Study Guide for Final Exam – All Chapters

*NOTE: This is just a guide. It is not a comprehensive list of what may be on the test.

*Studying tips: For every test, including lab tests and the final exam, you should start studying early. If you start studying one or two days before a test, you will feel overwhelmed and you will be under too much stress. Study every day using your textbook, class notes and any other resources available. *** Study the figures and tables discussed in class as well as those that have not been discussed in detail as they might help you understand the concepts. Study with a friend and quiz each other. It is essential for you to be able to recognize, understand and apply the concepts, and use scientific vocabulary learned in class.

** As stated in the Course Syllabus for BIOL 1406, it takes approximately 2-3 hours of study time for each hour of class time to master the material. This means that with 96 contact hours, the class and study time necessary to succeed in this class is close to 300 hours (close to 20 hours per week). If you have been devoting sufficient time to study for this class, and following the guidelines in the Course Syllabus, you just need to carefully review the material for the final exam. Contact your instructor early if you have any questions or doubts about the material; avoid leaving any questions or doubts for the last minute as your instructor may not be able to reply to you immediately— instructors have other classes and commitments.

** To prepare even better for the final exam, you should also use the Study Guides for previous tests, focusing on the topics described below.

*** FINAL EXAM INFORMATION:
- Date, time, and place: SEE YOUR COURSE SYLLABUS – Your instructor will remind you about this date.
- Exam contents: The final exam is comprehensive (cumulative); it covers material from the entire course; all the chapters and topics covered during the whole term. All or part of the final exam may be departmental.
- Exam format: * 100 multiple choice questions. * This may vary according to the Life Sciences Department.
- The Final Exam is 20% of your final grade in the course. See the Course Syllabus for details.

CHAPTER 1: Introduction: Themes in the Study of Life
1. Levels of biological organization of life (hierarchical organization): atom, molecule, etc.
2. Characteristics of living things, or properties of life: organization, response to environment, etc.
3. Binomial nomenclature system
4. Linnaean taxa or categories for the classification of organisms (domain, kingdom, phylum, etc.)
5. Three domains for classification of organisms
6. Six kingdoms for classification of organisms
7. Scientific method and its four general steps or operations in the correct order
8. Experimental design: independent variable, dependent variable, experimental group, control group

CHAPTER 2: The Chemical Context of Life
1. Most common (major) elements or atoms found in living things
2. Structure of atoms and how they interact: electrons, protons, neutrons, electron shells, etc.
3. Atomic number, mass number, atomic mass
4. Understand the Periodic Table of Elements
5. Ions, molecules and compounds
6. Main types of chemical bonds: covalent bonds, ionic bonds, hydrogen bonds

CHAPTER 3: Water and the Fitness of the Environment
1. Chemical structure and properties of water
2. Terms: solution, solvent, solute, hydrophilic, hydrophobic
3. Acids and bases: definition, relationship with the concentration of the hydrogen ion (H⁺), etc.
4. The pH scale: acidic pH, neutral pH, basic (alkaline) pH, buffers, etc.
CHAPTER 4: Carbon and the Molecular Diversity of Life

1. Inorganic versus organic molecules or compounds
2. Structure of carbon and its importance as the backbone of biological molecules
3. Chemical functional groups—hydroxyl, carbonyl, carboxyl, amino, sulfhydryl, phosphate; in what molecules are they present (for example, hydroxyl is found in sugars and some amino acids)

CHAPTER 5: The Structure and Function of Large Biological Molecules (Macromolecules)

1. Four main classes of biological (organic) molecules: carbohydrates, lipids, proteins, and nucleic acids.
   - Understand their basic structure (such as subunits that form them), main function(s) and properties, and main types or examples. *** Refer to the Study Guide for this chapter for details. Here are a few points to remember, but please, do not limit your study to these subtopics, remember that this is just a study guide and is not intended to mimic the actual exam.
     ✓ Carbohydrates: classified as monosaccharides, disaccharides or polysaccharides; provide energy and structure; include simple sugars (such as glucose and lactose), starch, etc.
     ✓ Lipids: are hydrophobic; consist mainly of hydrocarbons, fatty acids and glycerol; include fats, oils, phospholipids, steroids, waxes, some vitamins, etc.
     ✓ Proteins: formed by amino acids; include enzymes, structural proteins, transport proteins, defense proteins, etc.; levels of protein structure are primary structure, secondary structure, tertiary structure, quaternary structure.
       ➢ Structure of an amino acid
     ✓ Nucleic acids: formed by nucleotides; store and transmit genetic (hereditary) information; include DNA and RNA, etc.
       ➢ Structure of a nucleotide

