EXAM 1 OBJECTIVES

Chapter 1 – Biomolecules

terminology:	eukaryotic cells	prokaryotic cells	organelles
nucleus	conformation	Structural complementarity	denaturation
Weak chemical forces	Supramolecular complex	Biopolymer structural polarity	Building block
Metabolism	Metabolite	Steady state	homeostasis
Enzyme	ligand	ATP	NADPH
Nucleic acids	lipids	proteins	polysaccharides
Covalent bond	van der Waals interactions	hydrogen bond	ionic bond

Understand the structural features of representative biopolymers from each of the classes: protein, carbohydrate, and nucleic acid. Know the linkages and residues. Know how to indicate structural polarity.

A. Objectives for these **functional groups:**

saturated hydrocarbon	unsaturated hydrocarbon	hydroxyl	sulfhydryl
amine	aldehyde	ketone	carboxylic acid
amide	□-ketoacid	□-ketoacid	phosphate

Is it a weak acid or weak base? Which atoms act as electrophiles or nucleophiles? Any hydrogen bonding acceptors or donors? Any resonance forms of the group? What is the geometry of the group? In which class of biochemicals is the group is commonly found?

B. Objectives for these **linkages:**

amide	hemiacetal	acetal	disulfide bond
Schiff base(aldimine)	acid anhydride	ester	thioester
phosphoester	phosphoanhydride	acyl phosphate	

Know which **two functional groups** form the linkage and the general **kind of reaction** that forms the linkage

C. Objectives for these **reaction types:**

nucleophilic substitution (condensation-hydrolysis)	oxidation-reduction
addition-elimination (hydration-dehydration)	Bronsted-Lowry acid-base

Be able to **draw structures**, or **give names**, or the **product molecules** from any of these reactions given two reacting functional groups. Know the **order of oxidation/reduction** for organic functional groups

Chapter 2 – Water **Problems 1, 3, 6**

terminology:	Hydration shell	Clathrate	Hydrophobic interaction
Amphipathic	Amphiphilic	Micelle	Osmotic pressure
Hydronium ion	Hydrogen ion	Hydroxide ion	pH
Electrolyte, strong or weak	Conjugate acid-base	K_a	Phosphate system

Given the pKa of an acid-base equilibrium and the pH of its' solution, determine the fractions of the two conjugate forms.

Given the pKa of an acid-base equilibrium, the desired pH for a buffer solution, and the desired concentration, determine the concentrations of the two conjugate forms needed.

Convert between pH and $[H^+]$; pK_a and K_a.

Chapter 3 – Energy **Problems 1, 3, 6, 10**

terminology:	Thermodynamics	calorie	joule
enthalpy	entropy	Gibbs free energy	exergonic
endergonic	standard state	coupled process	reduced coenzymes
high-energy phosphates	high-energy thioesters		

A) In terms of free energy, what is the difference between an exergonic process and an endergonic process? What is meant by coupling of reactions? What is the difference between a reversible reaction and an irreversible reaction in terms of free energy?

B) Be able to use standard free energy changes of reactions in these processes to calculate free energies of individual reactions, coupled reactions, overall processes, and/or energy storage efficiency.

C) Know the difference between standard state reactions and nonstandard reactions and the affect of [product]/[reactant] on ΔG.

D) Understand a reaction free energy diagram and the different energy level positions for endergonic, exergonic, reversible and irreversible reactions.

EXAM 2 OBJECTIVES

Chapter 4, 5 -Peptides and Proteins

terminology:	zwitterion	peptide bond	polypeptide	asymmetric
chiral	enantiomers	optical activity	Amide plane	Amino acid residue
Oligopeptide	Monomeric	Multimeric	Fibrous protein	Globular protein
Membrane protein	Primary structure	Secondary structure	Tertiary structure	Quaternary structure
Conformation	□-helix	□-pleated sheet	□-turn	

A. Know how to indicate protein amino acid sequence direction and know the three letter abbreviations for amino acid residues. Be able to tell a D vs L amino acid from a Fischer projection. Know the amino acid classification by side group property.

B. Be able to list an amino acid sequence for a peptide when given the side group properties needed at each residue. For example, what peptide sequence would have the following properties?
- •has an acidic aa C terminus
- •has a basic aa N terminus and at #8
- •has an aromatic aa at #3
- •disulfide bond #2 to #6
- •hydrophobics at #5, #7 and #9 (large groups at #7, #9)
- •polar, non-ionizing aa at #4

C. Give a pair of amino acids as a specific example for these molecular interactions: hydrogen bonding, hydrophobic and ion-ion attractions.

