AP Biology

Interactive Student Study Guide

North Salem University

MISSION: *Engage students to continuously learn, question, define and solve problems through critical and creative thinking.*

Spring 2024

Photosynthesis and cellular respiration are key ecological concepts involved with energy flow. Photosynthesis converts solar energy into chemical energy (SUN →G3P→ Glucose) and cellular respiration converts glucose into ATP which is used to fuel life. Both processes are crucial for life on earth and both involve the electron transport chain, chemiosmosis and phosphorylation

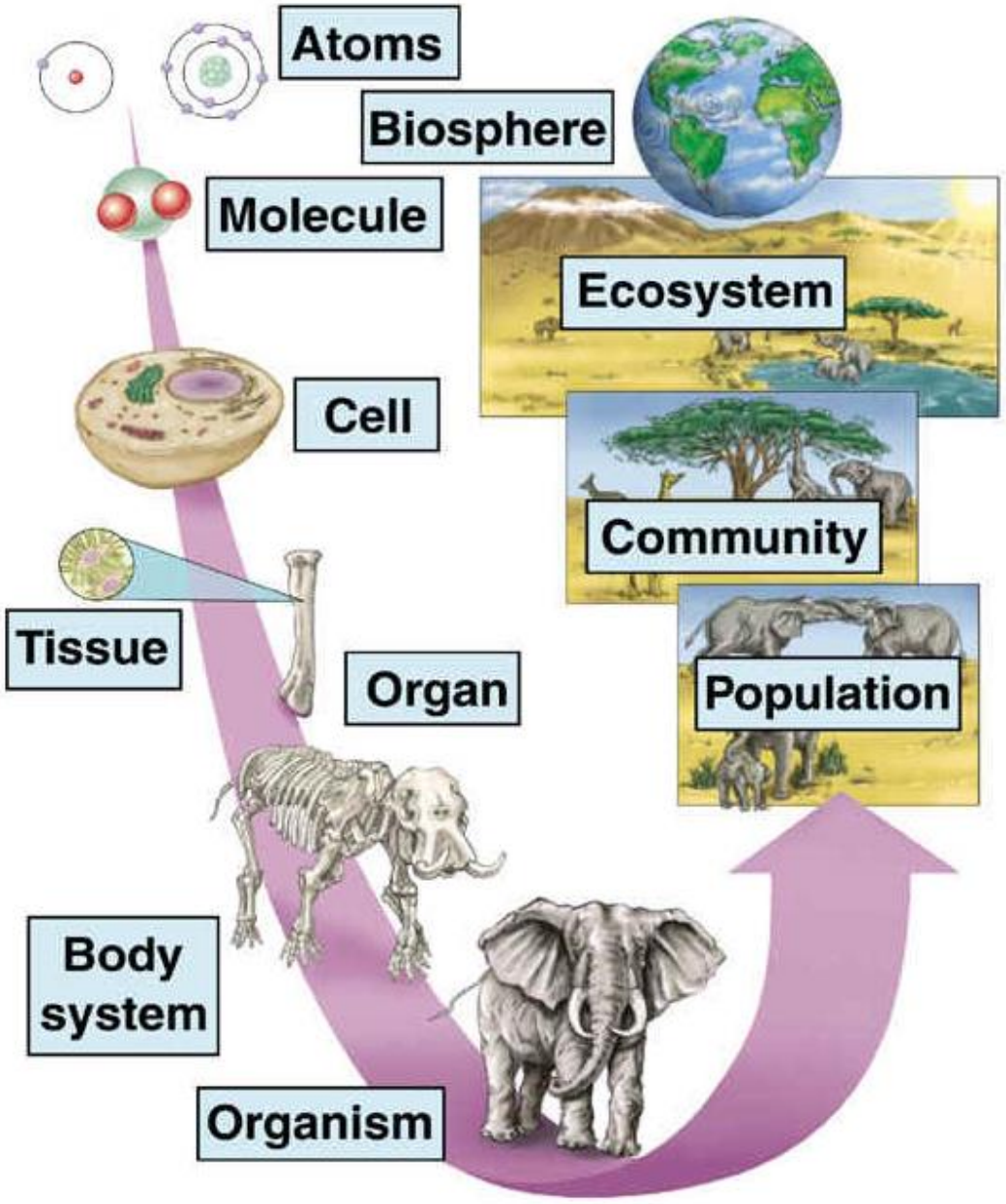
If you have any problems – please sign up for extra help after school.

Energy

Ch.10 - Photosynthesis
Ch.9 – Cellular Respiration

Organization of Life

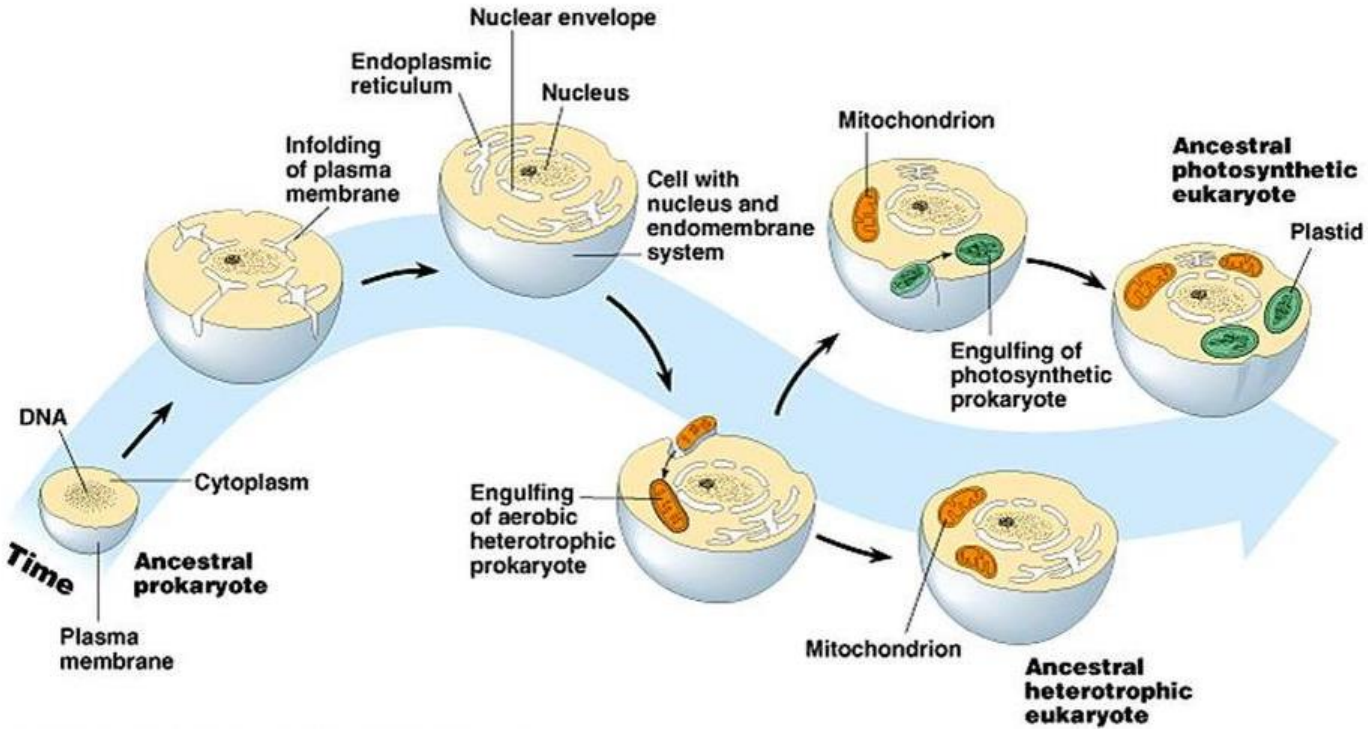
(Prior Knowledge)



Evolution of Eukaryotic Cells

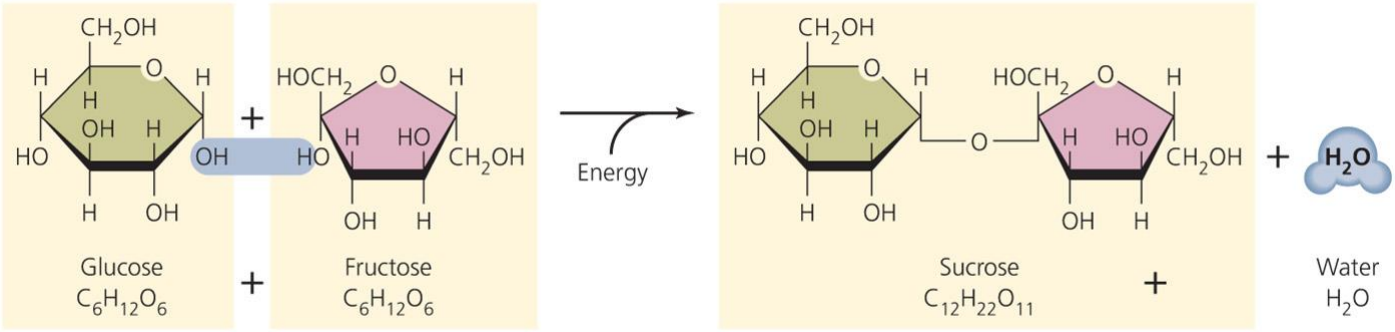
(Prior Knowledge)