CHAPTER 6: A Tour of the Cell

1. Common features of all cells (order, evolution, metabolism, etc.)
2. Microscopy
   a. Wavelength, magnification, resolution, and contrast
   b. Compound light microscope versus the electron microscope
3. Prokaryotic versus eukaryotic cells or organisms – their main characteristics; understand the differences between them
4. Cellular structures and organelles – understand their main function(s) and characteristics (as discussed), focusing on the following:
   - Plasma membrane, cytoplasm and cytosol, nucleus, ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes, vacuoles, mitochondria, chloroplasts, cytoskeleton, cilia and flagella, cell wall
5. Plant cell versus animal cell – understand their similarities and differences

CHAPTER 7: Cell Membrane Structure and Function

1. Structure, main characteristics and functions of the plasma membrane: fluid mosaic model that describes the structure of the plasma membrane (phospholipid bilayer with hydrophilic heads and hydrophobic tails, integral and peripheral proteins, carbohydrates, etc.), fluidity, selective permeability, etc.
2. Functions of integral and peripheral membrane proteins: transporter proteins, receptor proteins, etc.
4. Tonicity: isotonic, hypotonic, hypertonic
5. Active transport
6. Bulk transport in vesicles: endocytosis and exocytosis
CHAPTER 8: An Introduction to Metabolism
1. Metabolism, catabolism, and anabolism.
2. Forms of energy.
3. Exergonic reactions and endergonic reactions.
4. ATP: its structure and importance, how it couples anabolic and catabolic pathways in metabolism.
5. Enzymes: definition; properties (characteristics); activation energy; sequential steps in the mechanism of action of enzymes (how they work); factors that affect and regulate enzyme activity and how they affect it (temperature, pH, cofactors, enzyme concentration, substrate concentration, inhibitors), etc.

CHAPTER 9: Cellular Respiration: Harvesting Chemical Energy
1. Scientific definition of cellular respiration
2. Chemical equation that summarized cellular respiration
3. Oxidation and reduction reactions
4. Stages of aerobic cellular respiration: what region of the cell does each stage occurs (cytoplasm or mitochondrion); overall reactions or events in each stage as studied in class; reactants (initial molecules, or “input”) and products (final molecules, or “output”); essential coenzymes; amount of ATP produced in each stage(s).
   a. Glycolysis
   b. Acetyl CoA formation (Prep reaction)
   c. Citric acid cycle (Krebs cycle)
   d. Oxidative phosphorylation: Electron transport chain and chemiosmosis (ATP synthesis)
5. Fermentation: definition; two types

CHAPTER 10: Photosynthesis
1. Scientific definition of photosynthesis.
2. Photosynthetic organisms
3. Structure of chloroplasts
4. Photosynthetic pigments and their role (function)
5. Chemical equation that summarizes photosynthesis
6. Two major stages of photosynthesis: light reactions and Calvin cycle (light-independent reactions)
   • Main function or purpose of each stage and where in the chloroplast do they occur
   • Summary of major events or reactions in both stages
      ✓ Light reactions – (a) photosystem II generates ATP, (b) photosystem I generates NADPH, (c) splitting water maintains the flow of electrons through photosystems.
      ✓ Calvin cycle (light-independent reactions) – (a) carbon fixation (CO₂ uptake), (b) synthesis of G3P (CO₂ reduction), (c) regeneration of RuBP (the CO₂ acceptor).
7. Relationship between the light-dependent and light-independent reactions
8. Relationship between photosynthesis and cellular respiration; be able to compare them

CHAPTER 11: Cell Communication
1. Cell communication by direct contact: cell junctions, cell-to-cell recognition
2. Cell communication by indirect contact through messenger molecules: paracrine signaling (local regulators), synaptic signaling (neurotransmitters), endocrine signaling (hormones)
3. Three stages of cell signaling: reception, transduction, and response
4. Phosphorylation and dephosphorylation and the two protein enzymes involved (kinases and phosphatases)
5. Second messengers in transduction: cAMP (cyclic AMP) and calcium ions (Ca²⁺).
CHAPTER 12: The Cell Cycle

