Unit 1 Test - Metabolic Processes: Photosynthesis

Modified True/False

Indicate whether the sentence or statement is true or false. If false, change the identified word or phrase to make the sentence or statement true.

____ 1. The organelle that is unique to eukaryotic photoautotrophs is the *chromoplast*. _____

____ 2. Light energy is principally transferred by *chlorophyll b*. _____

____ 3. When exposed to bright white light chlorophyll fluoresces *green*. _____

____ 4. In general, photosynthesis rates are lower at *lower oxygen concentrations*. _____

____ 5. The location of the H^+ reservoir in the chloroplast is the *intermembrane space*. _____

Multiple Choice

Identify the letter of the choice that best completes the statement or answers the question.

____ 1. Of the following biological compounds, which one contains the element, nitrogen?

a. fatty acids
b. sugar
c. glycerol
d. starch
e. protein

____ 2. An oxidation/reduction is best shown by which of the following?

a. an amino and carboxyl group form a peptide bond
b. two small molecules chemically combine to form a large one
c. a base reacts with an acid to form water and a salt
d. electrons are transferred from one substance to another
e. a large molecule is broken into two smaller molecules

____ 3. The activity of an enzyme can be altered by changing the pH of its surroundings slightly. This change in pH works by

a. causing the enzyme to precipitate
b. masking its active site
c. increasing the activation energy of the reaction
d. breaking its peptide bonds
e. altering its three dimensional shape

____ 4. Which of the following is **not** a cofactor or coenzyme?

a. Zn^{2+}
b. Mn^{2+}
c. NAD^+
d. Fe^{2+}
e. $NADP^+$

____ 5. Which of the following statements concerning allosteric regulation is not true?

a. Allosteric sites are usually located next to, but separate from, the active site.
b. Alosterically controlled enzymes usually have quaternary structure.
c. 'Activators' tend to keep all the active sites available to the normal substrate.
d. 'Allosteric inhibitors' stabilize the inactive form of the enzyme.
e. Allosteric regulators attach to their sites using weak bonds.

____ 6. Which of the following processes most likely does **not** involve anaerobic conditions?

a. yeast causing bread dough to rise
b. bacteria working in an aeration tank at a sewage plant
c. bacteria in the soil help in composting
d. alcohol is produced in fermentation
e. sewage breaks down in a septic tank

____ 7. In an investigation of the pigments in the leaves of a particular plant, one spot moved 8.0 cm from the origin, while the solvent front moved 10.0 cm. What would the R_f value of the pigment be?

a. 80.0
b. 8.0
c. 2.0
d. 1.25
e. 0.8

____ 8. Photophosphorylation specifically refers to the

a. synthesis of glucose via carbon fixation
b. splitting water as a result of light
c. synthesis of ATP by photolysis
d. reduction of NADPH by electron transport
e. synthesis of ATP using light

____ 9. During carbon fixation, which of the following is a product?

a. ATP
b. 3-phosphoglycerate
c. NADPH
d. carbon dioxide
e. oxygen

____ 10. The name of the process whereby a plant uses oxygen in light.

a. transpiration
b. translocation
c. photophosphorylation
d. photorespiration
e. photosynthesis

Imagine you have five small glass jars that are sealed to the atmosphere. All the jars are filled with a bicarbonate solution (as a source of carbon dioxide) and an indicator. The differences between each jar are described below:

Jar #1: Has a small fish.

Jar #2: Has one small fish in addition to some aquatic plants.

Jar #3: Has three small fish in addition to some aquatic plants.

Jar #4: Has some aquatic plants.

Jar #5: Has some aquatic plants, but the jar is completely surrounded by aluminum foil.

The indicator shows you how much carbon dioxide is in each jar. The following table shows the relative amounts:

Colour of pH indicator solution	**Relative amount of carbon dioxide**
red	high
green	medium (equivalent to atmosphere)
blue	low

The following table shows the results of an experiment where the tubes were allowed to stand under natural light for several hours.

