The University of Jordan
School of Medicine
2017-2018

Course title: Introductory Biochemistry
Course code: 0501112
Credit hours: 2 credit hours
Calendar description: 8 weeks / Summer semester / Year 1
Course coordinator: Dr. Mamoun Ahram Dr. Nafez Abu Tarboush, and Dr. Diala Abu Hassan

Course description: This two-credit hour course is mandatory for first-year medical students. The course is designed to introduce medical students to biochemistry via covering the basic concepts of structures and functions of macromolecules, detailed information of enzymes, their mechanisms of action, regulation and their association to medicine, as well as cofactor critical for enzyme function.

Objectives (intended learning outcomes):
The overall objective is to enhance student understanding of advanced biochemistry-based medical topics to be covered in later courses.

A. Knowledge and Understanding: Student is expected to

A1- Differentiate the types and characteristics of non-covalent interactions
A2- pH and buffers : Recall the concepts of acids, bases, amphoteric molecules, and ionization of water and weak acids
A3- Apply the molecular expressions: molarity, normality, equivalence, pH, and pKa.
A4- Know the chemical concept of different types of buffers, buffering capacity, midpoint, and titration.
A5- Apply the Henderson-Hasselbalch equation and mechanisms of buffer actions.
A6- List of physiological buffers and translate knowledge in normal and abnormal condition.
A7- Review of basic organic chemistry and functional groups in biomolecules.
A8- Definition of Carbohydrates
A9- Chemistry of Carbohydrates
A10- Importance of Carbohydrates
A11- Classification of Carbohydrates (e.g. mono and disaccharides)
A12- Important disaccharides and polysaccharides
A13- Differentiate proteoglycans and glycoproteins and carbohydrates linked to blood groups.
A14- Define lipids and importance of lipids.
A15- Identify the classifications, drawing, structure, and function of lipids (fatty acids, triglycerides, waxes, phospholipids, glycolipids, and steroids.
A16- Differentiate the basic mechanism of lipid transport in blood
A17- Recall the complex structure of cell membranes
A18- Define proteins
A19- List amino acids
A20- Differentiate the structure, isomerism, classes of amino acids
A21- Identify the ionization states of amino acids
A22- Know the concept of isoelectric point

A23- List modified and specialized amino acids
A24- Recall of features of peptide bond
A25- Apply the concept isoelectric point of amino acids to polypeptides
A26- Recall the four levels of protein structure
A27- Differentiate the different secondary structures of proteins and their structural significance
A28- Understand the formation of tertiary structure of proteins
A29- Define quaternary structure
A30- Know the concept of complex protein structures (glycoproteins, lipoproteins, phosphoproteins)
A31- Apply the concepts of denaturation and renaturation to protein structure and function
A32- Apply the previous information to pathological defects in protein formation
A33- Recognize the different classes of proteins (fibrous, globular)
A34- Discuss different proteins from each class I(mainly collagen, myoglobin, and hemoglobin) in connection to their function in light of previous knowledge
A35- Define enzymes
A36- Recall the general properties and functions of enzymes, ribozymes.
A37- List the classes of enzymes and differentiate the reactions they catalyze
A38- Recall the major features of active sites
A39- Recall the concept of free energy and activation energy, transition state, abzymes.
A40- Differentiate between holoproteins and apoproteins
A41- Differentiate classes of cofactors
A42- Define and list vitamins and understands their contribution in enzymatic reaction (coenzymes)
A43- Identify the role of metals in enzyme activity of metal-activate enzymes
A44- Define enzyme kinetics
A45- Apply the concept of Vo, Vmax, and KM, and their biological significance
A46- Apply the above terms to the Michaelis-Menten equation
A47- Apply the enzyme units to understand the following terms: (rate of reaction (V_o), Vmax, specific activity, turnover number).
A48- Link the mechanisms of action of the different classes of inhibitors in relation o the Lineweaver-Burk or double-reciprocal plot
A49- Describe how enzyme activity can be regulated by physiological and pharmacological inhibitors
A50- Recall the concept of allosteric regulation
A51- Identify the role of small and large enzyme regulatory molecules
A52- Irreversible inhibition and suicide inhibition.
A53- Define the various modes of enzyme regulation.
A54- Discuss the effect of nonspecific inhibitors (temperature, pH) on protein structure and function
A55- Define isoenzymes and know their biological and clinical significance (Clinical enzymology).
A56- Application of centrifugation in cell fractionation.
A57- Principal and applications of dialysis and gel filtration chromatography.
A58- Various types of chromatography: ion exchange chromatography, affinity chromatography, HPLC.
A59- Electrophoresis and isoelectric focusing.
A60- Colorimeter.

A61- Immunological and molecular techniques.

B. Intellectual Analytical and Cognitive Skills: Student is expected to

B1- Calculate pH and changes in pH according to different variables
B2- Predict changes in blood pH according to equilibrium of bicarbonate buffering system
B3- Differentiate between the various sugar molecules, lipids, and amino acids
B4- Calculate isoelectric point of small polypeptides
B5- Predict changes in enzyme kinetics according to inhibitor type
B6- Calculate enzyme units
B7- Determine enzyme class according to catalyzed reaction and involved cofactor
B8- Turn over number and specific activity.

