BIOLOGY 1

WORKSHEET II - Selected Answers

(PHOTOSYNTHESIS, CELLULAR RESPIRATION, PROTEIN SYNTHESIS)
3. Write the equation for cellular respiration.

4. Draw a mitochondrion and label all structures. Indicate where the Krebs cycle and the electron transport chain occur.

5. Discuss the role of the following in cellular respiration:

   a. Cytoplasm
      The cytoplasm is where glycolysis takes place. Glycolysis is a reaction where six carbon glucose is split into two pyruvic acid molecules. The energy created by splitting glucose is used to make two ATP’s and two NAHPP’s. The process that occurs in the cytoplasm does not require oxygen, thus it is anaerobic.

   b. Cristae of the mitochondria
      The cristae is the inner membrane of the mitochondria. The electron transport chain takes place in the cristae. This is where most of the ATP is made in cellular respiration. Three ATP’s are generated for every NADPH that passes its electrons down the electron transport chain. Two ATP’s are generated for every FADH that passes its electrons down the chain. The final electron acceptor is oxygen. When oxygen accepts two electrons the waste product water is produced.

   c. Matrix of the mitochondria
      The matrix is where both the transition reaction and the Krebs Citric Acid Cycle take place. Pyruvic acid, which was produced in glycolysis, moves from the cytoplasm into the fluid matrix of the mitochondria and enters the transition reaction. In the transition reaction, a carbon is removed from three carbon pyruvic acid converting it to a two carbon compound called acetyl-Coenzyme A. The carbon that was removed from pyruvic acid is eliminated from the cell as carbon dioxide (One of the waste products of cellular respiration). Once the two carbon compound acetyl-Coenzyme A is created it enter the Kreb’s Citric Acid cycle.

   d. Glycolysis
      The cytoplasm is where glycolysis takes place. Thus six carbon glucose is split into two pyruvic acid molecules. The energy created by splitting glucose is used to make two ATP’s and two NAHPP’s. The process that occurs in the cytoplasm does not require oxygen, thus it is anaerobic.
e. The Krebs Cycle (Citric Acid Cycle)
The two carbon acetyl-Coenzyme A that was created in the transition reaction combines with a 4 carbon compound to make 6 carbon citric acid. Citric acid goes through a number of reactions in the citric acid cycle. The end result is that 2 carbons are removed for the 6 carbon citric acid creating a 4 carbon compound. The 2 carbons are removed from the cell as the waste product carbon dioxide. The energy released when citric acid is processed in the cycle results in the creation of 1 ATP, 3 NADH’s, 1 FADH, and 2 carbon dioxides for every turn of the cycle. The cycle turns once for every pyruvic acid that enters the matrix of the mitochondria. Since the cycle turns once for every pyruvic acid, it turns twice for every glucose that is processed in cellular respiration. (Remember - in glycolysis, glucose is split into two pyruvic acids.

The Krebs Cycle turns twice for every glucose molecule. Thus 2 ATP’s, 6 NADH’s, 2 FADH’s, and 4 carbons dioxides. The Krebs Cycle occurs in the matrix of the mitochondria.

f. The electron transport chain
The electron transport chain takes place in the cristae. This is where most of the ATP is made in cellular respiration. Three ATP’s are generated for every NADPH that passes its electrons down the electron transport chain. Two ATP’s are generated for every FADH that passes its electrons down the chain. The final electron acceptor is oxygen. When oxygen accepts two electrons (2 hydrogens) the waste product water is produced.

g. Glucose
Glucose is a carbohydrate. Carbohydrates are the primary source of energy in the diet since they are broken down by the digestive system into glucose. Glucose is a form of chemical energy. However, it cannot be used directly by the cell. In cellular respiration the energy in the chemical bonds of glucose is used to make ATP. I refer to ATP as cellular gasoline. It is a form of energy that can be used directly by the cell.

h. Lactic acid
Lactic acid is a waste product that is produced by animals and some bacteria when oxygen becomes limiting for the aerobic phase of cellular respiration. The steps of cellular respiration that occur in the mitochondria require oxygen. (Remember that oxygen is the final electron acceptor of the electron transport chain). If oxygen is not available the NADH produced in glycolysis passes 2 electron to pyruvic acid. Add 2 electrons (2 hydrogens) to pyruvic acid created the anaerobic waste product lactic acid.
I. Oxygen
The cristae is the inner membrane of the mitochondria. The electron transport chain takes place in the cristae. This is where most of the ATP is made in cellular respiration. Three ATP’s are generated for every NADPH that passes its electrons down the electron transport chain. Two ATP’s are generated for every FADH that passes its electrons down the chain. The final electron acceptor is oxygen. When oxygen accepts two electrons the waste product water is produced.

j. Carbon dioxide and water
These are the waste products of cellular respiration when oxygen is available. Carbon dioxide is produced in both the transition reaction and the Krebs cycle. Water is produced in the electron transport chain.

k. Alcohol (ethanol) and carbon dioxide
When yeast metabolize glucose for energy anaerobically these are waste products. Thus they are waste products of anaerobic respiration.

