This study guide is intended to provide you with a basic outline of exam content, help you organize the material, and direct you to the most important concepts. Take your time to fill out this guide referring to your textbook, handouts, classmates and myself as necessary. You will do very well on the exam if you successfully complete this study guide and can apply the concepts it outlines. Best of luck!

**Chapter 1: Introduction to Life Science**

- **Scientific Method:**
  1. Observation:
     a. How observations made
     b. Describe the role of observation in the scientific method
     c. How does an observation differ from a hypothesis
     d. Be prepared to provide an example of an observation
  
  2. Questioning and Hypothesis formation:
     a. Define hypothesis
     b. Describe the characteristics of a good hypothesis
     c. Be prepared to provide an example of a hypothesis
  
  3. Data Collection:

  4. Experimentation:
     a. Variable:
        - dependent variable:
        - independent variable:
        b. Experimental group:
     c. Control Group:
     d. Reductionism:
     e. Validity:
        - peer review
     f. Be able to identify the previous concepts from an example experiment

  4. Conclusions, Theories, Laws
     a. Inductive reasoning
     b. Deductive reasoning
     c. How does a hypothesis differ from a theory or a law

  5. Communication
1. Characteristics of Living Things:
   • Define, describe, provide examples each of the following:
     • Cells are fundamental structural units of living things (Cell Theory)
       a. Unique structural organization
       b. Metabolic processes
       c. Generative processes
       d. Responsive processes
         • Adaptations
         • Evolutions
       e. Control process
         • Homeostasis
       f. Emergent properties

2. Levels of Organization of Life
   • Define, arrange, provide examples of each of the following:
     a. Atoms:
     b. Molecules:
     c. Organelles:
     d. Cells:
     e. Tissues:
     f. Organs:
     g. Organ systems:
     h. Organism:
     i. Population
     j. Community
     k. Ecosystem:
     l. Biosphere

Chapter 2: The Basics of Life Chemistry

1. Matter:
   a. Define matter:
   b. Mass of matter is measured in grams (g)

2. Energy:
   a. Potential energy: stored energy, available to do work
   b. Kinetic energy: energy of motion
   c. Five forms of energy:
      1. Mechanical energy: energy of movement
      2. Nuclear energy: energy from reactions involving atomic nuclei
      3. Electrical energy: flow of charged particles
      4. Radiant energy: energy in heat, light, x-rays and microwaves
      5. Chemical energy: energy in chemical bonds
   d. Law of Conservation of Energy:
      • Be prepared to describe how this law applies to biology
3. The Nature of Matter
   a. Atoms:
   b. Elements: chemical substances composed of the same kind of atoms, atoms with the same numbers of protons and electrons

4. Atomic Structure:
   a. Protons:
      • Charge:
      • Location in atom:
      • Atomic number:
      • Atomic mass:
   b. Neutrons:
      • Charge:
      • Location in atom:
   c. Electrons:
      • Charge:
      • Location in atom:

5. Isotope:
   • How do isotopes of the same element differ from each other

6. Ions:
   • Cation:
   • Anion:
      • Be prepared to calculate the charge of an ion
      • Determine if an atom will be an anion, cation given the numbers of protons, neutrons, and electrons and electronegativity

7. Valence:
   • Octet Rule:
      • Be prepared to complete a chart similar to 2.2 using the periodic table

9. Electronegativity:
   • Use trend in periodic table to compare electronegativity

10. Oxidation/Reduction:
    • Differentiate Oxidation/Reduction
       • LEO says GER describes Oxidation/Reduction
    • Redox Reactions are very important in biological processes
    • Which reactant is oxidized/reduced in Cellular Respiration/Photosynthesis

11. Chemical Bonds
    • Making/breaking of chemical bonds
    • Be prepared to use molecular formulas and chemical equations
12. Bonding of Atoms:
   A. Covalent Bonds:
      • Definition of covalent bond
      • Covalent bonds are the strongest most stable chemical bond
      • Determine how many covalent bonds relevant elements will make
      • Multiple bonds between atoms (double and triple bonds)
      • Polar covalent bonds
      • Nonpolar covalent bonds
   
   B. Ionic Bonds:
      • Understand the ionic molecules NaCl and MgCl₂
      • Which atom is the cation, which atom is the anion
      • What are the charges on each
      • Dissociate in H₂O
   
   C. Hydrogen Bonds:
      • Formed between molecules
      • Formed by molecules containing polar covalent hydrogen bonds
      • (H-O, H-N)

13. Unique properties of H₂O
   • Polar
   • Cohesion
   • Adhesion
   • High specific heat
   • High heat of vaporization
   • Solid less dense than liquid
   • Good solvent
   • Ionization of water:
      • Hydrogen ion (H⁺)
      • Hydroxide ion (OH⁻)
      • Hydronium ion (H₃O⁺)

14. Mixtures and Solutions
   • Mixture: matter that contains two or more substances
   • Homogeneous mixture:
   • Heterogeneous mixture:
15. Solutions
   • Homogeneous mixture of ions or molecules of two or more substances
   • Two parts of a solution:
     1. The solvent:
     2. The solutes:
       • Aqueous solutions: water is the solvent
       • Concentrations of solutions - (M) = Amount of solute / Liters of solution
         • Be prepared to calculate concentration (M) given grams of solute and volume of solution

16. Chemical Reactions:
   • Define/describe the following 5 types of reactions
   • Be prepared to identify the type of reaction by the products and reactants
     3. Hydrolysis Rxn.
     4. Phosphorylation Rxn.
     5. Acid–base Rxn.

