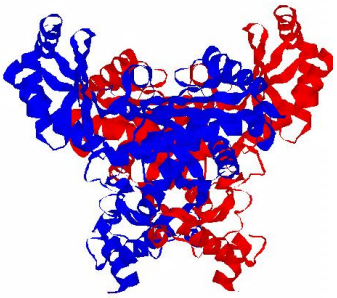
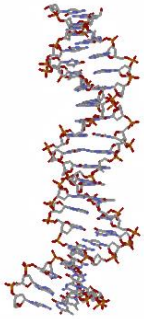


Biochemistry I
Abilene Christian University
Fall 2014



Chem 453.01/ Biol 472.01 MWF 10:00-10:50
3 credit hours SC 117

Dr. Autumn Sutherlin, Associate Professor of Biochemistry
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E-mail: autumn.sutherlin@acu.edu

Office Hours: T: 2-5 R: 1-5

ACU Mission: "To educate students for Christian service and leadership throughout the world."

Department Mission: "To prepare students for careers in chemistry, biochemistry, chemical education, and health professions by displaying high professional standards and by modeling Christian values, leadership, and service."

Course Description: Biochemistry I covers the chemistry, structural aspects, and properties of amino acids, peptides, proteins, vitamins, carbohydrates, lipids, nucleic acids and their application in elementary metabolism.

Prerequisite: At least a C in CHEM 324 Organic Chemistry II

Course Purpose and Audience: This course is designed to prepare upper level biochemistry, biology, and chemistry majors for graduate school, professional school in human or veterinary medicine or pharmacy, or the work force in health and biotechnology related fields.

Texts:

Required: "Biochemistry, 7th Ed." by Jeremy Berg, John Tymoczko, and Lubert Stryer. W.H. Freeman and Company: New York, 2012.

"Selected Activities from Foundations of Biochemistry, 3rd Ed." by Jenny Loertscher and Vicky Minderhout. Pacific Crest: Seattle, WA, 2011.

Optional: "Student Companion to Accompany Biochemistry, 7th Ed." by Richard Gumport, Frank Deis, Nancy Counts Gerber, and Roger Koeppe II. W.H. Freeman and Company: New York, 2012.

Other Required Materials: iPhone®, iPodTouch®, iPad®, other tablet or smart phone with ResponseWare App from Turning Point registered at student.turningtechnologies.com.

Other Resources: bcs.whfreeman.com/berg7e, Course Blackboard

Attendance Policy: This class is structured to involve student participation through answering of questions via ResponseWare, discussing concepts, and working in groups. Attendance is expected and required. To be counted as present the student must have a **functioning internet accessible device (smart phone, tablet, laptop, etc.)** as attendance will be registered using the iDevice. The professor may drop a student from the class who has more than **9** absences (excused and unexcused) with a **WF**. If you will miss class for a school-sponsored trip, you must bring the required signed dean's notice one week before the anticipated absence as per ACU policies. Absences will be excused for illness with accompanying doctor's note, death in the family, school sanctioned trips, or other reasons approved by the instructor. Habitually late students will be dealt with on an individual basis. **Absences for interviews:** If you are going to miss class for a school interview, you need to e-mail me the information of the dates you will miss.

Course Requirements:

Homework: Daily readings will be assigned with accompanying questions posted in Blackboard. Answers are due at **11:50 PM** the night before the material will be covered in class. These questions are very important as they will shape the lecture.

Other homework will be assigned as deemed necessary by the professor. The homework and its due date will be announced in class. Additional homework is due at the **BEGINNING** of class on the day it is due.

Homework will not be accepted late.

Quizzes: Eleven quizzes will be given during the semester on non-exam weeks. Quizzes will be based upon assigned homework, material covered in lecture, and assigned reading for the previous week. Quizzes will be delivered online through Blackboard. Generally, quizzes will be available from after class on Fridays until Monday at 8 AM. Your lowest quiz score will be dropped.

Quizzes will not be accepted late.

