Metabolism Review

A. "Top 10"

1. Energy production through chemiosmosis
    a. pumping of H+ ions onto one side of a membrane through protein pumps in an Electron Transport Chain (ETC)
    b. flow of H+ ions across a membrane down the concentration gradient through ATP synthase
2. Coupled reactions get the work done
    a. oxidation & reduction
    b. ETC & pumping of H+ (protons)
3. Respiration
    a. mitochondria
        - ETC in inner membrane: cristae increase surface area
        - H+ ion concentrated in intermembrane space & flows into matrix through ATP synthase
        - oxidative phosphorylation: O2 final electron acceptor + NAH/FADH to donate electron
        - Kreb's cycle produces electron carriers: NADH, FADH
        - high ATP production (~36 ATP)
    b. anaerobic: glycolysis, fermentation
        - low ATP production (~2 ATP)
4. Photosynthesis
    a. chloroplasts
        - H+ ion concentration in inner thylakoid space & flows out into stroma
        - photophosphorylation: light energy + splitting of water to donate electron
        - light dependent reactions: Photosystem II (produces ATP) & Photosystem I (produces NADPH)
    b. Calvin cycle
        - light independent reaction
        - carbon fixation through RuBisCo enzyme
        - use ATP & NADPH from light reactions to produce of 3C sugars
5. Regulation of metabolism is through negative feedback of enzyme pathways

B. Sample Multiple Choice Questions

1. The carbon that makes up organic molecules in plants is derived directly from
    a. combustion of fuels
    b. carbon fixed in photosynthesis
    c. carbon dioxide produced in respiration
    d. carbon in the lithosphere
    e. coal mines

2. If plants are grown for several days in an atmosphere containing $^{14}CO_2$ in place of $^{12}CO_2$, one would expect to find
    a. very little radioactivity in the growing leaves
    b. large amounts of radioactive water released from the stomates
    c. a large increase in 14C in the starch stored in the roots
    d. a large decrease in the rate of carbon fixation in the guard cells
    e. an increase in the activity of RuBP carboxylase in the photosynthetic cells

3. The O2 released during photosynthesis comes from

a. CO_2
b. H2O
c. NADPH
d. RuBP
e. $C_6H_{12}O_6$

4. Which of the following is an important difference between light-dependent and light independent reactions of photosynthesis?

a. The light-dependent reactions occur only during the day; the light-independent reactions occur only during the night.
b. The light-dependent reactions occur in the cytoplasm; the light-independent reactions occur in chloroplasts.
c. The light-dependent reactions utilize CO2 and H2O; the light-independent reactions produce CO2 and H2O.
d. The light-dependent reactions depend on the presence of both photosystems I and II; the light-independent reactions require only photosystem I.
e. The light-dependent reactions produce ATP and NADPH; the light-independent reactions use energy stored in ATP and NADPH.

5. The end products of the light-dependent reactions of photosynthesis are (1990:43)

a. ADP, H_2O, NADPH
b. ADP, G3P, RuBP
c. ATP, CO_2, H_2O
d. ATP, NADPH, O_2
e. CO_2, H+, G3P

6. Which of the following enzymes is responsible for CO2 fixation in C3 plants?

a. succinate dehydrogenase
b. RuBP carboxylase
c. hexokinase
d. amylase
e. DNA polymerase

7. During respiration, most ATP is formed as a direct result of the net movement of

a. potassium against a concentration gradient
b. protons down a concentration gradient
c. electrons against a concentration gradient
d. electrons through a channel
e. sodium into the cell

10. Oxygen consumption can be used as a measure of metabolic rate because oxygen is

a. necessary for ATP synthesis by oxidative phosphorylation
b. necessary to replenish glycogen levels
c. necessary for fermentation to take place
d. required by all living organisms
e. required to break down the ethanol that is produced in muscles