The Endosymbiotic Theory



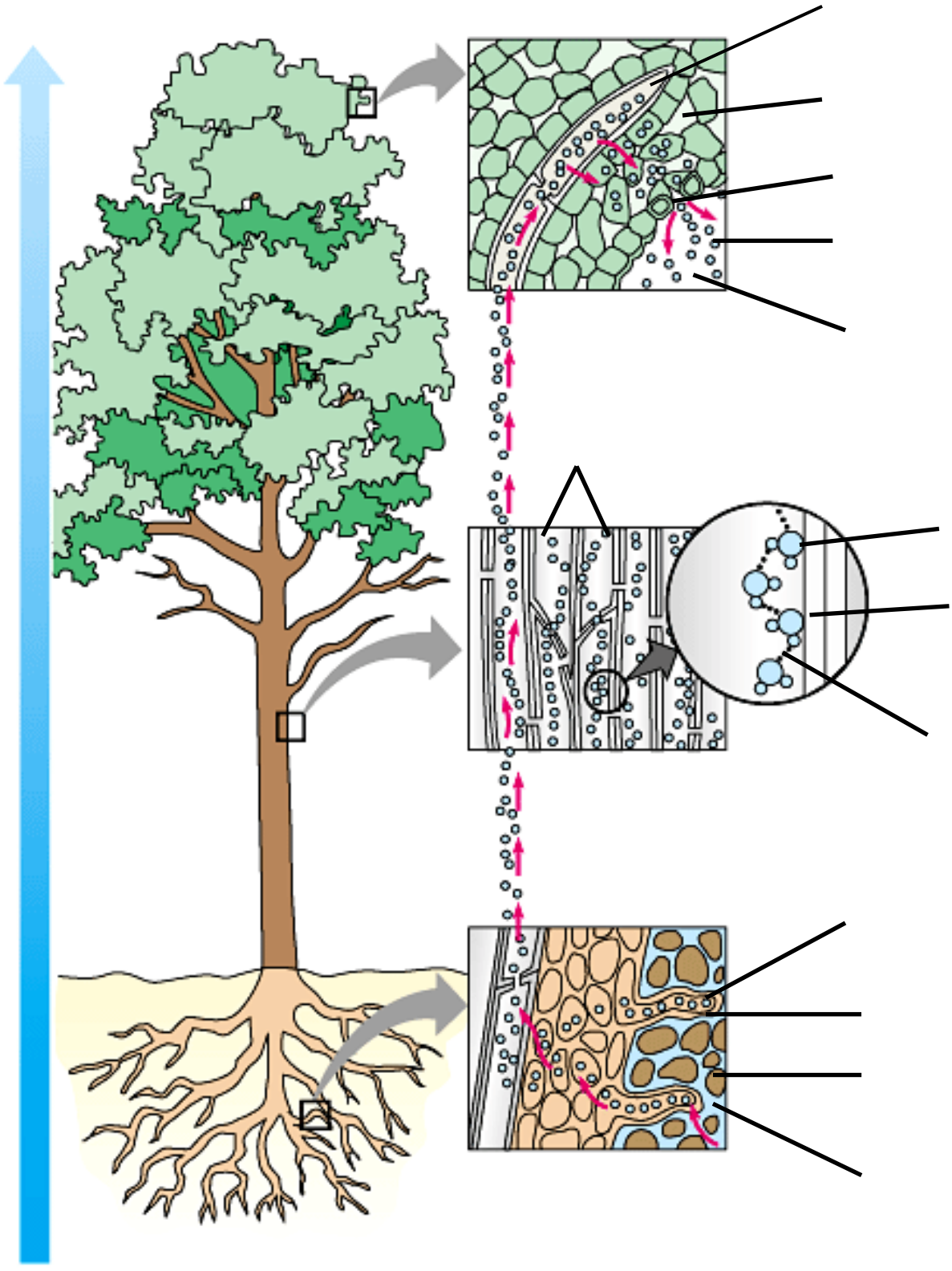
Dehydration Synthesis of Carbohydrates

(Prior Knowledge)



Ascent of Water in a Tree

(Prior Knowledge - Figure 36.1)



First Law of Thermodynamics:

(Prior Knowledge)

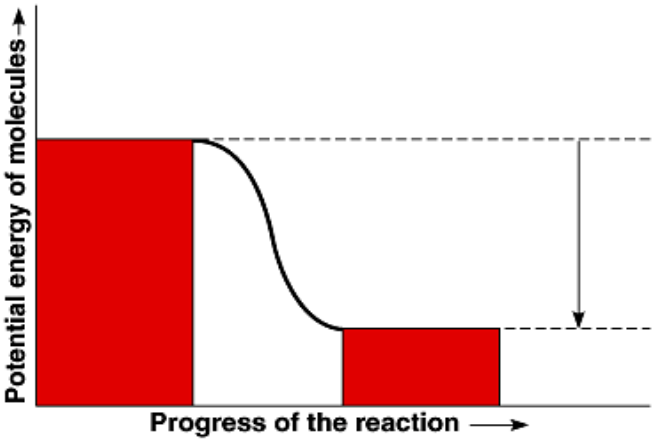
Energy cannot be _____ or _____.

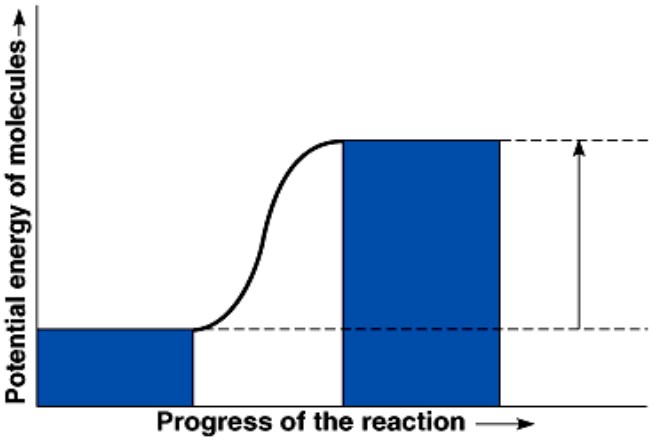
(Energy can be transformed from one form to another)

In cellular metabolism, exergonic reactions power endergonic reactions.

(energy coupling)

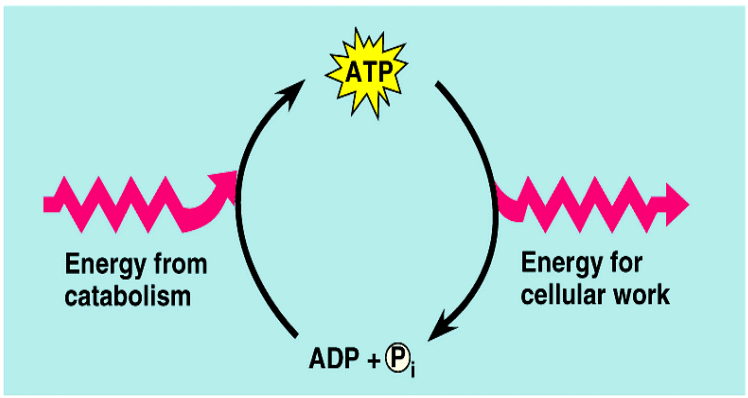
_____ _____





Example: _____

Example: _____



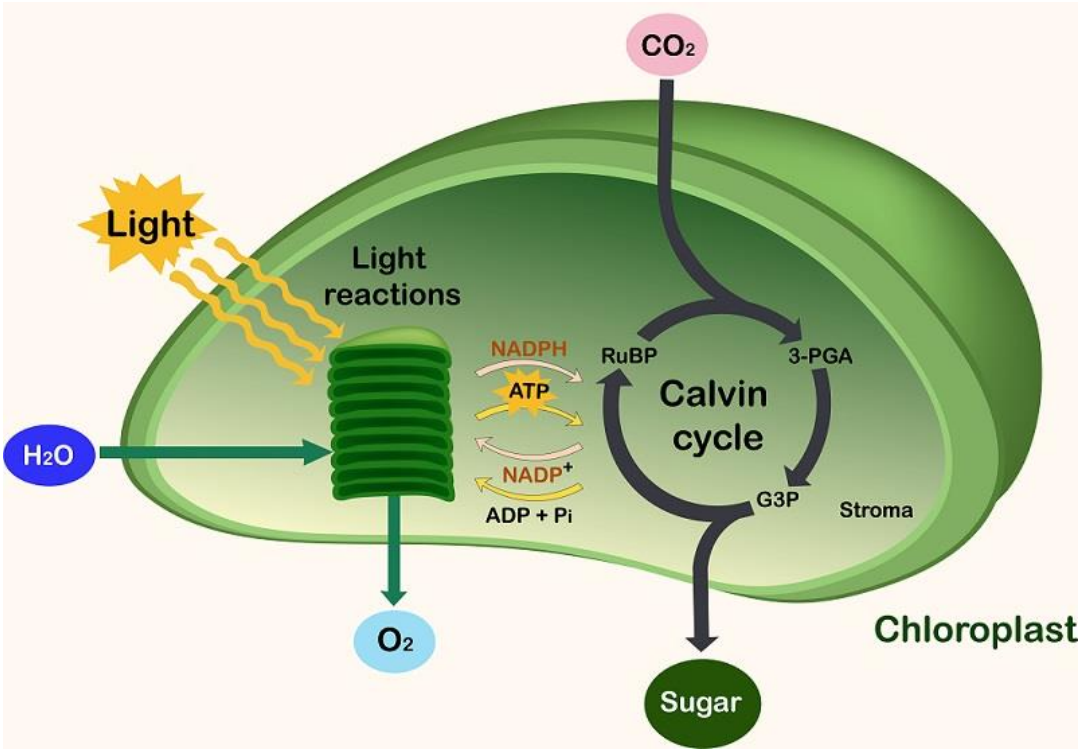
Chapter 10: Photosynthesis

This chapter covers in detail how autotrophs (green plants) ***reduce*** *the carbon dioxide and convert it into organic compounds (glucose) that can then be to converted into ATP (the energy of cells).*

