Butler Community College
Science, Technology, Engineering, and
Math Division

Robert Carlson
New Fall 2017
Implemented Fall 2018

COURSE OUTLINE
Biochemistry

Course Description
CH 275. Biochemistry. 4 hours credit. Prerequisite: CH 240 with a C or better. This course will enable the student to develop knowledge of concepts and techniques in the field of biochemistry. The student will study the major classes of biological molecules, such as proteins, lipids and nucleic acids. The student will study the major metabolic pathway and developments related to molecular biology. This course is designed for students in pre-pharmacy.

Required Materials
For complete material(s) information, refer to https://bookstore.butlercc.edu

Butler-Assessed Outcomes
The intention is for the student to be able to
1. Demonstrate advanced scientific methods in the field of biochemistry.
2. Demonstrate knowledge of mathematical and graphical techniques as well as interpretation of data as they apply to biochemistry.
3. Apply advanced scientific reasoning to real world problems in biochemistry.

Learning Outcomes
The intention is for the student to be able to
1. Describe the properties of water and apply these properties to aqueous solutions.
2. Identify the amino acids which are utilized in the construction of proteins and the properties of these amino acids, including pH, acid-base characteristics and solubility.
3. Describe the different levels of protein structure and describe how protein structural determinations are accomplished.
4. Define the major classes of enzyme catalyzed reactions and explain principles of enzyme kinetics.
5. Compare and contrast the major classes of lipids and their functions.
6. Describe the structure and functions of biological membranes and how they relate to cellular processes.
7. Compare the structures of mono-, di- and polysaccharides and give examples of each
8. Utilize thermodynamic equations to determine energy relationships in metabolic reactions.
9. Identify the catabolic and anabolic reactions involved with the major metabolic pathways, including glycolysis, the citric acid cycle, oxidative phosphorylation, photosynthesis, fatty acid and nitrogen metabolism.
10. Describe the primary, secondary and tertiary structures of DNA and RNA.

11. Describe the reactions and processes involved with the central dogma theory of molecular biology, including replication, transcription and translation.
12. Apply principles involved with gene expression to recombinant DNA technology (genetic engineering).

Learning PACT Skills that will be developed and documented in this course
Through involvement in this course, the student will develop ability in the following PACT skill area(s):
Analytical Thinking Skills

- Critical thinking - Through the production of mathematical, graphical and written assignments, the student will demonstrate scientific reasoning.

Major Summative Assessment Task(s)
These Butler-assessed Outcome(s) and Learning PACT skill(s) will be demonstrated by
1. Completing a final assessment of the course using the American Chemical Society's national standardized exam for one semester biochemistry.
2. Writing a research paper on a topic of the student's choice relating to biochemistry.

Skills or Competencies
These actions are essential to achieve the course outcomes:
1. Using scientific method.
2. Use mathematical and graphical techniques as they apply to biochemistry.
3. Apply biochemistry concepts to real-world situations.

Learning Units
I. Investigate the properties of water and the application of aqueous solutions to biochemical systems.
   A. Compare and contrast the different types of intermolecular forces.
   B. Describe the different types of acids and bases.
   C. Cite examples of buffer systems.
   D. Calculate pH and composition of buffers using the Henderson-Hasselbach equation.
   E. Describe the effects of changes in pH on the uptake and release of O_2 and CO_2 in red blood cells.

II. Describe the structure and functions of amino acids and small peptides.
   A. Classify amino acids structures according to ionic properties and polarity.
   B. Investigate the stereochemistry of amino acids.
   C. Predict the acid-base characteristics of amino acids and peptides.
   D. Investigate the reactions and functions of small peptides and amino acids.

III. Explain aspects of protein structure.
   A. Compare and contrast the four levels of protein structure.
   B. Describe different protein purification techniques.
   C. Determine the most appropriate chromatography method for a given set of circumstances.

D. Determine the primary structure of polypeptides for a set of data.
E. Compare and contrast the different types of secondary structures.
F. Describe the structure and functions of collagen.
G. Summarize the tertiary structures of proteins.
H. Compare and contrast differences in the structures and functions of Hb and Mb.
I. Relate the quaternary structures of Hb to cooperative binding of O_2.
J. Describe the effects of bisphosphoglycerate on Hb and Mb.

IV. Examine the properties of enzymes.
A. Classify major classes of enzymes.
B. Correlate the relationship between free energy, catalysts and kinetics.
C. Interpret enzymes kinetics according to the Michaelis-Menton scheme.
D. Determine the effects of inhibitors and activators on Km and Vmax values.
E. Describe allosterism and allosteric enzymes.
F. Compare and contrast the concerted and sequential models for allosteric enzymes.
G. Describe zymogen activations.
H. Explain the difference modes of catalytic action enzymes.
I. Draw the mechanism for serine proteases.
J. Classify coenzymes.

V. Describe the structures and functions of lipids and biological membranes.
A. Compare and contrast different classes of lipids.
B. Describe the structures and properties of fatty acids.
C. Describe the structures and functions of steroids.
D. Explain the synthesis of eicosanoids.
E. List the functions of eicosanoids.
F. Compare and contrast the functions of the lipid soluble vitamins.
G. Detail the reactions of the action of vitamin A in the process of vision.
H. Describe the composition and structure of membranes.
I. Compare and contrast the methods of membrane transport.
J. Detail the action of the Na^+, K^+-ATPase.
K. Describe enzyme receptors and the action of the insulin receptor.