Participation: The participation grade will be based on regular answering in-class quizzing using iDevices, working in groups, and contributing to peer instruction during class. You may lose participation points by missing or being late to class on a regular basis, talking excessively to neighbors during class, disrupting class, and using your iDevice or cell phone at non-designated times (texting, playing games, etc.)

Exams: Three exams will be given during the semester. Attendance is required at exams. The professor must be notified **BEFORE** the exam if you will not be able to attend. Make-up exams will only be given for excused absences (see attendance policy.)

Final: The final will consist of two equal parts. The first half will be taken from the portion of the material covered in class since the third exam. The second half will be comprehensive.

Grading:

Summary of Activities:

3 Exams	51%
Final	34%
Quizzes	5%
Homework & Participation	10%
Total	100%

Grade Distribution:

A	90.00 – 100 %
B	80.00 – 89.99%
C	70.00 – 79.99%
D	60.00 – 69.99%
F	59.99% and below

Academic Integrity: Violations of academic integrity and other forms of cheating, as defined in ACU's Academic Integrity Policy, involve the intention to deceive or mislead or misrepresent, and therefore are a form of lying and represent actions contrary to the behavioral norms that flow from the nature of God. Violations will be addressed as described in the Policy. While the university enforces the Policy, the most powerful motive for integrity and truthfulness comes from one's desire to imitate God's nature in our lives. Every member of the faculty, staff and student body is responsible for protecting the integrity of learning, scholarship and research. The full Policy is available for review at the Provost's office web site (http://www.acu.edu/campusoffices/provost) and the following offices: provost, college deans, dean of campus life, director of student judicial affairs, director of residential life education and academic departments.

The first instance of cheating will result in a 0 for the assignment. A second incident will result in an F in the course.

Dress Code: Students should conform to the dress code as outlined in the Student Handbook. Students wearing inappropriate attire will be asked to leave class.

Course Content with Learning Objectives for each chapter.

The following chapters and topics will be covered in Biochemistry I. Learning Objectives are adapted from the Association of Biochemistry Course Directors.

1 – Introduction to Biochemistry and Chemistry Review
1a. Know the common organic functional groups.
1b. Describe the essential role water plays in life.
1c. Define and explain briefly the role of entropy, and enthalpy in biochemical reactions.
1d. Define and explain Gibbs free energy (ΔG), standard free energy (ΔG^{o}), and the equilibrium constant (K_{eq}) as it applies to biochemical reactions.
1e. Define and explain the roles of covalent bonds, Van der Waals forces, ionic interactions, polar interactions, hydrogen bonds, and hydrophobic interactions in biological settings.

11 – Carbohydrates
11a. Identify the biological roles and know the structures of the major monosaccharides, disaccharides, and polysaccharides found in the human body and diet.
11b. Apply the formation of hemi-acetals and acetals to monosaccharide cyclization and di- and polysaccharide formation.
11c. Identify reducing and non-reducing sugars.

12 – Lipids and Cell Membranes
12a. Draw the structures of simple fatty acids, triacylglycerols and glycerolphospholipids.
12b. Recognize the major membrane lipids.
12c. List and describe the roles of each of the major components of membranes and integrate each into a working model of a generic membrane, including: phospholipids, sphingolipids, cholesterol, and protein
12d. Describe lipid arrangements in water and the driving force behind self-assembly.
12e. Explain the role of membrane fluidity and describe how it can be altered by various lipids.
12f. Define and explain the role of membrane proteins.
12g. Describe how asymmetry is achieved in biological membranes.

4 – DNA, RNA, and the Flow of Genetic Information
4a. Know the structures of the nucleic acid bases as base paired nucleotides.
4b. Compare and contrast the structure of DNA and RNA, explaining the difference between the constituent bases, sugars, nucleosides and nucleotides.
4c. Describe the double-stranded, helical, and antiparallel chain structure of DNA and how it

relates to the processes of DNA replication, transcription, recombination and repair.)
4d. Compare and contrast the different types of RNA.
4e. Describe other nucleic acid comformations in addition to the double helix.
4e. Summarize the central dogma of molecular biology.
4f. Summarize the mechanism of DNA replication, transcription and translation.
4g. Describe the universal features of the genetic code and describe its biological relevance.

