Biology 11A Lecture Notes – Test 1

Chapter 1 – Introduction

A. Characteristics of Life
   a. Organization – levels biosphere → atom. (Fig 1.1). The cell is the basic unit (Fig. 1.3)
   b. Acquires Energy and Materials (Fig. 1.4b-e)
   c. Reproduces
   d. Regulation – homeostasis is staying the same
   e. Growth and Development
   f. Adaptation: evolution

B. Diversity and Unity
   a. Classification: Kingdom vs. Domain Systems (Fig. 1.5b) (draw)
   b. Form/Function
   c. Interconnected with others and environment

C. Scientific Method (Fig. 1.8a)
   a. Observation: observable phenomenon
   b. Hypothesis: prediction that explains observation
   c. Experiment: tests hypothesis
   d. Conclusion: accept or reject hypothesis

D. Social Implication
   a. Technology – application of scientific knowledge.
   b. Social Responsibility: ethics and preserving the planet.
   c. Connected to your lives: article essay (Fig. 1.9)

Chapter 2 - Chemistry

A. Levels of organization – functions begin at molecular level (Fig. 1.1)

B. The Atom (Fig. 2.4a)
   a. Nucleus in center – made from protons (+) and neutrons (=). Both have an atomic weight of 1
   b. Shell on outside. Made up of electrons (-) with close to zero weight. Electrons orbit the nucleus.
   c. Common elements (Tab. 2.1)
   d. Isotopes are atoms with a different number of neutrons.
      i. E.g. carbon isotopes (Table 2.4)
      ii. E.g. radioisotopes in medical fields (Fig. 2.5)

C. Chemical Bonds
   a. Atoms form bonds with each other mostly because of electron stability. Atoms are happiest when outer shells have 2 or 8 electrons. If not, they try to share or give them to achieve this.
   b. Compound is a molecule made up of different types of atoms.
   c. Bonds
      i. Ionic – when electron is transferred. This results in charged atoms called ions. (Fig. 2.7 and 2.7 movie)
ii. Covalent – when electron is shared. A molecule is more than one
atom held together with a covalent bond (Tab. 2.8 and 2.8 movie)
   1. Polar – asymmetrical, slight charge
   2. Non-polar – symmetrical, no charge
iii. Hydrogen – polar molecules form bonds from slight – and +
   charges. (Fig. 2.9, 2.10)

D. Water – polarity and size give it unique properties (Fig. 2.10)
   a. Liquid vs. ice (Fig. 2.13)
   b. Cohesive and adhesive: surface tension and water column (Fig. 2.11).
   c. Heat sink – resists temperature change. Calorie is defined as energy
       required to raise 1 ml or g of water 1 °C. Heat is given off by evaporation,
       e.g. sweating.
   d. Solvent – solutes dissolve in it. (Fig. 2.14) (Audesirk 2.2 movie)
   e. Acidity and basicity – pH scale (Fig. 2.15). Logarithmic and direction.
       Buffers help maintain same pH.

E. Chemical reactions
   a. Reactants → Products (Fig. 2.18)
   b. Balancing reactions
      i. Practice balancing
         1. C₆H₁₂O₆ + O₂ → CO₂ + H₂O
         2. H₂O₂ → H₂O + O₂