VI. Describe the structures and functions of carbohydrates.
A. Describe the structures of common monosaccharides and disaccharides.
B. Compare and contrast the structures and functions of polysaccharides.

VII. Relate principles of thermodynamics to biological systems.
A. Relate thermodynamic properties to equilibrium and spontaneity of chemical reactions.
B. Calculate the change in free energy for systems not at equilibrium and not at standard conditions.
C. Calculate the [ ] from equilibrium constant data (or an equilibrium constant from [ ] data).

D. Calculate the [ ] from standard reduction potentials.
E. List high energy groups utilized in metabolism.
F. Compare and contrast catabolic and anabolic pathways in metabolism.

VIII. Describe the pathways involved with carbohydrate metabolism.
A. Write the reactions of glycolysis.
B. Discuss the energetics involved with glycolysis.
C. Describe the regulation of glycolysis including activators and inhibitors of the major regulatory enzymes.
D. Write the reactions involved with glycogen metabolism.
E. Describe the control of glycogen metabolism including the effect of the c-AMP cascade.
F. Write the reactions involved with gluconeogenesis.
G. Describe how glucagon can affect the control of the reactions of glycolysis and gluconeogenesis in liver cells.
H. Describe the major products of the pentose phosphate shunt and write the overall reaction of the pathway.
I. Detail the steps involved with the reaction of pyruvate in the pyruvate dehydrogenase complex.
J. Describe the regulation of the pyruvate dehydrogenase complex including the activators and inhibitors of enzymes in the complex.
K. Write the reactions of the citric acid cycle.
L. Describe the regulation of the citric acid cycle including activators and inhibitors of the major regulatory enzymes.
M. Write the reactions involving the entry and exit of metabolites into and out of the citric acid cycle.
N. Describe the major reactions occurring in the compartments of the mitochondria.
O. Write the reactions of the electron transport system.
P. Describe the effects that un-couplers and inhibitors of oxidative. phosphorylation have on the production of ATP.
Q. Describe the chemiosmotic coupling theory and its relationship to the generation of ATP.
R. Describe how a proton gradient can be utilized by the ATPase to drive the production of ATP.
S. Write the reactions required to oxidize NADH in the cytoplasm under aerobic conditions.
T. Explain how the action of cytochrome P450 is involved with oxidation reactions occurring in the liver.

IX. Describe the processes involved in the light reactions of photosynthesis.
A. Describe the major reactions occurring in the compartments of the chloroplast.
B. Describe the photochemical pigments found in the antenna complex.
C. Explain the role of carotenoids in photo-protection for photosynthesis.
D. Explain the steps involved in the principal photochemical events in the light reactions of photosynthesis.

E. Write the products of the Z-scheme of the light reactions of photosynthesis.

X. Describe the reactions involved with lipid metabolism.
   A. Compare and contrast the types of lipoproteins.
   B. Write the reactions involved in the transport of fatty acids into the mitochondria.
   C. Write the reactions for the catabolism of saturated fatty acids.
   D. Calculate the number of ATP produced from the complete oxidation of a fatty acid.
   E. Write the reactions for the formation of ketone bodies.
   F. Write the reactions involved with transporting acetyl-SCoA from the mitochondria to the cytoplasm.
   G. Write the reactions involved with fatty acid synthesis.
   H. Describe the synthesis of the phospholipids and cholesterol.

XI. Describe reactions involved with amino acid metabolism.
   A. Describe the nitrogen cycle and the reactions of the nitrogenase complex.
   B. List the ketogenic and glycogenic amino acids.
   C. Draw the mechanism for transamination reactions.
   D. Write the overall reaction of the urea cycle.

XII. Explain aspects of the structure of nucleic acids.
   A. Compare and contrast the structures of purines and pyrimidines.
   B. Describe the structures of nucleotides and nucleosides.
   C. List Chargaff's rules as they apply to the primary structure of DNA.
   D. Describe the secondary structure of B form DNA.
   E. Compare and contrast the structures of B form DNA and Z form DNA.
   F. Describe the tertiary structures of DNA.
   G. Determine the linking number associated with a piece of DNA.

XIII. Describe the processes associated with the central dogma theory of molecular biology.
   A. Diagram the central dogma theory of molecular biology.
   B. Describe the processes required to sequence a piece of DNA.
   C. Discuss the experiments which show that replication is semiconservative.
   D. Describe the processes and reactions necessary to replicate DNA.
   E. Compare and contrast different types of mutations in DNA.
   F. Describe repair mechanisms for DNA.
   G. List the requirements for transcribing a piece of DNA.
   H. Describe the processes and reactions necessary for transcription.
   I. Discuss post-transcriptional modifications of RNA.
   J. Discuss regulation of transcription and the Lac Operon.
   K. Interpret the universal genetic code.
   L. Describe the structures of t-RNA and r-RNA.
   M. Describe the processes and reactions necessary for translation.
   N. List post-translational modifications of proteins.

Learning Activities
Learning activities will be assigned to assist the student to achieve the intended learning outcome(s) through lecture, instructor-led class discussion, guest speakers, group activities, drills/skill practice, and other activities at the discretion of the instructor. These activities may be either face-to-face or online.

Grade Determination
The student will be graded on learning activities and assessment tasks. Grade determinants may include the following: daily work, research papers, quizzes, chapter or unit tests, comprehensive examinations, projects, presentations, class participation, and other methods of evaluation at the discretion of the instructor.