5 – Exploring Genes and Genomes
5a. Describe the principles, methods, and applications of Northern, Southern blot, microarray, PCR, and DNA sequencing.
5b. Describe how recombinant DNA technology is used to clone and express genes.

2 – Protein Composition and Structure and Review of pH
2a. Define and explain pH and pK_a in relation to amino acids and proteins.
2b. Apply the Henderson-Hasselbalch equation to solve pH problems.
2c. Explain what is meant by the isoelectric point (pI) and calculate the pI for an amino acid or small polypeptide.
2d. Examine and assess the charge on a small peptide at a given pH.
2e. List and name the 20 amino acids that commonly occur in proteins and classify them according to chirality, polarity, size, and charge.
2f. Draw the structure of and list the one letter and three letter abbreviations of the 20 amino acids and small peptides.
2g. Define and discuss the following terms: peptide bond, peptide backbone, N-terminus, C-terminus, disulfide bridges, α-helices, β-sheets, β -strands, β -turns.
2h. Discriminate between primary, secondary, tertiary, and quaternary protein structure.
2i. Describe the bonds and forces (peptide, disulfide, and hydrogen bonds; hydrophobic, dipole-dipole, van der Waals and electrostatic interactions) that contribute to the conformation of proteins and the interaction of proteins with other biomolecules. Apply these forces to the levels of protein structure.
2j. Propose reasons why folded proteins have a finite number of conformations.
2k. Describe the relationship of primary structure to tertiary and quaternary structure.

3 – Exploring Proteins and Proteomes
3a. Given a simple protein, outline a general purification scheme.
3b. Compare and contrast the major ways of determining protein 3D structure.
3c. Describe the role of antibodies in studying proteins.

6 – Exploring Evolution and Bioinformatics
6a. Compare and contrast the difference between conservative and non-conservative amino acid substitutions. Describe how these relate to conserved amino acid residues.
6b. Compare and contrast the relationship among homologs, paralogs and orthologs.
6c. Describe the role of sequence alignments in the understanding of the function of proteins and nucleic acids.
6d. Compare and contrast divergent and convergent evolution.

8 – Enzymes: Basic Concepts and Kinetics
8a. Define and describe the roles of the following enzyme-related terms: zymogen/proenzyme, coenzyme, co-factors, prosthetic group, apoenzyme, holoenzyme, and isozymes.
8b. Explain how an enzyme functions as a catalyst in lowering the activation energy of reactions.
8c. Propose a thermodynamic explanation of why enzymes cannot alter the equilibrium of reactions.
8d. Define the term transition state and propose a role for the transition state in lowering activation energy.
8e. Explain the lock and key and induced fit models of enzyme catalysis. Defend which is the “better” model.
8f. Define initial velocity (v_o) and explain the effect of substrate concentration on enzyme velocity for a single subunit enzyme.
8g.. Explain Michaelis-Menton kinetics and be able to apply the Michaelis-Menton equation to calculate velocity, maximum velocity (V_{max}), the Michaelis-Menton constant K_m, and the turnover number (K_{cat}).

8h. Describe the significance of an enzyme's K_m value in metabolic systems.
8i. Draw a Lineweaver-Burke plot, defining V_{max} and K_m and use the plot to evaluate types of inhibition, including: competitive, non-competitive, and uncompetitive.
8j. Given v_o, substrate concentration, and inhibitor concentration, calculate $V_{max,}$ K_m, K_i, and K_{cat}.
8j. Compare and contrast the different types of inhibitors, with examples including: irreversible inhibitors, competitive, noncompetitive and uncompetitive inhibitors.

9 – Catalytic Strategies
9a. Name an example and describe basic catalytic mechanisms, including: serine proteases, covalent and acid-base catalysis.
9b. Draw the full mechanisms for chymotrypsin and carbonic anhydrase.
9c. Given a mechanism, identify the common mechanisms employed by the enzyme.
9d. Compare and contrast the common protease mechanisms.