Remember: Photosynthesis is a **FOOD THING**! A form of **AUTOTROPHIC NUTRITION** where plants ***REDUCE*** $\mathbf{CO_2}$ to produce $\mathbf{C_6H_{12}0_6}$. What a plant does with its glucose is the same thing you do with yours. It gets sent to the mitochondria where it is ***OXIDIZED*** and used to **phosphorylate** ADP into ATP…the fuel of cells**.**

OBJECTIVES:

__1. Distinguish between autotrophic and heterotrophic nutrition.
__2. Describe the structure of chloroplasts and indicate their locations within plant cells. Describe why and where most chloroplasts are located in a leaf.
__3. Explain how chloroplast structure relates to its function.
__4. Write a summary equation for photosynthesis.
__5. Explain the role of redox reactions in photosynthesis.
__6. Describe, in general, the two main stages of photosynthesis.
__7. Describe the relationship between an action spectrum and an absorption spectrum.
__.8 Describe the ETC, chemiosmosis and photophosphorylation as it takes place in the chloroplasts.
__.9 Summarize the carbon-fixing reactions of the Calvin cycle and describe how RuBP is regenerated.
__10. Describe the role of ATP and NADPH in the Calvin cycle.
__11. Describe the fate of photosynthetic products.

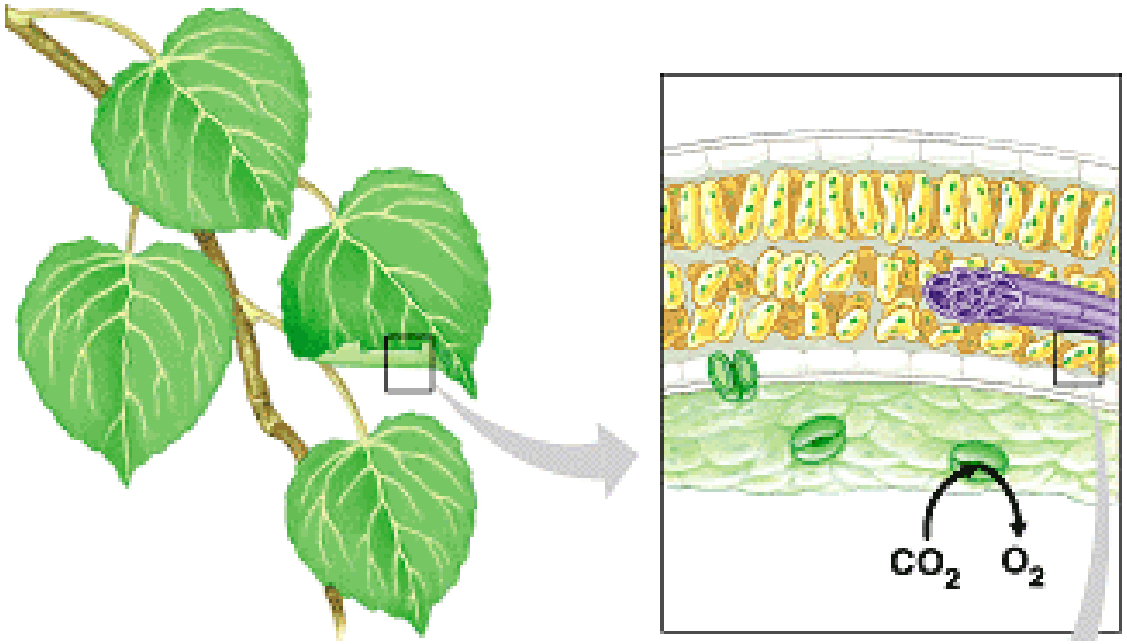


Part I. Photosynthesis in Nature

1. As a review, define the terms *autotroph* and *heterotroph*. Keep in mind that plants have mitochondria and chloroplasts and do both cellular respiration and photosynthesis!

2. Where is the major site of photosynthesis in most plants?

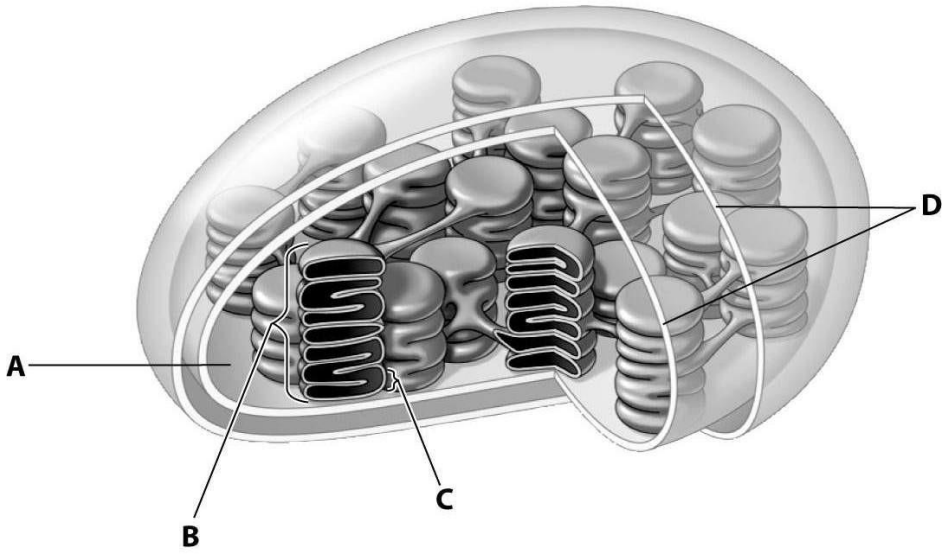
3. Label the diagram below and use it to explain how CO_2 and O_2 enter and exit the leaf? What processes do you think control the passage of these gases in and out of the leaf? Why are most of the stomata are located on the underside of the leaf?



*** * * HOMEOSTASIS * * ***

4. Why are plants green and what function does this pigment serve?

5. Chloroplasts are the photosynthetic organelles of plants. Label the diagram of the chloroplast below.

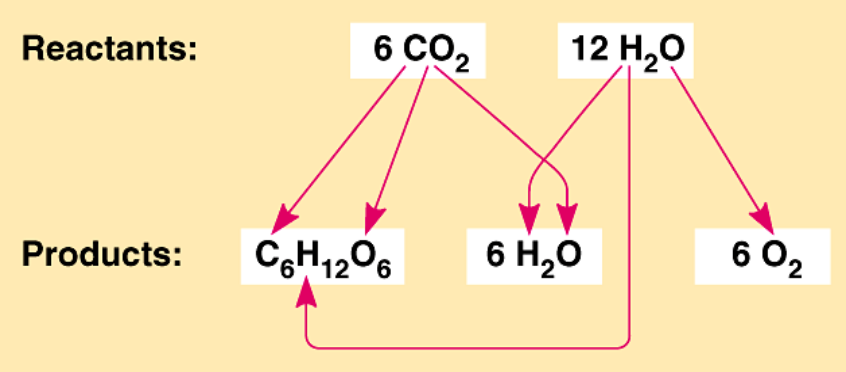


	Name	Function
A		
B		
C		
D		

Part II. The Pathways of Photosynthesis

6. Write out the formula for photosynthesis *(use the one that indicates only the net consumption of water*). The formula is the opposite of cellular respiration. You should know both formulas from memory.

7. Use the diagram to the right and O_{18} as the basis of your answer to explain how we know that the oxygen released in photosynthesis comes from water and not carbon dioxide.