Chapter 3 – Biological Molecules

A. Organic molecules contain carbon and hydrogen (Fig. 3.1b).
   a. Important functional groups (Tab. 3.2).
   b. Macromolecules are made from monomers and polymers.
   c. Dehydration synthesis to link monomers and hydrolysis to separate (Fig
       3.3A and 3.3B).
B. Carbohydrates – sugars
   a. Chemical formula is usually (CH₂O)n
   b. Monosaccharide (Fig. 3.4)
   c. Making disaccharide, polysaccharide (Fig 3.5)
   d. Starch – a storage polysaccharide in plants (Fig. 3.7)
   e. Glycogen – storage in animals
   f. Cellulose – cell wall structure
C. Lipids – fats
   b. Triglyceride contains 3 fatty acid and 1 glycerol. Saturated vs. unsaturated
      (Fig. 3.8) fats. Unsaturated has double bonds and is not saturated with
      hydrogen.
   c. Phospholipids have a polar head with a phosphate group and a non-polar
      tail. (Fig. 4.5a)
   d. Steroids – four ring groups. E.g. cholesterol (precursor to other steroids
      and membrane component), estradiol, testosterone. (Fig. 3.9, 3.2)
D. Proteins
   a. Monomers are amino acids. Monomers are linked by peptide bonds.
   b. 20 different R groups. (Fig. 3.12-13)
   c. Function related to final structure. Temperature, pH and salt can affect final shape. Denaturation like boiled eggs. (Draw pacman)
   d. Levels of structure (Fig. 3.14 and Mov 3.14)
      i. Primary – basic sequence
      ii. Secondary – 3D motif, e.g. helix, sheet
      iii. Tertiary – whole protein structure
      iv. Quaternary – more than 1 protein

E. Nucleic Acids (Fig. 3.16A-C)
   a. Monomer is nucleotide (phosphate-sugar-base)
   b. DNA is string of deoxynucleotides. Has four bases ATGC. Genetic material.
   c. RNA is less stable. Has AUGC. Genetic messenger.

Chapter 4 – The Cell

A. Cell Features
   a. An adult person is made of approximately 100 trillion cells.
   b. Cell Theory:
      i. All living things are made up of cells.
      ii. The smallest living thing is a cell and cells may make up multicellular organisms.
      iii. Cells arise from preexisting cells.
   c. General features
      i. Plasma membrane – allows isolation of cell contents, regulation of materials into and out of cells, interaction with other cells.
      ii. DNA as genetic material.
      iii. Cytoplasm – fluid portion in the cell.
      iv. Obtains energy and nutrients from the environment.
      v. Organization and size permit homeostasis. Different shapes and sizes within range (Fig. 4.2b)
   d. Prokaryotes vs. Eukaryotes
      i. Prokaryotes are small, lack organelles. Most have cell walls. Some have pili, flagella, capsules. (Fig. 4.3b)
      ii. Eukaryotes are bigger, contain organelles, are more complex.

B. Eukaryotic Organelles
   a. Differences between plants and animals – plants have a cell wall, plastids, central vacuole. Animals have centrioles.
   b. Nucleus – “control center” (Fig. 4.6)
      i. Holds DNA in form of chromatin (DNA + protein). Chromosomes are the DNA part.
      ii. Nucleolus is center for ribosome assembly.
      iii. Nuclear envelope is membrane. Nuc. pores allow RNA to exit.
c. Ribosomes – “manufactures proteins” (Fig. 4.7)
   i. Made from RNA and proteins.
   ii. Found in cytosol and ER.

d. Endomembrane System and vesicle budding (Fig. 4.9b)
   i. Endoplasmic Reticulum – “manufacturing center” (Fig. 4.9a)
      1. Membranes form flattened tubes. Lumen is on inside.
      2. Rough ER has ribosomes. Proteins made and translocated into the lumen.
      3. Smooth ER has no ribosomes. Used for lipid metabolism.
   ii. Golgi Complex – “post office” (Fig. 4.10)
      1. Sorts incoming proteins and lipids
      2. “Tags” or modifies some for destination
      3. Packages them for final destination in vesicles.
   iii. Lysosomes – “digestive system” (Fig. 4.11)
      1. Contains digestive enzymes
      2. Tay-Sach’s disease is genetic and is caused by missing digestive enzyme. The enzyme digests lipids. Lipids build up and kill cell. Death occurs in children
iv. Vacuole – “storage and recycling plant”
   1. Store water, food, salts, pigments, and wastes.
   2. Like a large vesicle.
   3. Some protists have contractile vacuole (Fig. 4.12)
   4. Huge in plants=central vacuole