D. Know the acid/base behavior of ionizing groups. Given a pH and pK for a group, know the percentage ionized.

E. Know the amino acids having side groups that can function as general acid or base catalysts (Bronsted acids/bases;pK_a's). Know the amino acids having side groups that act as nucleophiles.

Chapter 8, 25 - Nucleic Acids and Protein Synthesis

terminology:	Nucleotide	Nucleic acid	DNA
RNA	Pyrimidine	Purine	Adenine
Guanine	Cytosine	Uracil	Thymine
Keto-enol tautomer	Pentose	Furanose	Nucleoside
Glycosidic bond	Phosphate group transfer	Pyrophosphate group transfer	Phosphoester linkage
Transcription	Aminoacyl-tRNA	Aminoacyl-tRNA synthetase	Codon
Anticodon loop	Translation	Ribosome	Initiation
Elongation	A site	P site	Termination

A. Understand the abbreviations for nucleotides. Know how to indicate nucleic acid base sequence. Understand the sequence direction of complementary nucleic acid strands.

B. Know the functions of rRNA, mRNA and tRNA.

C. Understand the structural relationships between DNA, mRNA and protein primary structure.

Chapter 5, 10, 11, 14 – Enzymes

terminology:	Conjugated protein	Prosthetic group	Glycoprotein	Lipoprotein
Nucleoprotein	Phosphoprotein	Metalloprotein	Hemoprotein	Flavoprotein
Regulatory protein	Transport protein	Storage protein	Structural protein	Protective protein
Catalytic power	Specificity	Regulation	Active site	Cofactor
Coenzyme	Holoenzyme	Apoenzyme	Structural analog	Lock and key
Induced fit	Covalent modification	Converter enzyme	Allosteric regulation	Effector
Proenzyme	Transition state	Enzyme-substrate complex	Transition state analog	Covalent catalysis
Acid-base catalysis	Metal ion catalysis	Vitamin		

A. Understand a reaction free energy diagram and how to interpret activation energy and transition state. Understand how a catalyst works with respect to this diagram. Calculate relative increase in reaction velocity from a lowering of E_a and vice versa.

B. Be able to explain the binding characteristics between an enzyme and each the following: substrate, coenzyme, activator, competitive inhibitor, non-competitive inhibitor, uncompetitive inhibitor.

C. Know the relationship between vitamins and coenzymes and why vitamins are needed for normal cell function.

D. Know the types of enzymes that typically utilize the following coenzymes: **TPP, FAD, NAD^+, NADPH, PLP, CoASH, biotin, and ATP**.

E. Be able to provide examples or recognize examples of the types of reactions catalyzed by dehydrogenases, reductases, kinases, aminotransferases, thiolases, hydrolases, synthases, carboxylases, decarboxylases, hydratases, dehydratases, isomerases, mutases, polymerases, and synthetases.

Chapter 7 – Carbohydrates

terminology:	Glycoconjugate	Aldose	Ketose	Chiral center
Fischer projection	Hemiacetal	Hemiketal	Pyranose	Furanose
Anomer	Anomeric carbon	Haworth projection	Aldonic acid	Reducing sugar
Alditol	Deoxy sugar	Acetal	Ketal	Glycoside
Reducing end	Nonreducing end	Starch	Glycogen	cellulose
Chitin	Glycosaminoglycan	chondroitin		

A. Be able to interconvert Fischer and Haworth projections of any monosaccharide. Be able to recognize and/or give examples of structural isomers, stereoisomers, enantiomers, diastereomers, epimers and anomers.

B. Know how to name linkages and residues in oligosaccharides.

C. Know the structures of glyceraldehyde, ribose, xylose, ribulose, glucose, mannose, galactose and fructose.

EXAM 3 OBJECTIVES

Chapter 14, 15, 19 - Metabolism Introduction & Carbohydrate Metabolism

For all pathways discussed in class, you should be able to:

- Recognize the structures and names of substrates and products in all enzyme catalyzed reactions.
- Indicate the name of any enzyme catalysts and cofactors for any specific reaction. Know the general reaction type. Understand the general enzyme mechanisms and intermediate structures for those specific reactions discussed in class.
- Understand the free energy considerations (production and use of ATP) and oxidation-reduction considerations (the general flow of electrons ($H\cdot$, $H:^-$, or e^-)) for each pathway.
- You should understand the basic principles of regulation for each pathway.

A. Understand the general features of catabolic and anabolic pathways in metabolism.

B. Know which pathways are the primary sources of ATP, NADH, NADPH, acetyl-CoA, □-ketoacid intermediates, and nucleotide biosynthesis precursors.