Observation	**Jar #1**	**Jar #2**	**Jar #3**	**Jar #4**	**Jar #5**
Starting colour of indicator	green	green	green	green	green
Final colour of indicator	red	green	red	blue	green

____ 11. The following are statements regarding the above results:

I. respiration is taking place in all five test tubes

II. respiration is exceeding photosynthesis in Jar#3

III. photosynthesis is occurring in Jar#5

IV. the lowest concentration of carbon dioxide is found in Jar#2

Which of the above statements are correct?

a. II and III
b. I and II
c. I and IV
d. II and IV
e. III and IV

Optional Multiple Choice - The correct answer is indicated by a (*)

1. Photoexcitation occurs when

a. 2ADP + 2Pi ---> 2 ATP on 2 cytochromes
b. light releases electrons from double covalent bonds on chlorophyll a
c. 2 H_2O ---> $4H^+ + O_2$ + 4 electrons
d. pallisade mesophyll
e. ultra-violet (UV)

2. In a C_3 plant most of the photosynthesis activity occurs in the

a. bundle sheath cells
b. spongy mesophyll
c. RUDP; 2PGA

d. pallisade mesophyll
e. pyruvic acid

3. C_4 plants "fix" CO_2 onto _____; to form _____.

a. RUDP; 2PGA
b. pyruvic acid; 2PGA
c. PEP; oxaloacetic acid
d. chlorophyll a (bulk); chlorophyll b
e. glucose, water

4. C_3 plants "fix" CO_2 onto _____; to form _____.

a. PEP; oxaloacetic acid
b. pyruvic acid; 2PGA
c. RUDP; 2PGA
d. Glycogen, pyruvate
e. Alcohol, aspartame

5. The antenna pigments include

a. chlorophyll a (bulk); chlorophyll b (all)
b. chlorophyll b (all); carotenoids (all)
c. Xanthophylls, cyanins
d. chlorophyll a (bulk); chlorophyll b (all); carotenoids
e. Glycine, methylglycol

6. The light reaction PRIMARILY absorbs light from the visible spectrum that is

a. ultra-violet (UV)
b. violet
c. red
d. The matrix
e. green

7. The light reaction occurs

a. the thyakoid membrane
b. in the matrix
c. in the stroma
d. Grana
e. Vacuole

8. The dark reaction occurs in the

a. matrix
b. thyakoid membrane
c. stroma
d. lammmellae
e. pancreas

9. In the following equation, the 6 O_2 originated from the

6 CO2 + 12 H2O ----1 ---2---> 6O2 + C6H12O6 + 6 H2O

a. 6 CO2
b. 12 H2O
c. 6 H2O
d. sulphur

e. antimony

10. In the following equation, the C_6 on glucose originated from the

$$\mathbf{6\ CO_2 + 12\ H_2O\ ----1\ ---2---> 6O_2 + C_6H_{12}O_6 + 6\ H_2O}$$

a. 12 H2O
b. 6 CO2
c. C6H12O6
d. Sulfur gas
e. air

11. 1 and 2 on the -------> are

$$\mathbf{6\ CO_2 + 12\ H_2O\ ----1\ ---2---> 6O_2 + C_6H_{12}O_6 + 6\ H_2O}$$

a. CO_2, H_2O
b. chlorophyll a and chlorophyll b
c. light and chlorophyll
d. aspartame and protein
e. DNA and chlorine

12. The major end products of the LIGHT REACTION is (are)

a. $4\ e^- + 4H^+ + O_2$
b. ATP, $NADPH_2$
c. $6O_2$, $6\ H_2O$
d. NADPH
e. FAD+

13. Carotenoids absorb light PRIMARILY from the _____ portion(s) of the visible spectrum.

a. red, violet
b. blue
c. green
d. black
e. yellow-orange

14. Both the end products of the LIGHT REACTION are used in the:

a. reduction of 2 PGA's to 2 PGAL's
b. oxidation of 2 PGA's to 2 PGAL's
c. fixation of CO_2 on RUP
d. Calvin cycle