f. Mitochondria – “powerhouse”
   i. Produce ATP from glucose
   ii. Structure: double membrane, intermembrane space, cristae (folds), matrix that has enzymes. (Fig. 4.14)
g. Chloroplasts – “solar power plant” (Fig. 4.15)
   i. Family of plastids that produce and store food.
   ii. Makes glucose using chlorophyll and carotenoids
   iii. Has three membranes. Inner most makes up thylakoid. Grana are stacks of thylakoids. Stroma is inside space. Thylakoid lumen is inside thylakoid. Enzymes in both stroma and thylakoid lumen.
h. Cytoskeleton – “framework” and movement. Cell division. (Fig. 4.17)
   i. Microfilaments – made from actin monomers. Small and helixed.
   ii. Intermediate filaments – medium sized
   iii. Microtubules – tubulin subunits wrapped in large helix
i. Cilia and Flagella – movement and water movement.
   i. Cilia are small and numerous, “eyelash”
   ii. Flagella are large and few, “whip”
   iii. Uses microtubules (Fig. 4.18)
j. Animal Cell Junctions (Fig. 4.21)
   i. Tight junctions – “cement” – leak proof.
Chapter 5 – Energy and Enzymes

A. Membranes
   a. Structure – Fluid Mosaic Model (Fig. 5.1)
      i. Phospholipid bilayer
         1. Phospholipids have polar head and nonpolar tail
         2. Tails inside, heads face out.
   b. Transport Across Membrane
      i. Passive transport – diffusion
         1. Down a concentration gradient (high → low). Can go across a membrane if permeable (Fig. 5.3) (movie)
         2. Facilitated transport – uses a protein (Fig. 5.6)
         3. Osmosis – diffusion of water across a membrane (Fig. 5.4)
            a. Tonicity – relation of solute concentrations across a membrane (Fig. 5.5)
               i. Isotonic: =
               ii. Hypotonic <
               iii. Hypertonic >
      ii. Active transport (Fig. 5.8)
         1. Against concentration gradient
         2. Requires energy
         3. Endocytosis and exocytosis transports very large particles (Fig. 5.9)

B. Energy
   a. Energy – capacity to do work
      i. Kinetic energy – movement. E.g. light, heat, mechanical
      ii. Potential energy – stored. E.g. chemical in bonds, electrical in battery, boulder on a hill.
   b. Laws of Thermodynamics
      i. 1\textsuperscript{st} – conservation. “Energy can neither be created nor destroyed.”
      ii. 2\textsuperscript{nd} – loss during conversion. Usable energy is lost in any conversion. (Fig. 5.11b)
      iii. Entropy – level of randomness. Less entropy stores more energy.

C. Chemical Reactions and energy
   a. Reactants → Products
   b. Metabolism – the sum of all chemical reactions in a cell. Reactions are linked into metabolic pathways.
   c. Exergonic – energy is released. These are spontaneous (Fig. 5.12)
   d. Endergonic – energy is used
   e. Coupled reactions – exergonic drives endergonic reactions.
   f. ATP is an energy-carrier molecule. Coupled with glucose breakdown and protein buildup (Fig. 5.13A-C)
D. Regulation of chemical reactions by Enzymes
   a. Enzymes are catalysts that speed up reactions by lowering activation energy (Fig. 5.14)
      i. Reactions must be spontaneous
      ii. Usually very specific for a reaction
      iii. (Show videos)
   b. Enzyme function (Fig. 5.15)
      i. Active site binds substrates (reactants).
      ii. Reaction occurs on enzyme
      iii. Release of products
   c. Enzyme regulation
      i. Environment
         1. Enzymes function at optimal pH, temperature, salt concentration
         2. Draw bell curve.
      ii. Activation
         1. Coenzymes – organic. e.g. vitamins
         2. Cofactors – inorganic. e.g. minerals
      iii. Inhibition
         1. Competitive inhibition – binds active site
         2. Noncompetitive regulation – binds elsewhere (Fig. 5.16)
         3. Feedback inhibition