C. Sample Free Response Questions

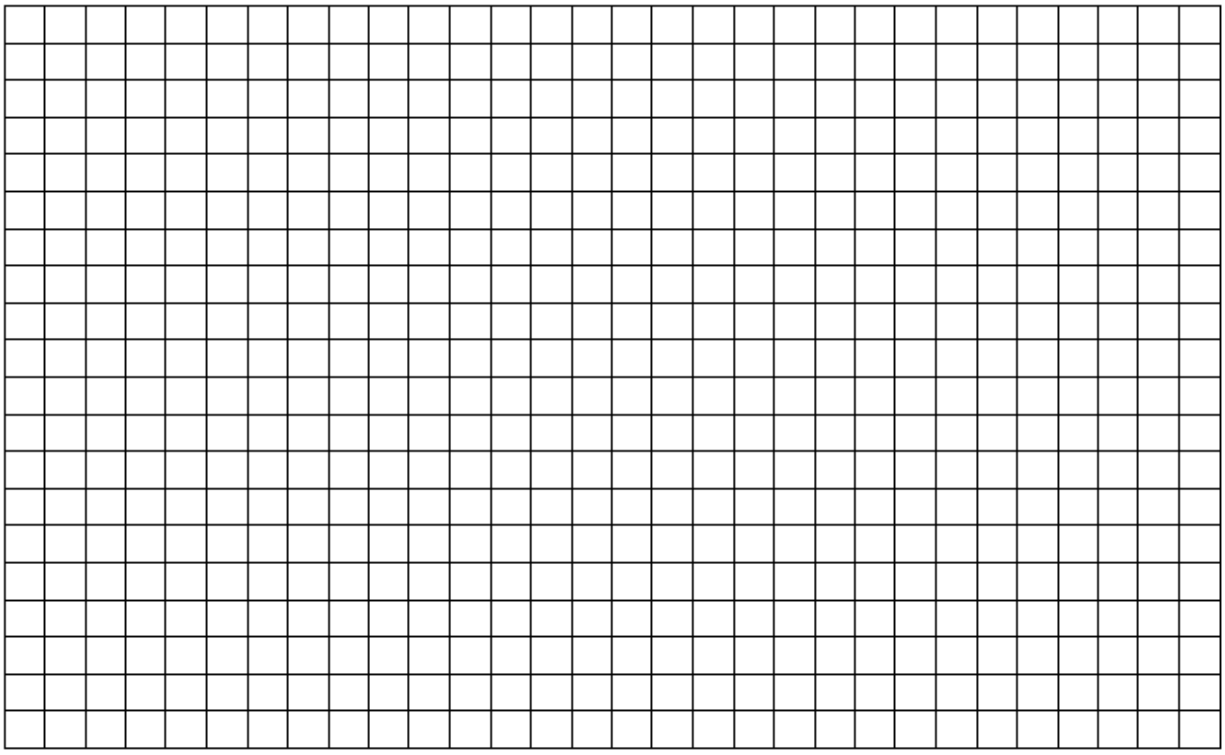
1. Yeast cells are placed in an apparatus with a solution of sugar (a major nutrient for yeast metabolism). The apparatus detects bubbles of gas released by the yeast cells. The rate of respiration varies with the surrounding temperatures as indicated by the data below.

Temperature (°C)	0	10	20	30	40	50	60	70
Number of bubbles of gas produced per minute	0	3	7	12	7	4	1	0

a. Graph the results on the axes provided. Determine the optimum temperature for respiration in the yeast.
b. Respiration is a series of enzyme-catalyzed reactions. Using your knowledge of enzymes and the data above, analyze and explain the results of this experiment.

- Cellular respiration is an enzyme (protein) driven reaction
- According to the data the optimum temperature for cellular respiration in this experiment is 30.
- The rate is slower below 30 because the cooler temperature decreases molecular movement and the reactions of respiration are slowed down
- The rate is slower above 30 because the high temperature causes the enzymes to denature

c. Design an experiment to test the effect of varying the pH of the sugar solution on the rate of respiration. Include a prediction of the expected results.



2. A controlled experiment was conducted to analyze the effects of darkness and boiling on the photosynthetic rate of incubated chloroplast suspensions. The dye reduction technique was used. Each chloroplast suspension was mixed with DPIP, an electron acceptor that changes from blue to clear when it is reduced. Each sample was placed individually in a spectrophotometer and the percent transmittance was recorded. The three samples used were prepared as follows.