15. Both the end products of the light reaction are used in the

a. conversion of PGAL to DHAP through a series of reactions
b. oxidation of NADPH
c. conversion of RUDP to PGAL through a series of reactions
d. Cellular respiration

16. Which condition below favours the highest rate of PHOTOSYNTHESIS? (select only one)

(a) CO_2 0.2% light 7000 1x temperature 20°C

(b) CO_2 0.2% light 7000 1x temperature 15°C

(c) CO_2 10 % light 7000 1x temperature 25°C

17. Regardless of light intensity and temperature, the rate of photosynthesis will not increase when the CO_2 concentration is

a. below 0.2%
b. above 0.03%
c. above 0.2%
d. up to 100%
e. below 0.011%

18. The rate of photosynthesis is observed by :

a. counting the O_2 bubbles given off
b. collecting O_2 gas from the reaction
c. looking at the water produced
d. both <a> and <b> are feasible
e. counting the number of sugars

19. Photosystem II receives electrons from

a. photolysis of water
b. 2 cytochromes
c. NADPH2
d. Mitochondria
e. rubisco

20. Photosystem II produces _____ for the dark reaction

a. ATP only
b. both ATP and $NADPH_2$
c. PGAL
d. Electrons
e. protons

21. In Photosystem I, chloroplasts use light to produce

a. histamine
b. CO_2
c. Carbon
d. Carbonic acid
e. NADPH

22. Light is one factor involved with the rate of photosynthesis. Two others are

a. temperature and CO_2
b. temperature and O_2
c. water and ozone
d. sulphur concentration and aluminium ion concentration
e. chlorine concentration and H ion concentration

23. The oxygen released through photosynthesis is derived from

a. CO_2
b. water
c. ATP

24. Rank the events <a> to <c> from which occurs first to which occurs last. Select the event that comes last.

a. P_{700} is oxidized

b. photophosphorylation
c. P_{680} is oxidized

25. Rank the events <a> to <c> from which occurs first to which occurs last. Select the event that comes first.

a. photophosphorylation
b. P_{680} is oxidized
c. P_{700} is oxidized

26. During the operation of photosystem I

a. NADPH is reduced and P700 is reduced
b. P680 is reduced along with ATP
c. P700 is oxidized and NADP+ is reduced
d. ATP is reduced
e. The chloroplast is excited

27. The general accomplishment of the DARK REACTION is the

a. synthesis of ATP
b. synthesis of PGAL
c. reduction of CO_2 by hydrogen
d. Production of sulphuric acid gas
e. The production a alanine

28. When light is absorbed by photosystem II

a. P_{700} is oxidized and CO_2 is liberated
b. P680 is oxidized and O2 is liberated
c. P680 is converted to P700
d. When the sun stops shining
e. When the asparate shuttle stops

Other multiple choice questions can be found at: http://www.thelifewire.com/ and,
http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell_awl/chapter10/deluxe.html

Completion questions

1. Temperature and pH affect enzyme activity. As with all other reactions, enzyme-catalyzed reactions _____ in speed with an increase in temperature. However, as the temperature increases beyond a critical point, the protein structure begins to get disrupted , resulting in _____ and loss of enzyme function. Every enzyme has a(n) _____ temperature at which it works best and activity tends to decrease on either side of this temperature. Most human enzymes work best at around _____. Some enzymes require nonprotein _____, such as zinc and manganese ions. Other enzymes may require organic _____ such as NAD^+ and $NADP^+$. A variety of substances inhibit enzyme activity. _____ are so similar to the enzyme's substrate that they are able to enter he enzyme's active site and block the normal substrate from binding. This process is reversible and can be overcome be increasing the concentration of the enzyme's substrate. Another class of inhibitors does not affect an enzyme at its' active site, they are called _____ and their effect cannot be overcome by adding more substrate.