17. Acids/ Bases
   • Acid: a chemical that releases H+ ions
   • Base: a chemical that accepts H+ ions, or releases hydroxide (\(\cdot\)OH) ions
   • Salt:
   • Buffer: a chemical that resists a change in pH
   • Be prepared to identify a compound as an acid or base (see table 2.3)
   • \(\text{pH} = -\log[H^+]\)
   • Be prepared to use the pH scale to describe acidity/basicity (alkalinity)
   • Be prepared to calculate a pH value given \([H^+]\)
   • Be prepared to describe why pH drops as solutions become more acidic
   • Acid (AH)/Base (BOH) Reactions: produce a salt (AB) and water

\[
\text{AH} + \text{BOH} \rightarrow \text{AB} + \text{H}_2\text{O}
\]
Chapter 3: Organic Molecules

1. Define organic molecules:

2. List the 4 classes of organic (biological) molecules:
   1.
   2.
   3.
   4.

3. Composition of organic molecules:
   1. Carbon skeleton
      • Covalently bonded
      • Every carbon needs 4 bonds
   2. Functional groups
      • Be prepared to identify the functional groups within the 4 classes of biomolecules (Fig. 3.7)

A. Carbohydrates (Saccharides, Sugars)
   1. Structure:
      • Elements carbohydrates are composed of
      • Exist in straight chains or cyclic conformations
      • Numbering the carbons of Ribose (Ribose vs. 2' Deoxribose)
   2. Carbohydrate Classification:
      A. Monosaccharides:
         a. Structure:
            • $C_nH_{2n}O_n$
            • Isomers differ in their stereochemistry (3D shape)
         b. Functions:
            • Directly oxidized for energy
      B. Disaccharides:
         a. Structure:
            • Hydrolyzed into two monosaccharides
         b. Functions:
            • Sucrose hydrolyzed to release glucose and fructose
C. Polysaccharides
   a. Structure:
      • Hydrolyzed into many monosaccharides
      • Glycogen, starches, fibers
   b. Functions:
      1. Structural molecules
         • Cellulose
         • Chitin
      2. Signaling molecules
         • Red blood cells
      3. Energy storage
         • Glycogen

B. Lipids (Fats)
   1. Structure:
      • Elements lipids are composed of:
         • Lower proportion of oxygen compared to carbohydrates, higher proportions of hydrogen compared to carbohydrates
      • Lipids are composed of 2 parts:
         Part 1: Fatty acids
         Part 2: A Glycerol
   A. Fatty Acids:
      • Hydrocarbon chain with carboxyl group at one end
      • Fatty acids are polar molecules
      • Be prepared to differentiate saturated and unsaturated fatty acids
   B. Glycerol
      • 3-carbon chain with 3 hydroxyl groups
      • Binds fatty acids through three individual dehydration reactions
   C. Phospholipids:
      • One fatty acid of a lipid is replaced with a phosphate group
      • A very polar molecule with a hydrophilic head and hydrophobic tails (amphiphilic)
   2. Functions:
      A. Make up cell membranes
         • Phospholipid bilayer:
         • Cholesterol:
         • Fluid Mosaic Model:
      B. Store Energy
         • Store more energy than carbohydrates, why?
      C. Signaling molecules
         • Steroids
C. Proteins

1. Structure:
   • Amino acids are the building blocks of:
   • Each amino acid is composed of 4 parts attached to a central carbon:
     1. Amine Group
     2. Carboxylic Acid Group
     3. Side Chain (R group)
     4. Hydrogen
   • Describe the importance of the side chains (R) in protein folding and function:
   • Be prepared to find a peptide bond in a polypeptide chain
   • Define 4 levels protein structure and understand what forces hold these levels of structure together and their relative stabilities (i.e. which levels would denature first as you alter the environment of a protein)
     1. Primary:
     
     2. Secondary:
     
     3. Tertiary:
     
     4. Quaternary:

2. Functions:
   A. Structural proteins
   B. Regulator proteins
      • Enzymes, chaperones, hormones
      • Three Rules for a Protein to be an Enzyme:
        1. 
        2. 
        3. 
   
   C. Carrier proteins
      • Transport proteins, lipoproteins

D. Nucleic Acids

1. Structure:
   A. Nucleotides are the building blocks of nucleic acids
   • Each Nucleotide is composed of 3 parts:
     1. Ribose Sugar
        • Identify the entity on the ribose carbons (fig.3.15):
          1’ carbon:
          2’ carbon:
          3’ carbon:
          5’ carbon:
2. Nitrogenous Base
   • There are 5 nitrogenous bases (fig. 3.15)
     1.
     2.
     3.
     4.
     5.
   • Which Nitrogenous Bases are used in DNA, which are used in RNA:
   • Which nitrogenous bases form base pairs with each other

3. Phosphate Group
   • Forms the 3'-5' Phosphodiester bonds of the DNA/RNA 'backbone'

B. Putting Together the Nucleotides to Make Nucleic Acids
   • The backbone is formed by 3'-5' phospho-ribose linkages (covalent bonds)
   • DNA is a Double-Stranded Helix (twisted ladder)
   • Complementary strands are held together through Base Pairing:
     • What type of bond holds the 2 strands together?
     • Which bases form base pairs with each other:
     • Be prepared to compare the structures of DNA and RNA (slides 89 and 90)
     • Be prepared to describe how the complementary property of DNA is related to its function

C. Chromosome:

2. Functions
   A. DNA
      • Define DNA:
      • Functions of DNA (slide 82 and 103):
      • Be prepared to describe how the genetic code is stored in the DNA molecule
      • Gene:

   B. RNA
      • Define RNA
      • Functions of RNA (slide 82 and 104):

   C. Other Nucleotide Molecules
      1. ATP
      2. NAD+ and FAD