Methods of instructions

28 lectures

Method of evaluation

Exam I	40%
Exam II (final)	50%
Personal assessment	10%

Recommended textbooks:

Biochemistry; Mary K. Campbell and Shawn O. Farrell, Brooks Cole; 6th edition
Marks' Basic Medical Biochemistry: A Clinical Approach; Lieberman and Marks, 4th edition.

Recommended electronic web address

- NCBI Bookshelf: (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=Books)
- The Medical Biochemistry Page: (http://web.indstate.edu/thcme/mwking/home.html)
- Biochemistry, Garret and Grishan, Second Ed.: (http://web.virginia.edu/Heidi/home.htm)

Outline

No.	Topic	No. of lectures	Lecturer	Date
1.	**Introduction** 1. Common elements of the human body 2. Type and characteristics of non-covalent interactions 3. Properties of carbon 4. Properties of water 5. Functional groups	2	Ahram & Abu Hassan	27,28/ 5
2.	**Acid, base, pH, and buffer** 1. What are acids? What are bases? 2. What is an amphoteric molecule? 3. Molecular expressions: molarity, normality, equivalence (practical exercises) 4. Ionization of water and weak acids 5. pH and pKa 6. Henderson-Hasselbalch equations 7. Buffers definition, buffering capacity, midpoint, and titration 8. Calculations of pH, pKa, titration 9. Polyprotic buffers 10. Physiological buffers (bicarbonate, phosphate, and proteins)	3	Ahram & Abu Hassan	29,30/ 5 3/6
3.	**Macromolecules and carbohydrates** 1. General structure and isomerism 2. Classes of macromolecules 3. Condensation vs. hydrolysis reactions 4. Definition of carbohydrates 5. Classes of carbohydrates (mono-, di-, oligo-, and polysaccharides) 6. Monosaccharides a. Classes (based on functional groups and number of carbons) b. Structural aspects of monosaccharides (steroisomers, D- vs. L-isomers; drawing of noncyclic sugars, diastereomers, enantiomers, epimers, cyclization, drawing of cyclic sugars, anomers, hemiacetal vs. hemiketal) 7. Substituted monosaccharides (glycosides, amino sugars, sugar esters, sugar acids-oxidation, sugar alcohols-reduction, deoxy sugars) 8. Disaccharides (naming, reducing vs. nonreducing, common disaccharides) 9. Oligosaccharides (raffinose, sialic acid, uses as drugs) 10. Polysaccharides (glycogen, starch, cellulose, dextran) 11. Glycosaminoglycans (types, structures, functions) 12. Proteoglycans vs. glycoproteins 13. Blood typing	3	Ahram & Abu Hassan	4,5,6/6
4.	**Lipids**	3	Ahram	10,11,

	1. Type of lipids 2. Fatty acids a. characteristics, complex structures, naming systems) b. Types and physiological/pathological functions of arachidonate and omega fatty acids 3. Triglycerides (structure, functions) 4. Waxes (structure) 5. Phospholipids (structure, types, function) 6. Sphingolipids (structure, types, function) 7. Glycolipids (structure, types, function) 8. Steroids (structure, types, function) a. Cholesterol b. Bile acids c. Lipoproteins 9. Cell membranes a. Structure b. Components and functions c. Effect of cholesterol on membrane fluidity d. Mobility of phospholipids 10. Membrane transport 11. Vesicular transport		& Abu Hassan	12/6
5.	**Amino acids** 1. General structure and isomerism 2. Classes of amino acids (detailed description) 3. Ionization, isoelectric point 4. Modified and specialized amino acids	2	Ahram & Abu Hassan	13, 19/6
6.	**Polypeptides and protein structure** 1. Levels of protein structure 2. Primary structure a. Features of peptide bond (names of bonds, cis vs. trans, preferred orientation and angles, backbone and side chain, directionality b. The concept of protein molecular weight c. Isoelectric point of polypeptides concept and calculation) 3. Secondary structures (features of a-helices, b-strands and -sheets, turns, loops, importance of noncovalent interactions and amino acid sequences, supersecondary structure-motif) 4. Tertiary structure (depictions, importance of noncovalent interactions and disulfide bonds, concept of domains, determination of structure formation, spontaneous vs. chaperone –assisted formation) 5. Quaternary structure (naming, and formation) 6. Complex protein structures (glycoproteins, lipoproteins, phosphoproteins) 7. Denaturation and renaturation 8. Pathological defects in protein formation (Alzheimer's, prion)	2	Ahram & Abu Hassan	20, 24/6