2. In a general, overall comparison of the reactions that occur during cellular respiration and photosynthesis, it can be said that the main reactant in respiration is _____, while in photosynthesis it is _____ and _____. In contrast to this, the main products of cellular respiration are _____ and _____, while in photosynthesis the main product is _____ with an interesting waste product _____ that is very useful to many creatures on Earth. Cellular respiration is a process that _____ energy , while photosynthesis _____ energy.

Matching

Match each item with the correct statement below.

a. ground state
b. excitation
c. fluorescence
d. primary electron acceptor
e. antenna complex
f. reaction centre
g. photosystem I
h. photosystem II
i. noncyclic electron flow
j. Z protein
k. photophosphorylation
l. cyclic electron flow

____ 1. The release of energy as light as an electron returns to ground state.

____ 2. The absorption of energy by an electron.

____ 3. The lowest possible potential energy level of an electron.

____ 4. Contains chlorophyll P680.

____ 5. Transmembrane protein of chlorophyll a that absorbs light energy.

____ 6. Contains chlorophyll P700.

____ 7. Web of chlorophyll molecules that transfers energy to a reaction centre.

____ 8. Light-dependent formation of ATP.

____ 9. Photon-energized electrons move to produce only ATP.

____ 10. Protein that helps split water into hydrogen ions, oxygen and electrons.

Short Answer

1. "Plants are the only important photosynthetic organisms." Comment on this statement.

2. What are the roles of water and light in photosynthesis?

3. Photosystem I usually converts most of the light energy it receives to ATP and NADPH by noncyclic electron flow. There are times when some of the energy is used by cyclic electron flow.

a. What is cyclic electron flow?

b. Why is it called 'cyclic'?

c. At what times does cyclic electron flow occur?

4. Complete the following table to compare the various 'types' of photosynthesis.

	C3	**C4**	**CAM**
Usual areas were these plants are found.			
First enzyme to fix			

carbon dioxide			
Name of molecule formed immediately following carbon dioxide fixation.			
Is there an 'energy cost' associated with carbon dioxide fixation? (Y/N)			

5. Design an experiment to show whether sulphur dioxide, a gas produced during many industrial processes, has an effect on photosynthesis. Be sure to include a clear hypothesis.

Essay

1. You may have come into this course with the impression that plants photosynthesize during the day and respire at night. Based on what you have learned in this course comment on this impression.

2. Compare and contrast C_4 and CAM photosynthesis in terms of their abilities to counter the process known as photorespiration.

Unit 1 Test - Metabolic Processes

Answer Section according to government expectations

MODIFIED TRUE/FALSE

1. ANS: F, chloroplast REF: C OBJ: 3.1

LOC: MP1.05

2. ANS: F, chlorophyll *a* REF: K/U OBJ: 3.2

LOC: MP1.01

3. ANS: F, red REF: K/U OBJ: 3.3

LOC: MP1.01

4. ANS: F, higher oxygen concentrations REF: C OBJ: 3.5

LOC: MP1.05

5. ANS: F, interior of the thylakoid REF: C OBJ: 3.6

LOC: MP2.05

MULTIPLE CHOICE

1. ANS: E REF: K/U OBJ: 1.2 LOC: MP1.02

2. ANS: D REF: K/U OBJ: 1.3 LOC: MP1.04

3. ANS: E REF: K/U OBJ: 1.4 LOC: MP1.03

4. ANS: D REF: K/U OBJ: 1.4 LOC: MP1.03

5. ANS: A REF: K/U OBJ: 1.4 LOC: MP1.03

6. ANS: B REF: K/U OBJ: 2.1 LOC: MP1.06

7. ANS: E REF: I OBJ: 3.2 LOC: MP2.06

8. ANS: E REF: K/U OBJ: 3.3 LOC: MP1.05

9. ANS: B REF: K/U OBJ: 3.3 LOC: MP1.05

10. ANS: D REF: K/U OBJ: 3.4 LOC: MP1.06

11. ANS: B REF: I OBJ: 3.6 LOC: MP2.06

OPTIONAL M.C. QUESTIONS:

1b, 2d, 3c, 4c, 5d, 6c, 7a, 8c, 9b, 10b, 11c, 12b, 13b, 14a, 15c, 16a, 17c, 18d, 19a, 20a, 21e, 22a, 23b, 24a, 25b, 26c, 27b, 28b

COMPLETION

1. ANS:

increase

denaturation

optimal

37°C

cofactors

coenzymes

Competitive inhibitors

non-competitive inhibitors

REF: K/U OBJ: 1.4 LOC: MP1.03

2. ANS:

glucose

carbon dioxide/water

water/carbon dioxide

carbon dioxide/water

water/carbon dioxide

glucose

oxygen

releases

stores

REF: K/U, C OBJ: 3.6 LOC: MP1.06, MP2.05

MATCHING

1. ANS: C REF: C OBJ: 3.3 LOC: MP1.06

2. ANS: B REF: C OBJ: 3.3 LOC: MP1.06

3. ANS: A REF: C OBJ: 3.3 LOC: MP1.06

4. ANS: H REF: C OBJ: 3.3 LOC: MP1.06

5. ANS: F REF: C OBJ: 3.3 LOC: MP1.06

6. ANS: G REF: C OBJ: 3.3 LOC: MP1.06

7. ANS: E REF: C OBJ: 3.3 LOC: MP1.06

8. ANS: K REF: C OBJ: 3.3 LOC: MP1.06

9. ANS: L REF: C OBJ: 3.3 LOC: MP1.06

10. ANS: J REF: C OBJ: 3.3 LOC: MP1.06

SHORT ANSWER

1. ANS:

While plants may be the most visible photosynthetic organisms, they are not the only ones and probably not the most important ones. In addition to the higher plants, which are usually the most familiar with people, organisms such as algae, photosynthetic protists and cyanobacteria also carry out photosynthesis. Given the size of the oceans, the photosynthetic organisms that live in this environment probably have a huge effect on global oxygen and carbon dioxide levels.

REF: MC OBJ: 3.1, 3.5 LOC: MP3.03

2. ANS:

- Water is needed as a source of hydrogen ions and electrons which are used in reduction reactions.

- Light is needed as a source of energy to excite electrons of chlorophyll, which results in the splitting of water to form oxygen and release the hydrogen ions and electrons mentioned previously.

REF: K/U OBJ: 3.3 LOC: MP1.05

3. ANS:

a. In cyclic electron flow when photosystem I is struck by a photon with the correct energy, it will release electrons to the same carrier molecules as non-cyclic electron flow. These electrons move through a cytochrome system and cause hydrogen ions to move from the stroma across the thylakoid membrane to the inside of the thylakoid. The higher concentration of hydrogen ions inside the thylakoids can be used to make ATP. The chlorophyll molecule of PS I oxidizes the final electron carrier, gaining electrons to return to its reduced form.

b. The term 'cyclic' is used because the chlorophyll of PS I serves as both the electron donor and electron acceptor.

c. Cyclic electron flow would appear to occur when reserves of $NADP^+$ are low, which would imply that levels of NADPH are high. These means there will be a shortage of electron acceptors, which results in electrons being accepted by the cytochrome electron carrier system.

4. ANS:

	C3	**C4**	**CAM**
Usual areas were these plants are found.	temperate	temperate to tropical	arid
First enzyme to fix carbon dioxide	rubisco	PEP carboxylase	PEP carboxylase
Name of molecule formed immediately following carbon dioxide fixation.	3-phosphoglycerate	oxaloacetate	oxaloacetate
Is there an 'energy cost' associated with carbon dioxide fixation? (Y/N)	No	Yes, ATP	Yes, ATP

REF: K/U, MC OBJ: 3.3, 3.4 LOC: MP1.05, MP3.03

5. ANS:

Hypothesis: any clear statement indicating they understand the role of a hypothesis in framing the investigation.