1. Basic terms studied in class, for example: chromosome, chromatin, mitotic spindle, etc.
2. Major stages or phases of the eukaryotic cell cycle and main activities or events in each phase:
   a. Interphase: G_1 phase; S phase; G_2 phase.
   b. Mitotic (M) phase: Mitosis and cytokinesis
      1) Mitosis: General definition or description; phases—prophase, prometaphase, metaphase, anaphase, and telophase—and the summarized major events in each of these phases.
      2) Cytokinesis: Description; difference between animal cells and plant cells
3. Prokaryotic cell division: binary fission
4. Regulation of the eukaryotic cell cycle: key regulatory molecules, checkpoints, apoptosis
5. Cancer: characteristics of cancer cells, proto-oncogenes, tumor-suppressor genes, carcinogenesis

CHAPTER 13: Meiosis and Sexual Life Cycles

1. Basic terms, for example: sister chromatids, somatic cells, haploid, diploid, gametes, etc.
2. General definition or description of meiosis
3. Phases and final results of meiosis: general understanding of the major events of each phase
   a. Meiosis I: prophase I, metaphase I, anaphase I, telophase I, and cytokinesis
   b. Meiosis II: prophase II, metaphase II, anaphase II, telophase II, and cytokinesis
4. Main differences between mitosis and meiosis: cells in which they occur; final chromosome number, number of daughter cells produced, events that are unique in meiosis, etc.

CHAPTER 14: Mendel and the Gene Idea

1. Terms, for example: gene, haploid, diploid, genotype, phenotype, allele, locus, homozygous, heterozygous, dominant allele, recessive allele, etc.
2. Mendel’s model of inheritance: his experimental results, his laws of inheritance—segregation and independent assortment
3. Solving genetics problems for crosses involving one trait and two traits
4. Incomplete dominance: offspring with intermediate phenotype
5. Codominance and multiple alleles: ABO blood groups
6. Other patterns of inheritance: pleiotropy, epistasis, polygenic inheritance
7. Pedigree analysis
8. Dominantly inherited disorder versus recessively inherited disorder

CHAPTER 15: The Chromosomal Basis of Inheritance

1. Sex-linked (X-linked) genes and X-Y system in humans
2. Linked genes and genetic recombination
3. Alterations of chromosome number or structure:
   a. Changes in chromosome number: polyploidy, aneuploidy (monosomy, trisomy)
   b. Alterations of chromosome structure: deletion, duplication, inversion, translocation
CHAPTER 16: The Molecular Basis of Inheritance (DNA Structure and Function)

1. Nucleic acids: DNA and RNA: structure, function, and basic properties of each one; similarities and differences between DNA and RNA
2. Flow of genetic information: relationship between DNA, RNA, and protein
3. Bacterial transformation and results of Griffith’s experiments
4. Watson and Crick’s model for the structure of the DNA molecule—the double helix: two strands of nucleotides, sugar-phosphate backbone, four complementary nitrogenous bases, hydrogen bonds, etc.
5. Three stages of DNA replication—unwinding, complementary base pairing (elongation) and joining—main events of each stage, main enzymes, RNA primer, leading strand, lagging strand, Okazaki fragments, complementary base pairing (A-T, G-C), the 5’→3’ direction of synthesis, etc.

CHAPTER 17: From Gene to Protein (Gene Expression)

1. Three basic stages of the flow of genetic information in a cell in order to translate it into specific proteins: DNA replication, transcription and translation: DNA → mRNA → proteins
2. Three main types of RNA and their functions
3. Terms, for example: RNA polymerase, promoter, codon, anticodon, etc.
4. The genetic code: 64 codons, start codon, stop codons, redundancy, universality, using the code, etc.
5. Transcription: process as a whole, its purpose and results, main events of it—initiation, elongation, and termination; components and their roles, for example: the promoter, RNA polymerase, terminator.
6. Translation: process as a whole, its purpose and results, main events of it—initiation, elongation, termination; components and molecules involved and their roles, for example: tRNA, mRNA, start codon, ribosome, A site, P site, E site, amino acids, peptide bond, polypeptide, stop codon
7. Comparison of transcription in prokaryotes versus transcription in eukaryotes
8. RNA processing: introns and exons; addition of 5’ cap and poly-A tail
9. Mutations: base-pair mutation, frameshift mutation, etc.