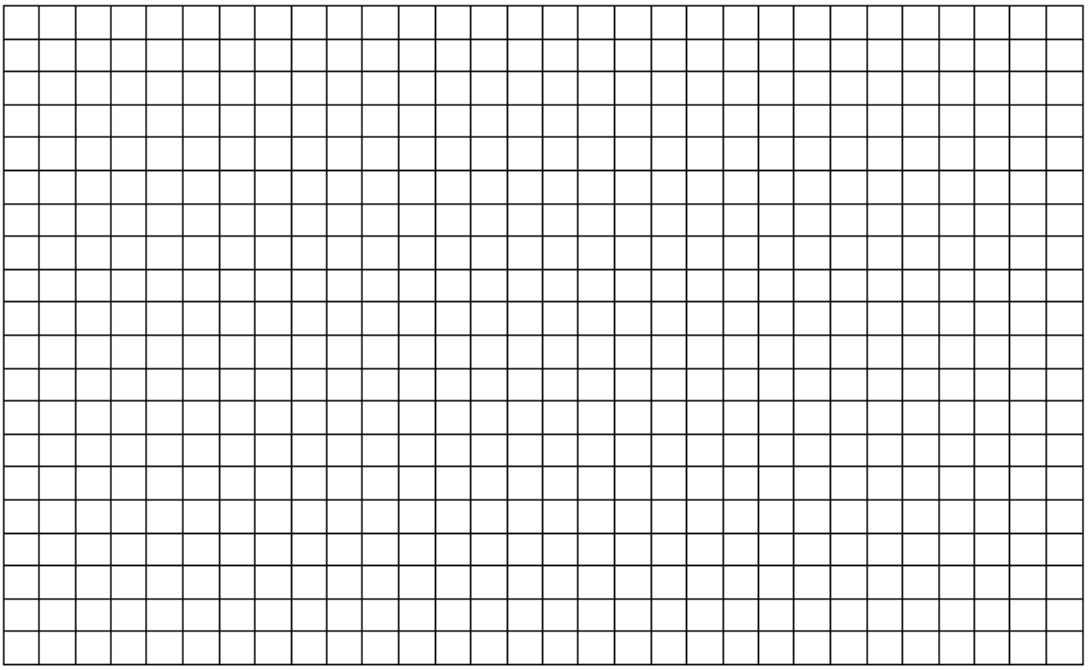
- Sample 1 — chloroplast suspension + DPIP
- Sample 1 — chloroplast suspension surrounded by foil wrap to provide a dark environment + DPIP
- Sample 1 — chloroplast suspension that has been boiled + DPIP

Percent Transmittance in Three Samples

Time (min)	Light, Unboiled % Transmittance Sample 1	Dark, Unboiled % Transmittance Sample 2	Light, Boiled % Transmittance Sample 3
0	28.8	29.2	28.8
5	48.7	30.1	29.2
10	57.8	31.2	29.4
15	62.5	32.4	28.7
20	66.7	31.8	28.5

a. On the axes provided, construct and label a graph showing the results for the three samples.
b. Identify and explain the control or controls for this experiment.
c. The differences in the curves of the graphed data indicate that there were differences in the number of electrons produced in the three samples during the experiment. Discuss how electrons are generated in photosynthesis and why the three samples gave different transmittance results.

- The samples in the dark can't complete the light reactions of photosynthesis. Without the light to excite the electrons of the photosystem chlorophyll molecules, NADPH cannot be produced (NADP+ only) and the production of ATP will also be disrupted
- The samples with boiled chloroplasts cannot go through photosynthesis because the boiling denatures the proteins of the photosystems preventing the aborption of light. The electron transport proteins and enzymes will also be denatured preventing the production of NADPH and ATP



Chapter Essentials

Chapter 6: Pathways that Harvest and Store Chemical Energy

Concept 6.1: ATP and Reduced Coenzymes Play important Roles in Biological Energy Metabolism

- ATP hydrolysis releases energy
- Redox reactions transfer electrons and energy
- The processes of NADH oxidation and ATP production are coupled

Concept 6.2: Carbohydrate Catabolism in the Presence of Oxygen Releases a Large Amount of Energy

- In glycolysis, glucose is partially oxidized and some energy is released
- Pyruvate oxidation links glycolysis and the citric acid cycle
- Energy is transferred from NADH to ATP by oxidative phosphorylation
- Chemiosmosis uses the proton gradient to generate ATP
- Chemiosmosis can be demonstrated experimentally
- Oxidative phosphorylation and chemiosmosis yield a lot of ATP

Concept 6.3 Carbohydrate Catabolism in the Absence of Oxygen Releases a Small Amount of Energy

Concept 6.4 Catabolic and Anabolic pathways are Integrated

- Catabolism and Anabolism are linked

Concept 6.5 During Photosynthesis, Light Energy is Converted to Chemical Energy

- Light energy is absorbed by chlorophyll and other pigments
- Light absorption results in photochemical change
- Reduction leads to ATP and NADPH formation

Concept 6.6 Photosynthetic Organisms Use Chemical Energy to Convert Carbon Dioxide to Carbohydrates