Controls: there should be some plants that will receive no treatment with sulphur dioxide, but otherwise are exposed to all the same conditions as the other plants.

Replicates: there should be mention of repeating the experiment on several plants for both the treated and untreated group.

Method: there should be some indication of how sulphur dioxide will be generated, how its application will be controlled and what will be measured to determine whether or not sulphur dioxide has an effect on photosynthesis or not.

REF: I OBJ: 3.5 LOC: MP2.04

ESSAY

1. ANS:

While it is true that plants photosynthesize during the day and respire at night it would be a mistake to assume that plants are this simple. Respiration is a process that continues on throughout the entire life of a plant, in other words it will occur both during the day and at night. Photosynthesis, on the other hand, having a requirement for light obviously can occur only when light is available. Many people choose to look at photosynthesis and respiration as 'opposite' processes. In terms of the gases they consume and produce, this is true, but from a biochemical point of view the reactions are extremely different. While respiration consumes oxygen and produces carbon dioxide, photosynthesis does the opposite. At night, only respiration is occurring and so there is a net production of carbon dioxide gas. As the sun rises and the light intensity increases, photosynthesis increase to a point where carbon dioxide consumption by photosynthesis equals carbon dioxide production by respiration. As light intensity increases further, the consumption of carbon dioxide in photosynthesis exceeds the production in respiration and there is a net consumption of carbon dioxide. In addition, photosynthesis will now produce more oxygen than respiration requires leading to net production of oxygen.

REF: K/U OBJ: 3.6 LOC: MP1.06

2. ANS:

Photorespiration is the oxidation of ribulose bisphosphate by rubisco and oxygen in light to form glycolate, which upon subsequent metabolism releases carbon dioxide. It is seen as a wasteful process both in terms of the carbon dioxide lost that could have become photosynthetic product, and the energy used along the way in releasing the carbon dioxide. This is a process that typically occurs in C_3 plants such as many deciduous trees. Two mechanisms have evolved in higher plants to counteract the process of respiration, they are C_4 and CAM photosynthesis.

C_4 photosynthesis is one response some plants have evolved to the problem of photorespiration. Plants such a corn and sugar cane are examples of such plants. The enzyme that fixes carbon dioxide in these plants is PEP carboxylase in the mesophyll cells of the vascular bundles, and the first product formed is oxaloacetate, a four carbon compound. PEP carboxylase has no oxygenase function as rubisco has so there is no initial problem with photorespiration. The oxaloacetate is converted to malate and shuttled into the bundle sheath cells where it is decarboxylated to pyruvate with the release of carbon dioxide which can now be fixed by rubisco which is present in these cells. However, the oxygen concentration in these cells is very low so photorespiration has been effectively eliminated but at the expense of some ATP. C_4 represents a spatial separation of photosynthesis.

CAM stands for crassulacean acid metabolism and is so named because it was first discovered in members of the plant family known as a the *Crassulacea* (e.g., cacti, pineapples, aloe). CAM is a way that some plants have evolved to avoid the problem of photorespiration. In this process the stomata of the plants are open during the night when it is cooler and less water can be lost. Carbon dioxide can enter, but the usual method of fixing the carbon, by using the energy produced in the light-dependent reactions obviously is not available. PEP carboxylase is used to fix carbon dioxide into organic acids which are stored in the vacuoles of the mesophyll cells. During the day, when the stomata are closed, the organic acids are decarboxylated and the carbon dioxide that is released is fixed by rubisco in the Calvin cycle which is located in the bundle sheath cells. There is a cost of some ATP in the process. CAM represents a temporal separation of photosynthesis.

REF: K/U OBJ: 3.4 LOC: MP1.05