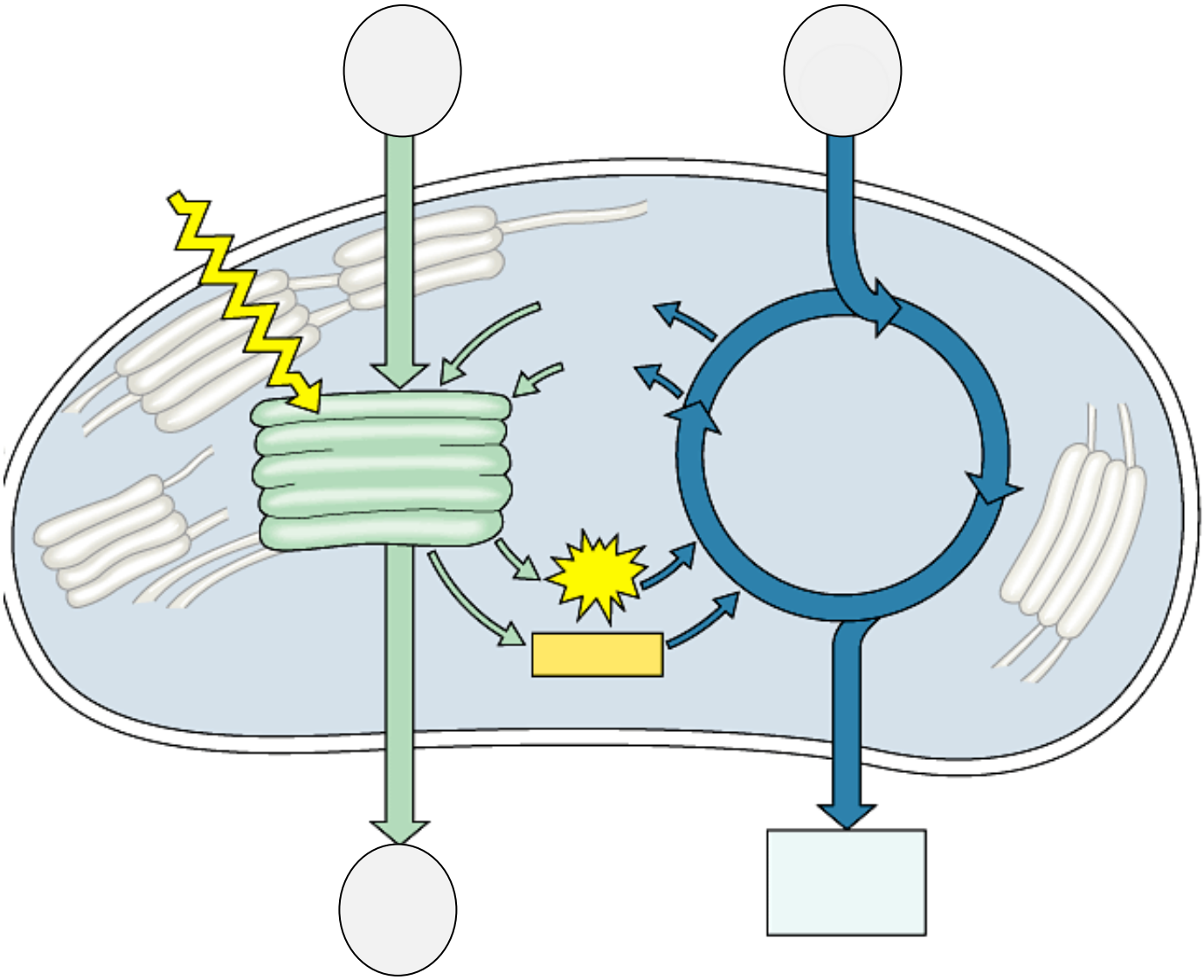
8. Photosynthesis is not a single process, but two processes, each with multiple steps.

a. BRIEFLY describe what occurs in the *light reactions* stage of photosynthesis. Be sure to use *NADP+ in your answer.*

b. BRIEFLY describe the *Calvin cycle*, utilizing the term *carbon fixation* in your discussion.

9. The details of photosynthesis will be easier to organize if you can visualize the overall process. Label **Figure 10.4**, below. As you work on this, underline the items that are cycled between the light reactions and the Calvin cycle.

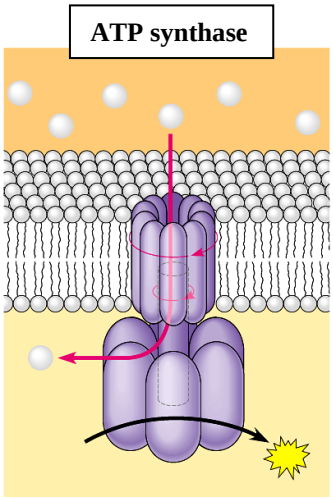
Concept: ***The light reactions and the Calvin Cycle cooperate in converting light energy to the chemical energy of food (sugar).***



Concept: ***The light reactions convert solar energy to the chemical energy of ATP and NADPH***

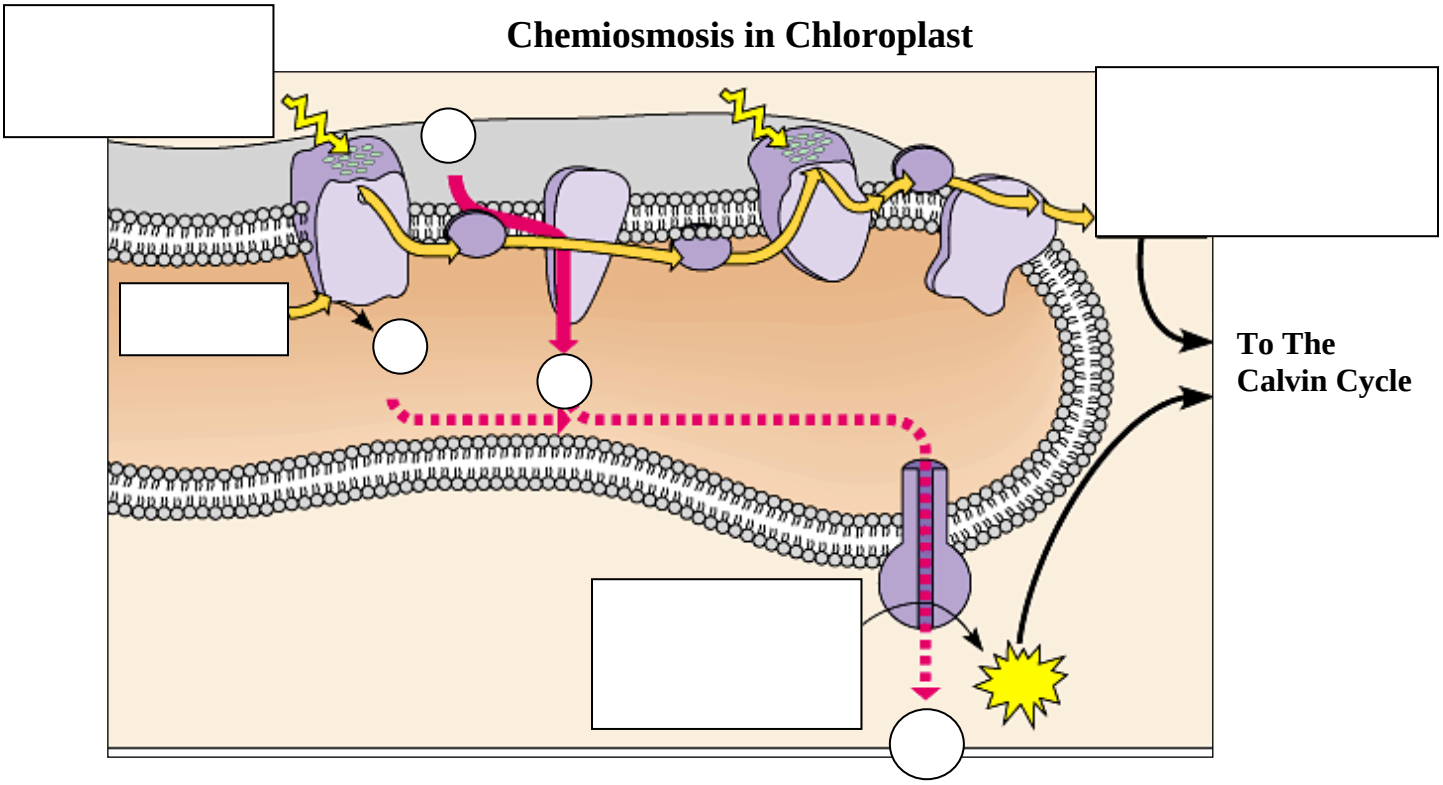
10. The last idea in this challenging concept is how chemiosmosis works in photosynthesis to generate ATP needed to build glucose in the next stage of photosynthesis. Define Chemiosmosis. *(p.167)*

11. Central to the generation of ATP during chemiosmosis is the protein complex ATP Synthase. Label the diagram to the right and use it to explain how it is used to generate ATP. *(p.167)*



12. Use the diagram below to help you explain the organization of the thylakoid membrane (*structure*) and the process of chemiosmosis (*function*). Label all the locations in the diagram first.

Chemiosmosis in Chloroplast



13. Hydrogen: atomic # = _____ Atomic mass = _____

14. Now that you know that Hydrogen is composed of 1 proton (H+) and 1 electron (-), what is **proton-motive force**?

MAIN IDEA:

The products of the light reactions (NADPH and ATP) are needed for the Calvin Cycle.