Chapter 6 – Cellular Respiration

A. Overview
   a. Relationship between photosynthesis and respiration (Fig. 6.1)
   b. This is why we breathe (Fig. 6.2)
   c. \( \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2 + 38 \text{ADP} \rightarrow 6 \text{CO}_2 + 6 \text{H}_2\text{O} + 38 \text{ATP} \)
   d. Two important coenzymes: NAD and FAD. These pick up electrons and transfer them later to make ATP. NAD makes 3 ATP, FAD makes 2 ATP. (Fig. 6.5b,c)
   e. ATP made in 2 ways
      i. Oxidative phosphorylation (Fig. 6.5C)
      ii. Substrate-level phosphorylation (Fig. 6.7B)
   f. Occurs in 4 sets of reactions: Glycolysis \( \rightarrow \) Acetyl-CoA Formation \( \rightarrow \) Kreb’s Cycle \( \rightarrow \) Electron Transport System
   g. Glycolysis occurs in cytosol, other three in mitochondria (Fig. 6.6)

B. Glycolysis
   a. Glucose \( \rightarrow \) Pyruvate
   b. Yields 2 ATP and 2 NADH (Fig. 6.7c)
   c. Energy investment steps
      • 2 ATPs used in 3 steps.
      • \( \text{C}_6 \rightarrow 2\text{C}_3 \text{ (G3P)} \) in 1½ steps.
   d. Energy harvesting steps
• 4 ATPs and 2 NADHs produced in 5 steps. Remember, these totals reflect doubling of reactions because of 2C₃ molecules.
• These ATPs are made by substrate level phosphorylation (direct transfer of phosphate by intermediate).
• Pyruvate moves to mitochondria.

C. Acetyl-CoA formation
   a. Yields 2 NADH (1 per pyruvate)
   b. Occurs in matrix of mitochondria.
   c. Pyruvate + CoA $\rightarrow$ CO₂ + Acetyl-CoA (Fig. 6.8)

D. Citric Acid Cycle (Fig. 6.9b)
   a. Yields 2 ATP, 6 NADH, and 2 FADH₂ (2 turns for 2 acetyl-CoA)
   b. Occurs in matrix of mitochondria.
   c. C₄ (oxaloacetate) + Acetyl-CoA $\rightarrow$ citrate (C₆) + CoA
   d. C₆ $\rightarrow$ C₅ $\rightarrow$ C₄ yielding 2 CO₂ + energy.

E. Electron Transport and Chemiosmosis
   a. Occurs on the inner mitochondrial membrane. (Fig. 6.10)
   b. Converts energy from NADH and FADH₂ to ATP (3/NAD, 2/FAD)
   c. Chemiosmosis – production of ATP by a proton (H⁺) gradient Protons have been into intermembrane space. High concentration drives movement of protons back into matrix. ATP synthase: force of proton movement turns matrix portion which powers ATP synthesis.
   d. Poisons work on respiration (Fig. 6.13)

F. Balance sheet: 38 ATP (34 from 10 NAD and 2 FAD)

G. Efficiency: glucose gives 2870 kJ/mol. ATP hydrolysis gives 32 kJ/mol. 38 X 32 gives 1216 kJ/mol. Therefore, aerobic respiration has about 42% efficiency.

H. Fermentation – a “shortcut” respiration process. It just regenerates NAD⁺ to run glycolysis. This produces ATP by substrate level phosphorylation only. Inefficient but very fast.
   1. Alcohol fermentation – done by yeast. Ethanol and CO₂ produced.

I. Metabolic pools – nutrients other than glucose can fuel respiration. They can also be made from respiration intermediates (Fig. 6.15).