosphate Pathway, Citric Acid Cycle), Respiratory Electron Transport System, Glyoxylate Cycle, and Fatty Acid Metabolism (beta-oxidation and synthesis).

## Prerequisites

BIOL 101, 102, 103, and 104 or MCDB 120 or MCDB 200; one term of organic chemistry

## Days, Time, and Location

MWF, 9.00-11.15, SPL 56

| Lecturers | Office | E-mail |
|---|---|---|
| Nicole Clay (NC) | 734 KBT | nicole.clay@yale.edu |

## Required Text

*Biochemistry*, 7th Edition, by Jeremy Berg, John Tymoczko and Lubert Stryer (W.H. Freeman and Co.)

- The text provides a clear introduction to the detailed world of biochemistry.
- The fifth and sixth editions are also fine (NOTE: chapter numbers are not always the same)
- The lectures form the core of the course; they do not always closely follow the text.
- The text is a valuable reference for primary lecture content and for background.

## Additional Materials

Narrated lecture videos and homework assignments will be posted on the ClassesV2 server.

## Graded Materials

There will be four one-hour examinations (each worth 20% of the final grade). Exam questions will be derived from the lecture material and problem sets. There will be ten graded quizzes (collectively worth 20% of the final grade).

## Academic Integrity

Academic integrity is the pursuit of scholarly activity free from fraud and deception. All University policies regarding academic integrity apply to this course. Academic dishonesty includes, but is not limited to, cheating, plagiarizing, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. All exam answers must be the student's own, and a student must not provide any assistance to other students during exams.

## Schedule

### I. Background for Biochemistry

1. May 29. Introduction to Flipped Classroom. Sizes of biological systems; Biochemical building blocks; Time scale of biochemical processes – *Ch 1*. Water; non-covalent bonds; association-dissociation; mass action, pH; titration – *Ch 1*. Thermodynamics and energy – *Ch 1.3, 8.2, and 15.1*.

### II. Structure and Function of Biological Macromolecules

2. May 31. Proteins I: amino acids, dissociable groups, peptide bonds, and configuration – *Ch 2*. Proteins II: structure levels, folding, alpha helices, beta sheets, collagen helices, tertiary structure, denaturation – *Ch 2*. Proteins III: coenzymes, prosthetic groups, allosteric proteins – *Ch 2 and 9*.

3. June 2. Carbohydrates: simple sugars, oligosaccharides, starch, glycogen, cellulose, complex sugars, glycoproteins, glycolipids – *Ch 11*. Nucleic acids: purines, pyrimidines, nucleosides, nucleotides, base pairing, DNA and RNA – *Ch 4*.

### III. Synthesis of Biological Macromolecules

4. June 5. **Exam 1**. Biological membranes: function, composition, fatty acids, lipids, fluidity and transport – *Ch 12*.

5. June 7. Protein synthesis – *Ch 30*. Replication and repair of DNA – *Ch 28*. Synthesis of RNA – *Ch 29*.

### IV. Enzyme Action

6. June 9. Enzymes I: Biological catalysis, inhibition and activation – *Ch 8*. Enzymes II: Mechanisms of enzyme action – *Ch 9*. Enzymes III: Modulation of enzyme activity, cascades – *Ch 10*.

### V. Metabolism: Enzymes, Coenzymes and Pathways

7. June 12. **Exam 2**. Glycolysis and $NAD^+$ (*Ch 16*)

8. June 14. Glycolysis and Gluconeogenesis – *Ch 16*. Glycogen Metabolism – *Ch 21 (skip Ch 21.3 hormones and Ch.21.1.5 PLP)*

9. June 16. Citric Acid Cycle, PDH complex, TPP, FAD, Lipoamide, Glyoxylate cycle – *Ch 17*. Amino acids from alpha-keto acids – *Ch 24.2*.

10. June 19. Ketone body synthesis, fatty acid synthesis and breakdown, Coenzyme B12 – *Ch 22*. Phospholipid and isoprenoid synthesis– *Ch 26 (skip cholesterol synthesis)*.

11. June 21. **Exam 3.** SAM and THF in methylation and methionine biosynthesis – *Ch 24.2*. PLP in amino acid metabolism and glycogen breakdown – *Ch 24.2* and *21.2*.

**VI. Capture of Energy by Coupling to Chemical Gradients**

12. June 23. Oxidative phosphorylation – *Ch 18*. Noncyclic photophosphorylation – *Ch 19*.
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13. June 26. Oxidative pentose phosphate pathway, coordination with glycolysis, Calvin cycle (nonoxidative pentose phosphate pathway) – *Ch 20*.

**VII. Integration of Metabolic Routes**

14. June 28. Glutamate, aspartate and serine families – *Ch 24.2*. Carbamoyl phosphate in pyrimidine biosynthesis and urea cycle – *Ch 25.1 and 23*. Cancer

15. June 30. **Exam 4**. Biochemistry Jeopardy.