6. Define:
   a. Aerobic
   b. Anaerobic
   c. Electron transport chain

7. Discuss your knowledge of cellular respiration. Include the following terms in your discussion:
   a. Anaerobic phase
   b. Aerobic phase
   c. Glycolysis
   d. Cytoplasm
   e. Mitochondria
   f. Transition reaction
   g. Krebs cycle
   h. Matrix of mitochondria
   i. Electron transport
   j. Cristae
8. Compare and contrast the differences in cellular respiration when oxygen is readily available and when oxygen becomes limited in supply. Include differences in ATP production, electron transport, and waste products. Also describe the locations where the chemical pathways occur.

\[ \text{O}_2 \text{ Available (Normal Pathway)} \quad \text{O}_2 \text{ limited (Anaerobic pathway)} \]

9. List at least five physiologic effects of an aerobic conditioning program?

You needed to be in class the day I talked about this to answer this question!!! Remember - You will get better grades if you come to class!

10. Cardiac Output = Heart Rate \times\ Stroke Volume

The number of times the heart beats in one minute \times The volume pumped per beat

\[ \text{C.O.} = 70 \text{ beats/minute} \times 70 \text{ ml blood/beat} = 4900 \text{ ml/minute} \]

(About 5 liters/minute)

Thus at rest, your entire volume of blood is pumped by the heart in one minute!!!

11. List the equation for photosynthesis:

12. Define:
   a. Transpiration
   b. Stomata
   c. Stroma
   d. Thylakoid
   e. Granum

13. Describe the difference between oxidation and reduction.
14. The purpose of photosynthesis is to make glucose. Glucose contains six carbons. Where does the carbon come from to make glucose?

15. Draw a closed stomate and an open stomate. Label the guard cells. Indicate when each stomate is open and closed in a C₃ plant.

16. Draw a chloroplast and label all structures. Indicate where the light and dark reactions occur.

17. What is produced in the:
   a. Light reactions: ____________________ and _________________
   b. Dark reactions: ____________________ and _________________

18. Discuss the role of the following in photosynthesis:
   a. Stomata
      The carbon in carbon dioxide is used to make glucose which has 6 carbons in it. Thus carbon dioxide is required for photosynthesis. Carbon dioxide can enter a leaf when the stomata are open. A stomate is a pore in a leaf surrounded by two guard cells. When the stomata are open and carbon dioxide enters, water is lost. The evaporative water loss by a plant through open stomata is called transpiration.
   
   b. Light
      Light is required for photosynthesis. To form the chemical bonds between the 6 carbons in a glucose molecule, energy is required. Light energy is the energy that drives the process. The light reaction convert light energy to ATP and NADPH (High potential energy molecules) ATP and NADPH are used to fuel the creation of glucose in the dark reactions.
   
   c. Chlorophyll
      Chlorophyll is the primary photosynthetic pigment. Chlorophyll absorbs light energy. (It does not absorb green light - it reflects it. Thus chlorophyll appears green.
   
   d. Carotenoids
      These are accessory pigments in the leaf. They are yellow, orange, and red pigments. They absorb the green light that chlorophyll cannot, thus they make more colors of light available for photosynthesis.
e. Stroma
This is the fluid in the chloroplast. The stroma is where the dark reactions occur. Six carbon dioxides and converted to glucose in the stroma, thus it is where glucose is made.

f. Thylakoid (Inner membrane of chloroplast)
This is where the light reactions occur. Thus chlorophyll is found on the thylakoid membrane. The thylakoid is where light energy is absorbed and converted to chemical energy in the form of ATP and NADPH.

g. Water
Water is the electron source for the formation of NADPH. When two electrons are removed from water, the waste product oxygen is produced.

h. Carbon dioxide
Carbon is removed from carbon dioxide to make glucose. It takes 6 carbon dioxides to make one 6 carbon glucose in photosynthesis.

i. ATP and NADPH (NADPH₂)
These molecules are made in the light reactions. They are used to fuel the dark reactions.

19. What is transpiration? How would you expect temperature, wind velocity, light intensity, and relative humidity to influence transpiration rates?

   a. Temperature:

   b. Wind velocity

   c. Light intensity

   d. Relative humidity
   RH is the amount of water in air. When it is raining the relative humidity is 100%. The higher the relative humidity the lower the transpiration rate. When the air is dry (like in the desert in the summer), the relative humidity is low, and the transpiration rate is high.
33. Consider the following mRNA strand:

\[ \textit{5'}\text{AUG UUA AAU UUC UCA UUA ACC U3'} \]

a. What is the primary structure of the protein (amino acid sequence) synthesized from this mRNA template?

\[ \textit{5'}\text{AUG UUA AAU UUC UCA UUA ACC U3'} \]

Met Leu Asn Phe Ser Leu Thr

b. Diagram the DNA segment which produced the above mRNA. Indicate which strand served as the template.

\[ \textit{5'}\text{AUG UUA AAU UUC UCA UUA ACC U3'} \]

TAC AAT TTA AAG AGT AAT TGG A

c. Diagram the tRNA for the first amino acid showing the amino acid attached and the anticodon.
d. If the mRNA was treated with nitrous acid (a mutagenic agent) which converts cytosine bases to uracil (C ----- U), what would the primary structure of the protein be?

Normal RNA

5’ AUG UUA AAU UUC UCA UUA ACC U3

Mutated RNA

AUG UUA AAU UUU UUA UUA AAU AUU U

Met Leu Asn Phe Leu Leu Leu Isoelucine

34. Consider the following DNA strand:

a. Draw the mRNA that would be synthesized from the DNA strand with the “arrow”

AUG GAU

Met - Asp

b. How long of a protein could be synthesized form the mRNA strand?

2 amino acids long.
AUG codes for the amino acid methionine
GAU codes for the amino acid aspartic acid

35. What kind of mutation causes sickle cell anemia? Why has this mutation been selected for in certain African populations?