CHAPTER 18: Regulation of Gene Expression

1. Gene expression is often regulated during transcription, but control at other levels is also important.
2. Regulation of gene expression in bacteria (prokaryotes):
   a. Metabolic control on two levels: regulating enzyme activity (feedback inhibition) or the expression of genes coding for enzymes (regulation of enzyme production).
   b. Repression and induction
   c. Operon model: regulator gene, promoter, operator, structural genes, repressible operon (example: trp operon), inducible operon (example: lac operon). *** Study the figures.
3. Regulation of gene expression in eukaryotes:
   a. Cell differentiation by differential gene expression
   b. Key stages at which eukaryotic gene expression may be regulated: * Study the examples and figures and have a general understanding of these stages.
      1) Chromatin modification = regulation of chromatin structure: histone modifications (histone acetylation), DNA methylation
      2) Transcription initiation: transcription factors, DNA control elements, enhancer, promoter.
      3) RNA processing: RNA splicing (removal of introns), addition of the 5’ cap and poly-A tail.
      4) mRNA degradation
      5) Translation: regulation of initiation proteins
      6) Post-translational protein processing and protein degradation: proteolytic processing, chemical modification (by kinases and phosphatases), protein degradation in proteasomes.
4. Cancer:
   b. Genetic changes that can turn proto-oncogenes into oncogenes: translocation or transposition, gene amplification, point mutation
CHAPTER 19: Viruses

1. Scientific definition of a virus
2. Are viruses living organisms? When are viruses considered alive and why? When are they considered non-living and why not?
3. General characteristics of viruses: size, structural characteristics, host range, specificity, etc.
4. Structure of a typical virus: DNA or RNA, capsid, envelope, spikes
5. Morphological types or shapes of viruses: helical, polyhedral, complex
6. Two mechanisms of multiplication (reproduction) of viruses: lytic cycle and lysogenic cycle
7. Stages of viral multiplication of bacteriophage: attachment, penetration (entry), biosynthesis, maturation (assembly), release
8. Multiplication of animal viruses:
   a. Stages of viral multiplication: attachment, penetration, uncoating, biosynthesis, maturation, release
   b. Multiplication of retroviruses (such as HIV): use enzyme reverse transcriptase to copy their RNA genome into DNA (the opposite of the usual direction), which can be integrated into the host genome.
9. Some viruses and the human diseases that they cause: Rhinovirus, Hepatitis B Virus, Herpes Simplex Virus 1, Herpes Simplex Virus 2, HIV (Human Immunodeficiency Virus)
10. Emerging viruses: Ebola virus, HIV, H1N1 Influenza A virus, H5N1 avian flu virus
11. What are viroids?
12. What are prions and what general disease do they cause?

CHAPTER 20: Biotechnology

1. Terms: biotechnology, genetic engineering, recombinant DNA, cloning, genetically modified organism (GMO, or transgenic organism), restriction enzymes, vectors, plasmids
2. PCR (Polymerase Chain Reaction): its purpose and its three stages or steps in the correct order: denaturation, annealing, and extension (you don’t need to describe the stages)
3. Gel electrophoresis: its purpose; interpreting the results (the band patterns on a gel)
4. DNA sequencing
5. What is the Human Genome Project and what is its significance?
6. What is gene therapy?
7. Major ethical and safety issues surrounding modern biotechnology and genetic engineering
8. Remember the following applications of genetic engineering:
   a. Agriculture/food industry: climate and disease resistance in plants, etc.
   b. Environment: recombinant bacteria that clean up toxic wastes (such as an oil spill), etc.
   c. Medicine/pharmaceutical products: gene therapy, antibiotics, antibodies, hormones, vaccines
   d. Genomics/research: study of genomes, Human Genome Project, etc.
   e. Forensic science and criminology: identification of dead persons and criminals
   f. Paternity or relationship tests

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