C. Know the names and structures of the important intermediates that directly link these pathways.

terminology:	anabolic pathway	catabolic pathway	redox coenzymes	ATP cycle
reciprocal regulation	covalent regulation	insulin	glucagon	epinephrine
gluconeogenesis	glycogenesis	glycogenolysis	glycolysis	pentose phosphate pathway
Cori cycle	oxidative phosphorylation	substrate-level phosphorylation	energy transduction	fermentation

Pathways:

Glycogen Metabolism
- A. Glycogenolysis
  - 1. Glycogen phosphorylase - covalent regulation
- B. Glycogenesis
  - 1. Glycogen synthase - covalent regulation
- C. Hormones

Glycolysis
- A. Kinases, substrate level phosphorylation
  - 1. Irreversible reactions
  - 2. Regulation
- B. Aldolase mechanism
- C. Glyceraldehyde-3-phosphate dehydrogenase mechanism
- D. Overall reaction

Gluconeogenesis

A. Bypassing the irreversible reactions of glycolysis
B. Pyruvate carboxylase and PEP carboxykinase mechanisms
C. Phosphatases and their regulation

Pentose Phosphate Pathway

A. Oxidative phase
B. Non-oxidative phase
    1. Transketolase mechanism
    2. Transaldolase mechanism
C. Overall reaction
D. Integration of glucose metabolism pathways

Chapter 6 - Lipids, Membranes & Transport

terminology:	active transport	acyl group	carotenoid	essential fatty acid
facilitated diffusion	fluid mosaic model	glycolipid	high-density lipoprotein	low-density lipoprotein
isoprene	lipid bilayer	saturated	monounsaturated	polyunsaturated
membrane potential	passive transport	terpene	acylglycerol phosphate	triacylglycerol
phospholipid	sphingolipid	steroid	concentration gradient	integral protein

A. Be able to describe and/or draw representative structures of triacylglycerols, acylglycerol phosphates, terpenes, steroid rings, HDLs and LDLs.

B. Know the primary components and general features of cell membranes.

C. Understand the terminology for the different types of membrane transport. (passive: mediated or nonmediated – active: primary, secondary, uniport, symport, antiport, electrogenic, electroneutral)

D. Understand the equation for free energy change of solute transport.

EXAM 4 OBJECTIVES

Chapter 20 - Lipid Metabolism

terminology:	adipocytes	hormone-sensitive lipase	fatty acid synthase
carnitine	acyl group	acetyl group	enoyl group
□-hydroxyacyl group	□-ketoacyl group	acyl carrier protein	malonyl group

Pathways:

□-Oxidation
- A. Acyl-CoA synthetase mechanism
- B. Reactions of the 2 carbon cycle
- C. Overall reaction

Palmitic Acid Biosynthesis
- A. Reactions of the 2 carbon cycle
- B. Contrast to oxidative pathway

Chapter 16 - Citric Acid Cycle
Chapter 17 - Electron Transport and Oxidative Phosphorylation

terminology:	aerobic pathway	multienzyme complex	electron transport chain
oxidative phosphorylation	mitochondria	membrane multi-enzyme system	oxidative decarboxylation
chemiosmotic coupling	concentration gradient	membrane electrical potential	ATP-ADP translocase

Pathways:

Pyruvate Dehydrogenase Complex
- A. Enzyme Complexes
  - 1. Enzymes
  - 2. Coenzymes
- B. Overall reaction

Citric Acid Cycle
- A. Citrate synthase mechanism
- B. Isocitrate dehydrogenase mechanism
- C. Reactions of cycle
- D. Overall reaction, oxidative phosphorylation

Mitochondrial Electron Transport Chain
- A. Enzyme complexes
- B. Electron carriers; electron flow
- C. Proton gradient generation; proton flow
- D. Free energy of proton transport
- E. ATP synthase

A. Know the overall redox reactions of the ETC that correspond to each of the four enzyme complexes and the electron carriers involved.
B. Understand the terms in the free energy equation for transport of protons across a membrane. Be able to do the calculation.

Chapter 21 - Amino Acid and Nucleotide Metabolism

terminology:	branched chain amino acid	deamination	essential amino acid
nonessential amino acid	nucleoside	purine	pyrimidine
transamination	glucogenic	ketogenic	urea cycle

Pathways:
Amino Acid Catabolism Nonessential Amino Acid Biosynthesis
Purine and Pyrimidine Ring Biosynthesis Urea Cycle - Reactions of cycle

Understand the general flow of nitrogen in animal amino acid catabolism and anabolism. Know the importance of aminotransferase reactions in amino acid biosynthesis and catabolism. Know the importance of glutamate, glutamine, aspartate and alanine in these processes. Be able to supply structures for products of decarboxylation, aminotransferase, and oxidative deamination reactions on amino acids.