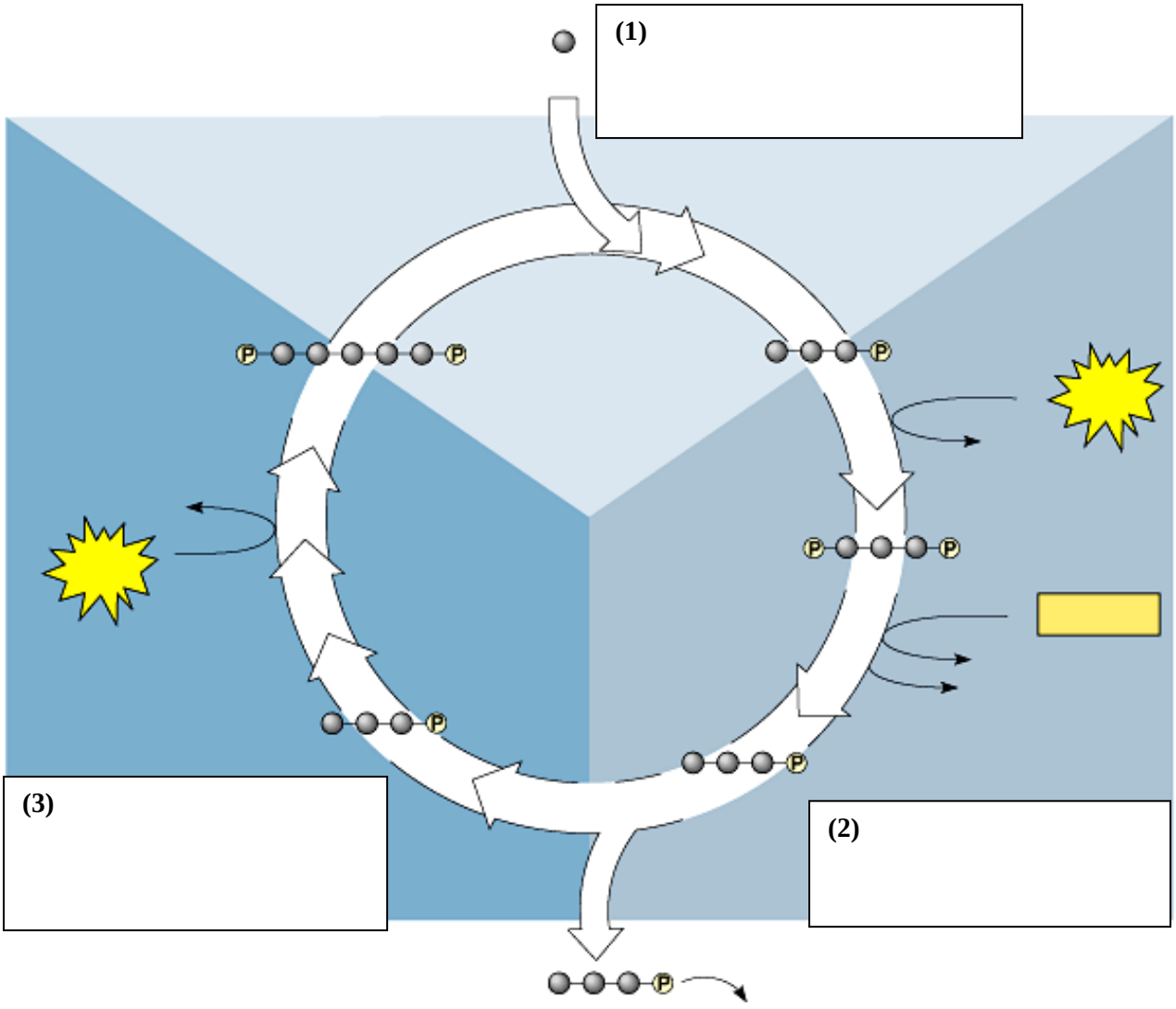
Concept: ***The Calvin cycle uses ATP and NADPH to convert (reduce/fix) CO_2 into G3P and $C_6H_{12}O_6$***

*The Calvin cycle is a **metabolic** pathway in which each step is governed by an enzyme, much like the Krebs/citric acid cycle from cellular respiration you will see in the next section. However, keep in mind that the Calvin cycle uses energy (in the form of ATP and NADPH) and is therefore **anabolic**; in contrast, cellular respiration is **catabolic** and releases energy.*

15. As previously stated, the light reactions store chemical energy in _____ and _____, which shuttle the energy to the carbohydrate-producing _____ cycle.

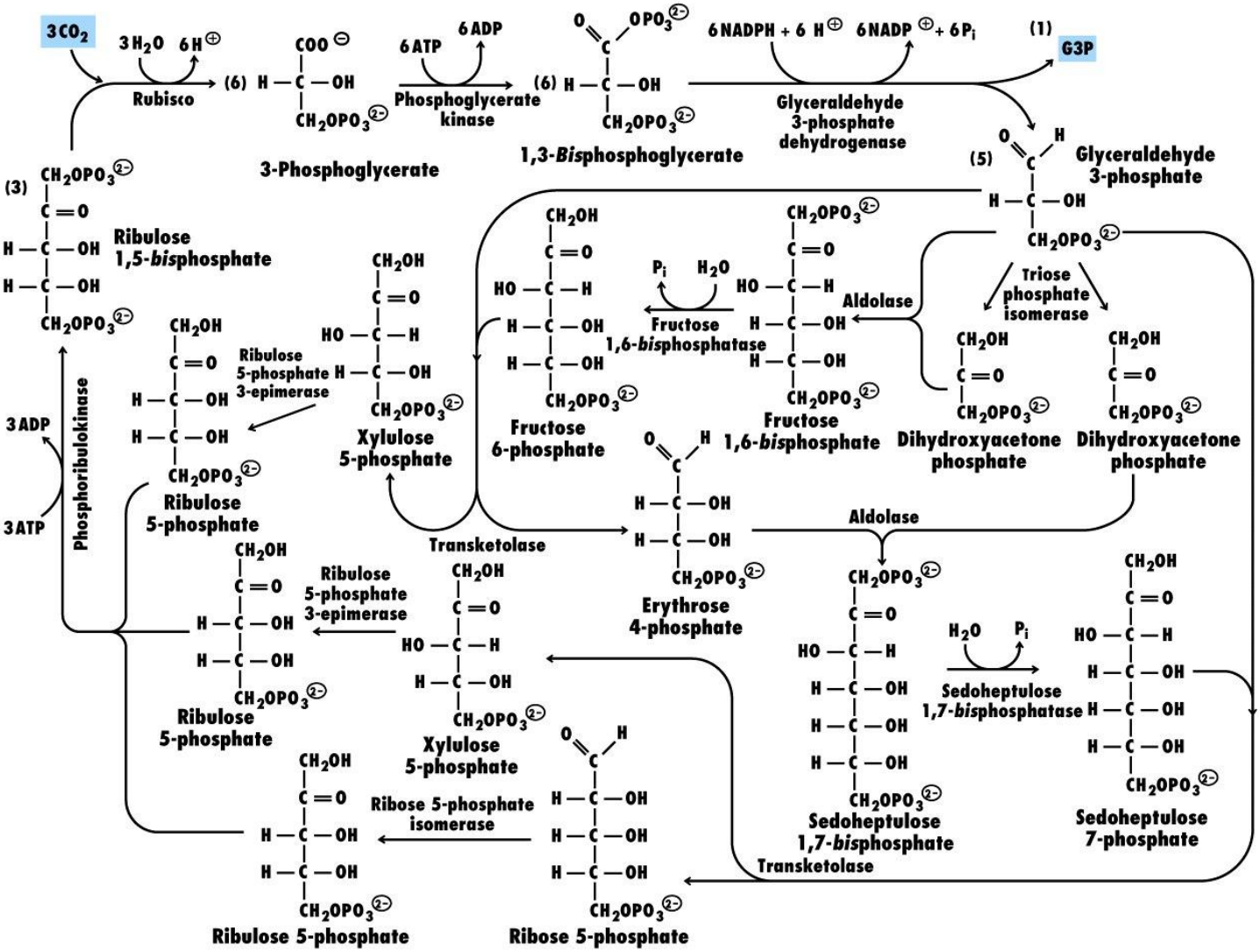
16. The carbohydrate produced directly from the Calvin cycle is not glucose, but the three-carbon compound _____. Each turn of the Calvin cycle fixes one molecule of CO_2; therefore, it will take _____ turns of the Calvin cycle to net one G_3P.

17. Use the diagram below to help you explain the important events that occur in the *carbon fixation* stage of the Calvin cycle.



The Calvin Cycle

(A closer look.)



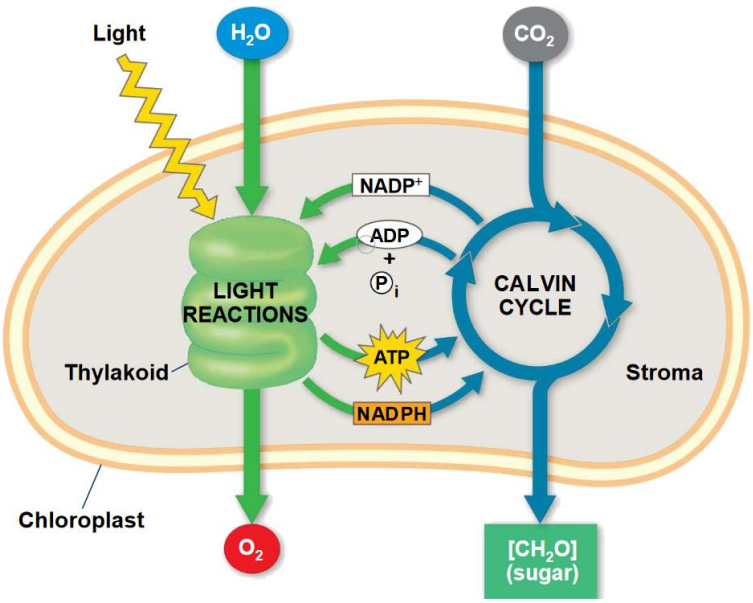
Chapter 10 - Summary

The process of **photosynthesis** transformed life on Earth. By harnessing energy from the sun, the evolution of photosynthesis allowed living things access to enormous amounts of energy. Because of photosynthesis, living things gained access to sufficient energy that allowed them to build new structures and achieve the biodiversity evident today.