7.	**Protein structure-function relationship (part I)** 1. What are fibrous proteins? 2. Collagen a. Function b. Overall structure c. Amino acid content d. Types 3. Elastin a. Function b. Overall structure c. Amino acid content 4. Keratin a. Function b. Overall structure c. Amino acid content	1	Ahram & Abu Hassan	25/6
8.	**Protein structure-function relationship (part II)** 1. What are globular proteins? 2. Heme 3. Myoglobin a. Function b. Tertiary structure c. Oxygen saturation curve 4. Hemoglobin a. Function b. Tertiary and quaternary structures c. Structural changes in relation to oxygen saturation curve	2	Ahram & Abu Hassan	26, 27/6
MID – TERM EXAM 30, 6, 2018 - SATURDAY				
9.	**Enzymes (introduction)** 1. General properties and function 2. Classes (examples of reactions) 3. Active sites (features) 4. Enzyme-substrate interaction	1	Ahram & Abu Tarboush	1/7
10.	**Enzymes (kinetics)** 1. Concept of free energy and activation energy 2. Enzyme kinetics 3. Hyperbolic plot (concept of V_0 and V_{max} and explanation) 4. Michaelis-Menten equation 5. Concept and biological significance of K_M 6. Enzyme units (V_{max}, turnover number, specificity constant, rate of reaction (V_0), enzyme activity, specific activity 7. The Lineweaver-Burk or double-reciprocal plot a. In relation to inhibitors (competitive, noncompetitive, uncompetitive) 8. Mechanisms of enzymatic reactions involving multiple substrates a. Inhibition of two-substrate reactions i. In relation to the Lineweaver-Burk or	3	Ahram & Abu Tarboush	2, 3, 4/7

	double-reciprocal plot			
11.	**Enzymes (mechanism of regulation)** 1. Concept of isoenzymes a. Examples: lactate dehydrogenases, hexokinase vs. glyucokinase b. Differential K_M, tissue specificity, and regulation 2. Factor of diffusion a. Compartmentalization (vesicular, and membrane-associated enzymes) b. Enzyme complexing (puruvate dehydrogenase) 3. Regulation of enzyme activity a. Inhibitors i. Physiological (trypsin inhibitor) ii. Synthetic 1. Irreversible inhibitors (methotrexate) 2. Transition-state analogs (Penicillin) 3. Suicide inhibitors 4. Allosteric regulation a. Sigmoidal plotallostric modifiers b. Modes of regulation (concerted vs. sequential) c. Example (aspartate transcarbamylase) 5. Enzyme regulatory molecules a. Small molecules (cAMP, protein kinase A) b. Large modifiers (G proteins) 6. Reversible enzyme modification a. Phosphorylation(glycogen phosphorylase) b. Others (adenylation, urydylation, riboasylation, methylation, ascetylation 7. Irreversible enzyme modification a. Zymogens 8. Modes of regulation a. Feedback regulation (inhibition and activation) b. Feed-forward regulation (activation and inhibition) c. Concepts of committed step reaction and rate limiting reaction 9. Nonspecific inhibitors (temperature, pH) 10. Enzymes in medicine a. Alanine transaminase, ALT, and aspartate aminotransferase, AST b. Isoenzymes i. lactate dehydrogenase, LDH ii. Creatine kinase, CK (also called creatine phosphokinase, CPK)	3	Ahram & Abu Tarboush	8, 9, 10/7
12.	**Enzymes (cofactors)** 1. Concepts of holoproteins vs. apoproteins 2. Classes of cofactors (metals, conenzymes, prosthetic	1	Ahram & Abu Tarboush	11/7

	groups, cosubstrates) 3. Vitamins (classes and general structures, examples of enzymes and reactions-note: reactions are relevant to metabolism) a. Vitamin C b. Vitamin B1 (pyruvate dehydrogenase, a-ketoglutate dehydrogenase) c. Vitamin B2 (flavoproteins, succinate dehydrogenase, pyruvate dehydrogenase) d. Vitamin B3 (NAD+ vs. NADH, pyruvate dehydrogenase) e. Vitamin B5 (coenzyme A, pyruvate dehydrogenase, citrate synthase) f. Vitamin B6 (aminotransferases) g. Biotin (Pyruvate caboxylase, acetyl CoA carboxylase) h. Vitamin B12 i. Folic acid (dihydrofolate reductase, link to methotrexate) 4. Lipoic acid (pyruvate dehydrogenase) 5. Metal-activate enzymes a. Metalloenzymes vs. metal-activate enzymes b. Example: alcohol dehydrogenase, carbonic anhydrase c. Enzymatic mechanism of carbonic anhydrase and enzyme activity vs. pH			
13.	**Protein analysis** 1. Salting out and in 2. Dialysis 3. Chromatography (size-exclusion, ion-exchange (relate to protein pI), affinity, centrifugation, cell fractionation 4. Electrophoresis (first- -dimensional), isoelectric focusing (second-dimensional electrophoresis 5. Immunoassays (blotting and ELISA) 6. Protein sequencing (Edman degradation, chemical and proteolytic fragmentation) 7. Structure determination (crystallography, nuclear magnetic resonance)	2	Ahram & Abu Tarboush	15, 16/7
FINAL EXAM 23/7/2018 – MONDAY				