

**REVIEW 3: METABOLISM UNIT — RESPIRATION & PHOTOSYNTHESIS****A. Top “10” — If you learned anything from this unit, you should have learned:**

1. Energy production through chemiosmosis
  - a. pumping of H<sup>+</sup> ions onto one side of a membrane through protein pumps in an Electron Transport Chain (ETC)
  - b. flow of H<sup>+</sup> 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<sup>+</sup> (protons)
3. Respiration
  - a. mitochondria
    - ETC in inner membrane: cristae increase surface area
    - H<sup>+</sup> ion concentrated in intermembrane space & flows into matrix through ATP synthase
    - oxidative phosphorylation: O<sub>2</sub> final electron acceptor + NADH/FADH to donate electron
    - Krebs'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<sup>+</sup> 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
  - c. C<sub>4</sub> & CAM plants
    - adaptation in hot, dry ecosystems because stomates closed a lot
    - reduce photorespiration: low carbon fixation in a high oxygen/low CO<sub>2</sub>
5. Regulation of metabolism is through negative feedback of enzyme pathways

**B. Labs**

## 1. Respiration

Be sure to review the procedures and the conclusions, and understand:

- a. Factors that affect rate of respiration
- b. How to set up a similar experiment
  - What was being measured?
  - How was generated CO<sub>2</sub> dealt with
- c. Controls vs. Experimental

## 2. Photosynthesis

Be sure to review the procedures and the conclusions, and understand:

- a. Factors that affect rate of photosynthesis
- b. How to set up a similar experiment
  - What was being measured?
  - How was generated CO<sub>2</sub> dealt with
- c. Controls vs. Experimental

**C. Sample Multiple Choice Questions**

1. The carbon that makes up organic molecules in plants is derived directly from (1994:8)
  - 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 <sup>14</sup>CO<sub>2</sub> in place of <sup>12</sup>CO<sub>2</sub>, one would expect to find (1994:20)
  - a. very little radioactivity in the growing leaves
  - b. large amounts of radioactive water released from the stomates
  - c. a large increase in <sup>14</sup>C 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  $O_2$  released during photosynthesis comes from (1994:33)
  - a.  $CO_2$
  - b.  $H_2O$
  - 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? (1994:34)
  - 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  $CO_2$  and  $H_2O$ ; the light-independent reactions produce  $CO_2$  and  $H_2O$ .
  - 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  $CO_2$  fixation in  $C_3$  plants? (1990:47)
  - 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 (1999:41)
- potassium against a concentration gradient
  - protons down a concentration gradient
  - electrons against a concentration gradient
  - electrons through a channel
  - sodium into the cell
8. Which of the following processes is carried out more efficiently by a C4 plant than by a C3 plant? (1999:45)
- light absorption
  - chemiosmotic coupling
  - photolysis
  - fixation of CO<sub>2</sub>
  - transport of sugar
9. On a sunny day, the closing of stomata in plant leaves results in (1999:52)
- a decrease in CO<sub>2</sub> intake
  - a shift from C3 photosynthesis to C4 photosynthesis
  - an increase in transpiration
  - an increase in the concentration of CO<sub>2</sub> in mesophyll cells
  - an increase in the rate of production of starch
10. Oxygen consumption can be used as a measure of metabolic rate because oxygen is (1999:16)
- necessary for ATP synthesis by oxidative phosphorylation
  - necessary to replenish glycogen levels
  - necessary for fermentation to take place
  - required by all living organisms
  - required to break down the ethanol that is produced in muscles

**D. Sample Free Response Questions**

1. 1999:1

The rate of photosynthesis may vary with changes that occur in environmental temperature, wavelength of light, and light intensity. Using a photosynthetic organism of your choice, choose only ONE of the three variables (temperature, wavelength of light, or light intensity) and for this variable

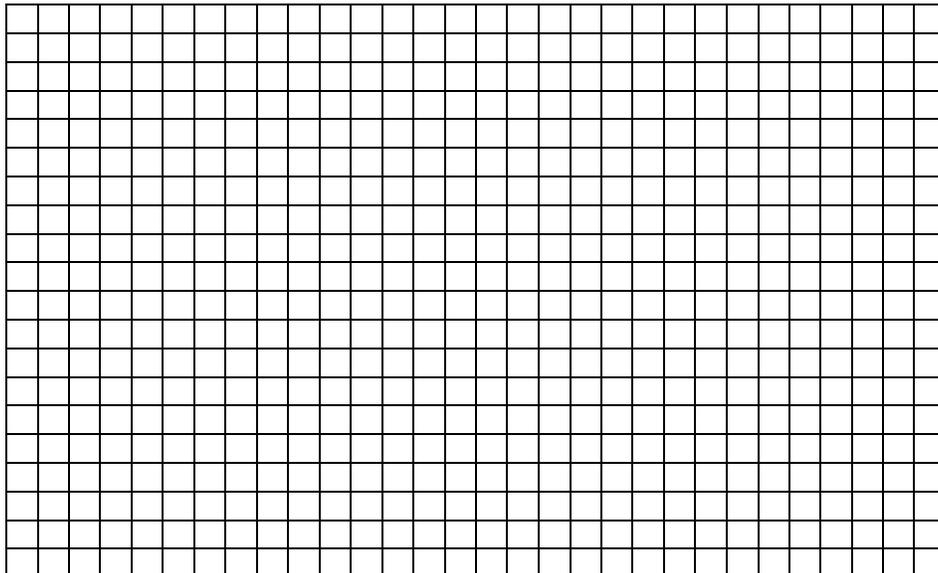
- design a scientific experiment to determine the effect of the variable on the rate of photosynthesis for the organism;
- explain how you would measure the rate of photosynthesis in your experiment;
- describe the results you would expect. Explain why you would expect these results.

2. 2005:1

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.
- 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.



## 3. 2004:3

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	Dark, Unboiled % Transmittance	Light, Boiled % Transmittance
	Sample 1	Sample 2	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.