Only certain organisms, called **photoautotrophs**, can perform photosynthesis; they require the presence of **chlorophyll**, a specialized pigment that absorbs certain portions of the visible spectrum and can capture energy from sunlight. Photosynthesis uses carbon dioxide and water to assemble carbohydrate molecules and release oxygen as a waste product into the atmosphere. Eukaryotic autotrophs, such as plants and algae, have organelles called **chloroplasts** in which photosynthesis takes place, and starch accumulates. In prokaryotes, such as cyanobacteria, the process is less localized and occurs within folded membranes, extensions of the plasma membrane, and in the cytoplasm.

The pigments of the first part of photosynthesis, the **light-dependent reactions**, absorb energy from sunlight. A **photon** strikes the antenna pigments of **photosystem II** to initiate photosynthesis. The energy travels to the reaction center that contains chlorophyll *a* and then to the **electron transport chain**, which *pumps* hydrogen ions into the **thylakoid interior** called the **lumen**. This action builds up a high concentration of **H+ ions**. The H+ ions flow through **ATP synthase** via **chemiosmosis** to form molecules of ATP, which are used for the formation of sugar molecules in the second stage of photosynthesis. **Photosystem I** absorbs a second photon, which results in the formation of an **NADPH** molecule, another energy and reducing power carrier for the light-independent reactions.

Using the energy carriers formed in the first steps of photosynthesis, the light-independent reactions, or the Calvin cycle, take in CO_2 from the environment. An enzyme, **RuBisCO**, catalyzes a reaction with CO_2 and another molecule, **RuBP**. After three cycles, a three-carbon molecule of **G3P** leaves the cycle to become part of a carbohydrate molecule. The remaining G3P molecules stay in the cycle to be <u>regenerated into RuBP</u>, which is then ready to react with more CO_2. Photosynthesis forms an energy cycle with the process of cellular respiration. Plants need **<u>both</u>** photosynthesis and respiration for their ability to function in both the light and dark, and to be able to interconvert essential metabolites. Therefore, plants contain both chloroplasts and mitochondria.



Chapter 10 - Review Questions

___1. What is the name given to organisms that can make their own food and thus sustain themselves without consuming organic molecules derived from other organisms?
A) chemotrophs
B) heterotrophs
C) synthesizers
D) autotrophs

___2. What is the likely origin of chloroplasts?
A) mitochondria that had a mutation for photosynthesis
B) photosynthetic prokaryotes that lived inside eukaryotic cells
C) prokaryotes with photosynthetic mitochondria
D) eukaryotes that engulfed photosynthetic fungi

___3. In most green plants, chloroplasts are -
A) concentrated in a zone of leaf tissue called the palisade mesophyll.
B) concentrated in a portion of the leaf called the stroma.
C) evenly distributed throughout the leaf tissue.
D) evenly distributed throughout the entire plant.

___4. CO_2 enters and O_2 escapes from a leaf through -
A) stomata. B) thylakoids. C) grana. D) stroma.

___5. In the chloroplast, sugars are made in a compartment that is filled with a thick fluid called the -
A) stomata. B) thylakoid. C) matrix. D) stroma.

___6. Chloroplasts contain disk-like membranous sacs arranged in stacks called -
A) cristae. B) thylakoids. C) grana. D) vacuoles.

___7. Where exactly is chlorophyll found in a plant cell?
A) stroma B) cristae C) cytoplasm D) thylakoid membranes

___ 8. The oxygen released into the air as a product of photosynthesis comes from -
A) water. B) glucose. C) carbon dioxide. D) chlorophyll.

___9. Which of the following molecules is both a reactant and a product of photosynthesis?
A) H_2O B) glucose C) O_2 D) chlorophyll

___10. A redox reaction involves the transfer of -
A) oxygen. B) water. C) electrons. D) carbon dioxide.

___11. What is the ultimate source of energy that drives photosynthesis?
A) light (photon) B) electromagnetism C) ATP D) cellular respiration

___12. The light reactions occur in the _____, while the Calvin cycle occurs in the _____.
A) stroma . . . thylakoid membranes
B) stroma . . . nucleus
C) cytoplasm . . . thylakoid membrane
D) thylakoid membranes . . . stroma

___ 13. Which color contributes the *least* energy to photosynthesis?
A) blue B) red C) orange D) green

___ 14. Carbon fixation -
A) occurs when carbon atoms from CO_2 are incorporated into an organic molecule.
B) supplies the cell with ATP.
C) occurs during the light reactions.
D) provides the cell with a supply of NADPH molecules.

___15. Why are most plants green?
A) Chlorophyll *a* reflects green light.
B) Chlorophyll *a* absorbs green light.
C) Chlorophyll *b* primarily uses green light as the source of energy for photosynthesis.
D) Green helps plants blend into their environment as a sort of camouflage.

___16. Of the following wavelengths of light, which would you expect to be reflected or transmitted by chlorophyll *a*?
A) blue B) green C) yellow D) red

___17. The electron transport chains of the light reactions -
A) are located in the stroma.
B) shuttle electrons along in a series of redox reactions.
C) provide energy for the citric acid cycle.
D) are found on the plasma membrane of mesophyll cells.

___18. The enzyme complex ATP synthase -
A) is a nucleic acid complex.
B) couples the flow of H^+ to the phosphorylation of ADP.
C) is found in the stroma.
D) helps transport H^+ against the concentration gradient.

___19. Photosynthetic organisms derive their carbon from -
A) carbon monoxide.
B) carbon dioxide.
C) hydrocarbons.
D) methane.

___20. ATP and NADPH -
A) power sugar synthesis during the Calvin cycle.
B) are products of the Calvin cycle.
C) provide energy to Photosystem I and Photosystem II.
D) are used in the electron transport chain to pump H^+ into the thylakoid space.

___21. The Calvin cycle constructs _____, an energy-rich molecule that a plant cell can then use to make glucose or other organic molecules.
A) G3P B) ATP C) NADH D) carbon dioxide

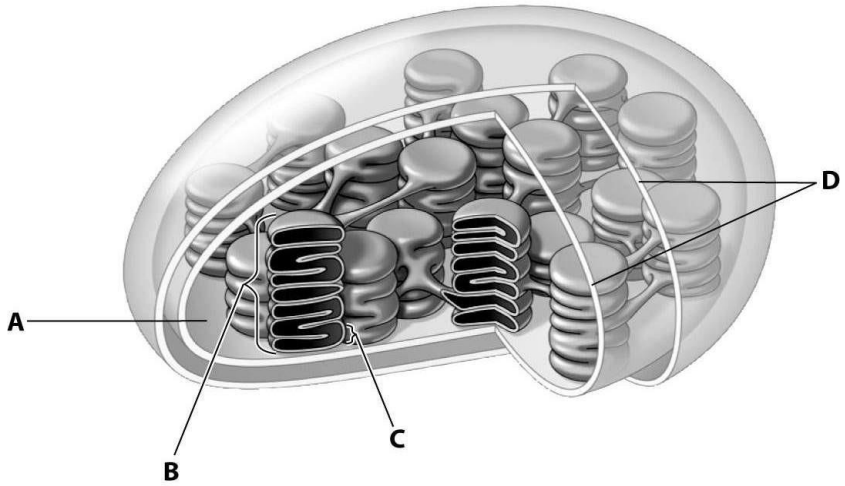
___22. The ultimate source of all the food we eat and the oxygen we breathe is -
A) cellular respiration.
B) photosynthesis.
C) glycolysis.
D) anaerobic metabolism.

___23. Plants use sugars as -
A) a fuel for photosynthesis.
B) a starting material for the Calvin cycle.
C) a source of electrons for chemiosmosis.
D) a fuel for cellular respiration

___24. Plant cells -
A) lack mitochondria and chloroplasts.
B) lack mitochondria but have chloroplasts.
C) have mitochondria but do not have chloroplasts.
D) have mitochondria and chloroplasts.

___25. Global warming due to the greenhouse effect may be -
A) moderated by photosynthesis, which removes carbon dioxide from the atmosphere.
B) made worse by photosynthesis, which adds carbon dioxide to the atmosphere.
C) reduced by the burning of fossil fuels, which removes oxygen from the atmosphere.
D) of little concern, since it is part of the normal cycle for the planet.

Base your answers to each of the following questions on the diagram to the right.