7 – Hemoglobin
7a. Explain the role of hemoglobin in the delivery of oxygen, removal of waste and buffering
7b. Define the composition of normal hemoglobin at various stages of development (include proteins and prosthetic groups)
7c. Describe the allosteric effects of H^+, 2,3-BPG, CO_2 and key mutations on the P_{50} of hemoglobin for O_2. Explain how these effects enable appropriate oxygen delivery to tissues, buffering of the blood, and CO_2 removal.
7d. Explain how oxygen is delivered from the mother to the fetus, taking into account structural differences between adult and fetal hemoglobin and O_2 binding affinity.

10 – Regulatory Strategies
10a. Distiguish among the general regulatory enzyme strategies.
10b. Define and draw a generic substrate versus velocity plot of an allosteric reaction.
10c. Define and explain allosterism and the important physiological role of allosteric enzyme inhibition or activation.
10d. Predict the effect of an allosteric activator or inhibitor on a substrate vs. velocity plot.
10e. Explain the role of isozymes, covalent modification, proteolytic cleavage and the amount of the enzyme in regulating enzyme activity.

15 – Metabolism: Basic Concepts and Design
15a. Relate the terms metabolism, catabolism, and anabolism.
15b. Describe the roles of activated carriers in metabolism
15c. Describe the significance of coupling reactions and the role thermodynamics plays in reaction coupling.
15d. Explain the role of ATP and its significance in metabolism.
15e. Describe the roles of FAD(H_2), NAD(H), and NADP(H) in metabolism.
15f. Identify the 6 major types of reactions and the three major regulatory strategies in metabolism.

16 – Glycolysis and Gluconeogenesis
16a. Describe the overall purpose of glycolysis, its reactants and products, and its cellular localization.
16b. Diagram glycolysis including enzymes and key intermediates.
16c. Describe the roles of hexokinase/glucokinase, phosphofructokinase-1 (PFK-1), and pyruvate kinase in glycolysis.
16d. Compare and contrast the mechanisms for regulating glycolysis including allostery, hormonal regulation and covalent modification.
16e. Compare and contrast aerobic and anaerobic glycolysis in terms of the tissues in which they occur, reactants and products, purposes, and the conditions in which they occur.
16f. Explain the concept of substrate level phosphorylation and why it is important
16g. Describe the role and fate of the cytosolic NADH produced in glycolysis
16h. Based on cellular conditions, predict the activation or inhibition of glycolysis.

17 – The Citric Acid Cycle

17a. Describe the overall purpose of the pyruvate dehydrogenase (PDH) complex, its reactants and products, and its cellular localization.

17b. Compare the general structure, regulation, and required cofactors/vitamins of the PDH complex to that of alpha-ketoglutarate dehydrogenase .

17c. Describe the overall purpose of the TCA cycle and its cellular localization.

17d. Diagram the PDH reaction and the TCA cycle including enzymes and key intermediates.

17e. Describe the roles of citrate synthase, isocitrate dehydrogenase, alpha-ketoglutarate dehydrogenase, succinyl-coA synthetase, succinate dehydrogenase, and malate dehydrogenase in the TCA cycle.

17f. Explain the effect of the following parameters on the activity of the TCA cycle and the mechanism(s) by which the effect occurs: mitochondrial NADH:NAD ratio, ADP:ATP ratio, succinyl CoA concentration

17g. Describe the central role of the TCA cycle in connecting glycolysis and oxidative phosphorylation.

17h. Based on cellular conditions, predict the activation or inhibition of glycolysis.

18 – Oxidative Phosphorylation

18a. Describe the purpose of the electron transport chain (particularly complexes I, III, and IV) and ATP synthase, their substrates and products, and their cellular localization.

18b. Explain how electron transport and ATP synthase are functionally coupled

18c. Explain how the process of oxidative phosphorylation is influenced by the availability of oxygen and NADH.