___26. Grana

___27. Stroma

___28. Thylakoids

___29. Site of the light reactions.

___30. Site of the Calvin Cycle.

___31. Location of chlorophyll *a* and *b* molecules.

___32. Which part of the chloroplast shown enhances its ability to produce glucose by increasing surface area?
A) structure A B) structure B C) structure C D) structure D

___33. Where do the Light Reactions take place?
A) structure A B) structure B C) structure C D) structure D

___34. Where does the Calvin Cycle take place?
A) structure A B) structure B C) structure C D) structure D

___35. Where does the Electron Transport Chain take place?
A) structure A B) structure B C) structure C D) structure D

Chapter 9: Cellular Respiration

This chapter covers in detail how organisms (aerobes and anaerobes) ***oxidize*** *the sugars produced in photosynthesis via the reduction of CO_2 and use this energy to convert ADP into ATP (the energy of cells).*

$$C_6H_{12}O_6 + \underline{6}O_2 \Rightarrow \underline{6}CO_2 + \underline{6}H_2O + \textit{36/38ATP}$$

(energy)

OBJECTIVES:

___ 1. Summarize the equation for cellular respiration.
___ 2. Define oxidation and reduction.
___ 3. Explain how redox reactions are involved in energy exchanges.
___ 4. Explain why organic molecules that have an abundance of hydrogen are excellent cellular fuels.
___ 5. Describe the role of NAD+ and the electron transport chain during respiration.
___ 6. Describe the regions where glycolysis, the Krebs cycle, and the electron transport chain occur.
___ 7. List the reactants, products and main events of glycolysis, the Krebs cycle, and the electron transport chain
___ 8. Describe the process of chemiosmosis.
___ 9. Explain how membrane structure is related to membrane function in chemiosmosis.
___ 10. Summarize the net ATP yield from the oxidation of a glucose molecule.
___ 11. Explain why fermentation is necessary.
___ 12. Compare the processes of fermentation and cellular respiration.
___ 13. Describe evidence that the first prokaryotes produced ATP by glycolysis.
___ 14. Describe how food molecules other than glucose can be oxidized to make ATP.

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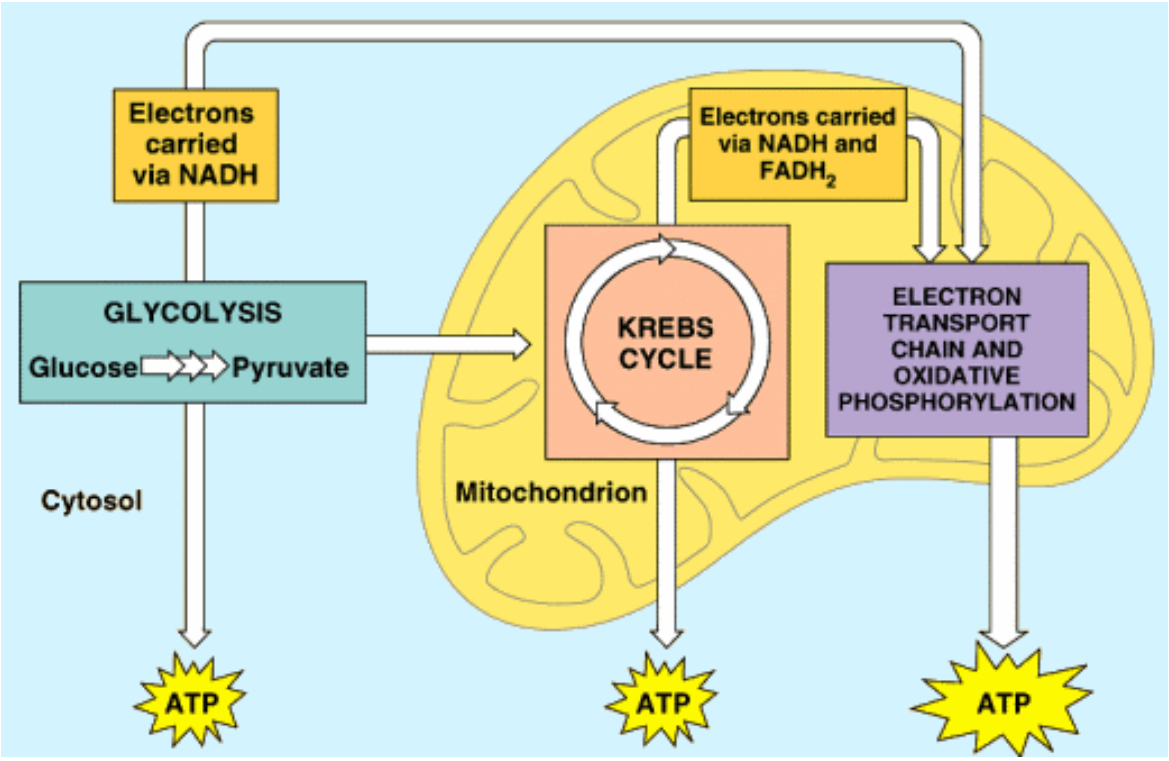
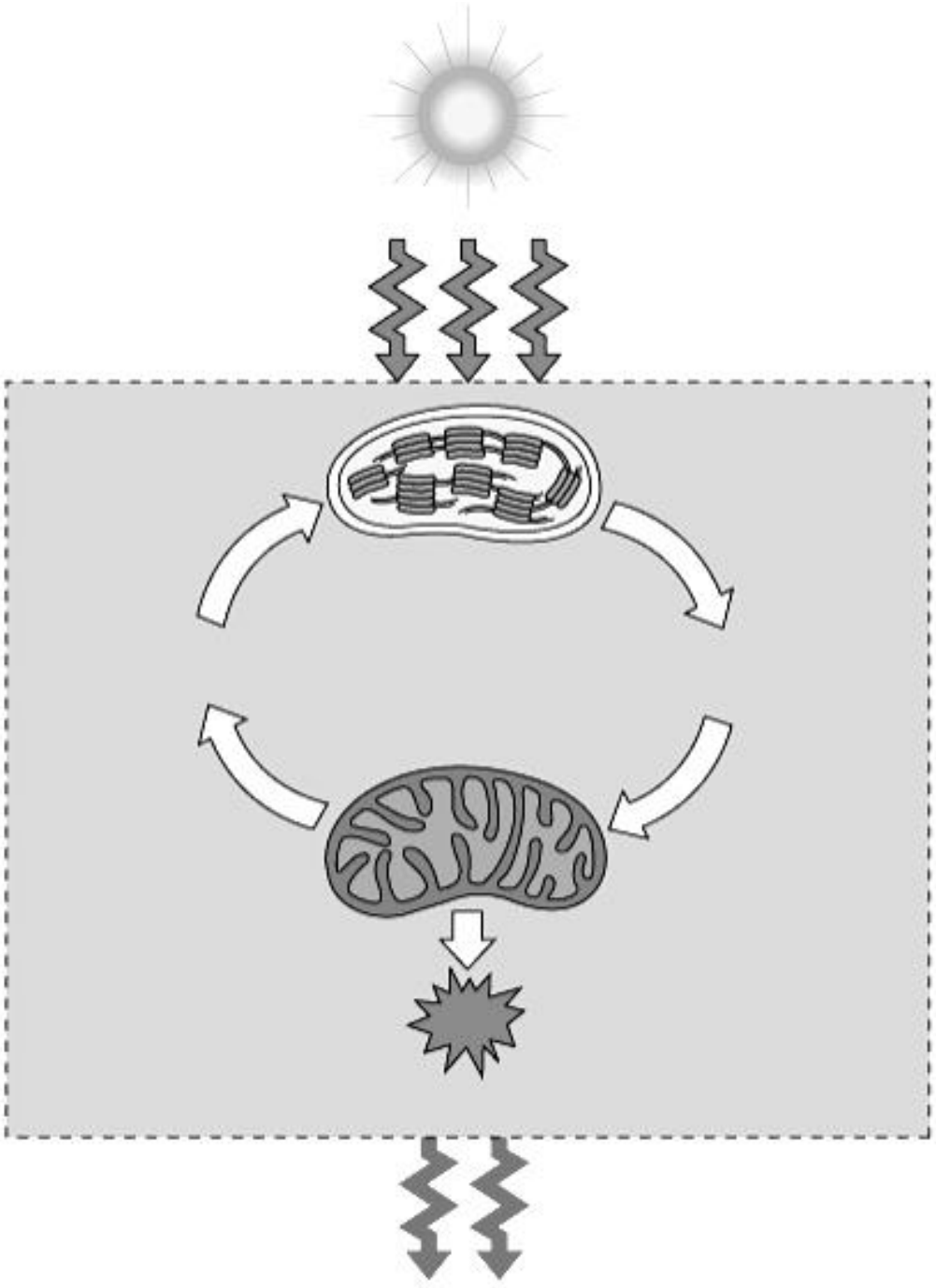


Overview: Before getting involved with the details of cellular respiration, take a second to look at the big picture. Photosynthesis and cellular respiration are key ecological concepts involved with energy flow. Label Figure 9.1 below and use it to help explain the flow of energy and chemical recycling that takes place in ecosystems.

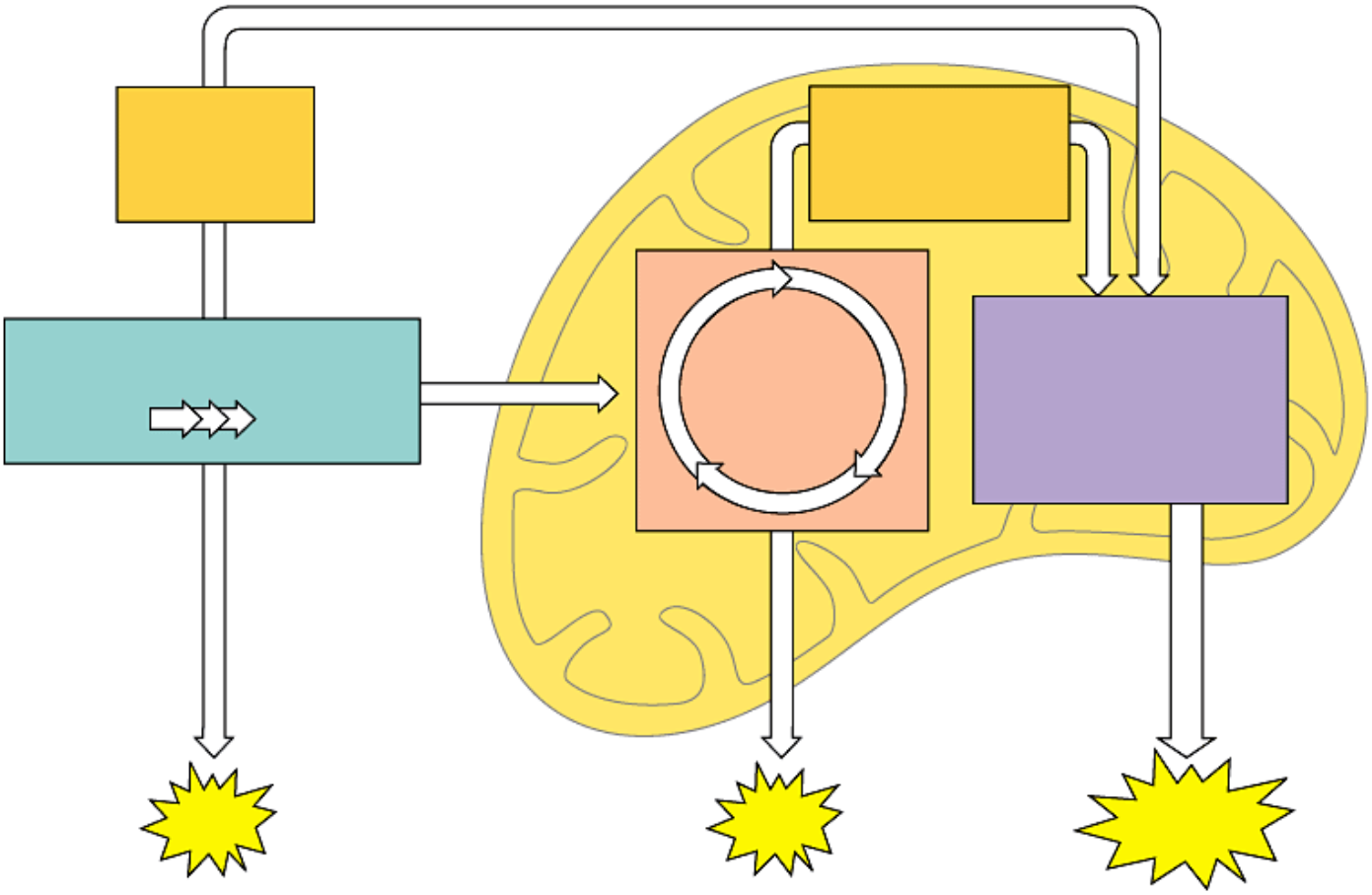


Principles of Energy Harvest

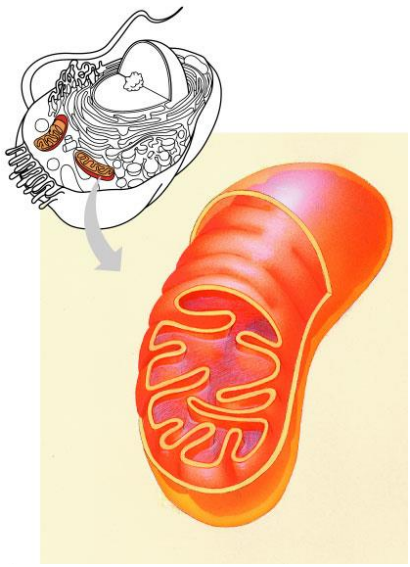
18. Both cellular respiration and photosynthesis are *redox reactions*. In redox, reactions pay attention to the flow of electrons. What is the difference between oxidation and reduction?

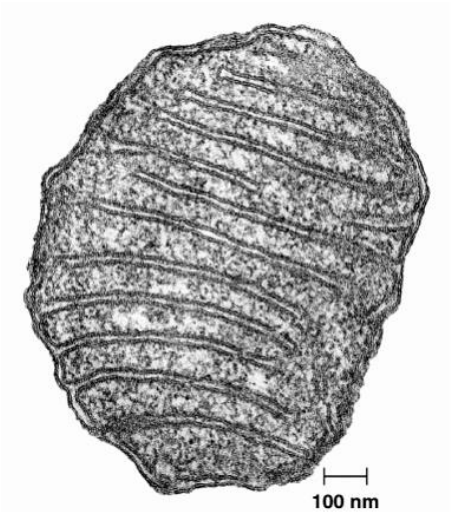
19. In cellular respiration, electrons are not transferred directly from glucose to oxygen. Each electron is coupled with a proton to form a hydrogen atom. Following the movement of hydrogens allows you to follow the flow of electrons. The hydrogens are held in the cell temporarily by what electron carrier or "taxi cab"?

20. Understanding the overall map of how cellular respiration works will make the details easier to learn. Use Figure 9.6 to label the missing information in the figure below.



21. Label the diagrams of the mitochondria below from Ch. 7 - Figure 7.17.





The Process of Cellular Respiration

22. Why is glycolysis an appropriate term for this step of cellular respiration?

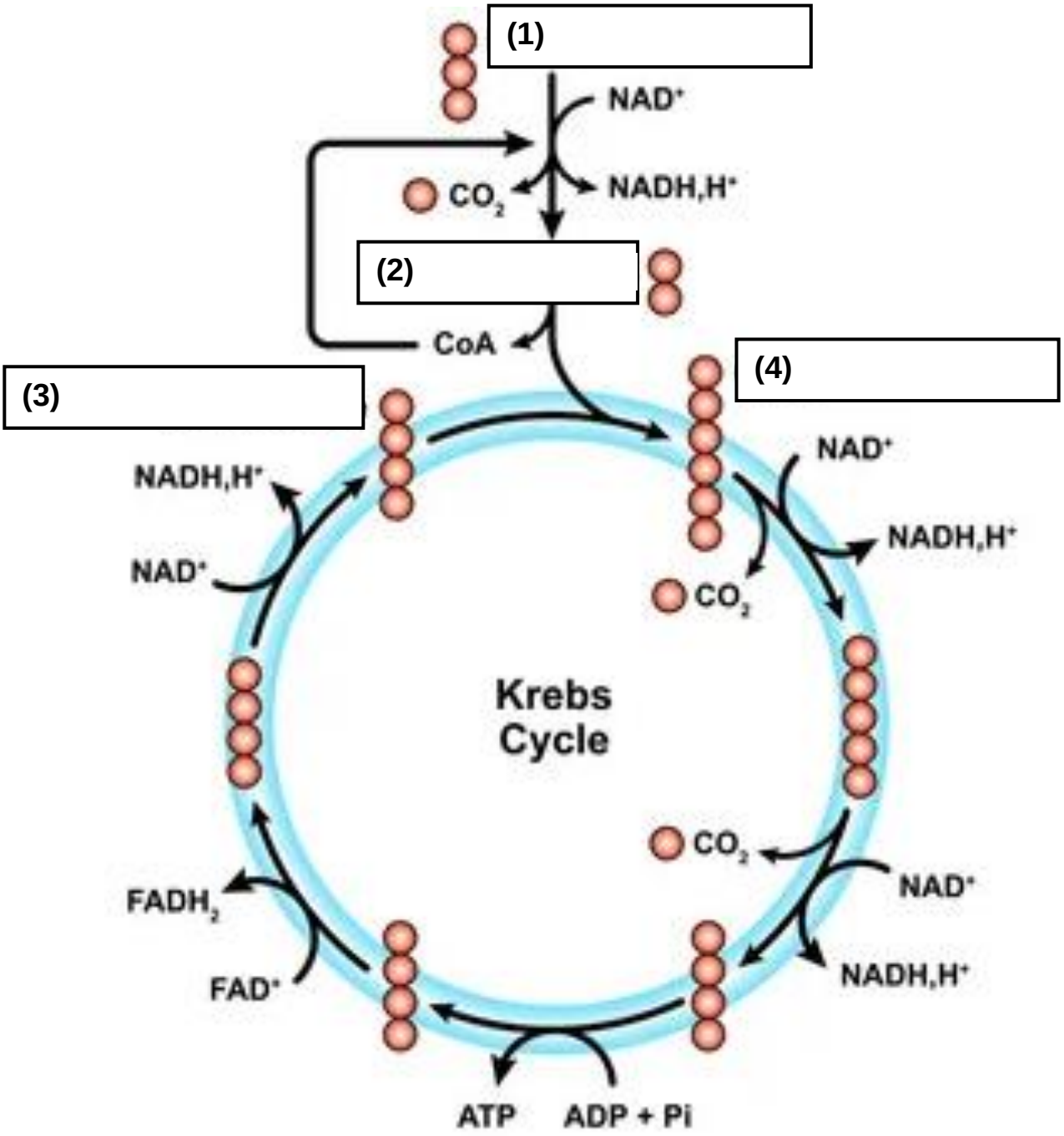
23. The starting product of glycolysis is the six-carbon sugar _____, and the ending product is two _____ carbon compounds termed _____.

24. Notice that glycolysis occurs in the _____ of the cell.

25. What is the relationship concerning glycolysis and oxygen and glycolysis and evolution?

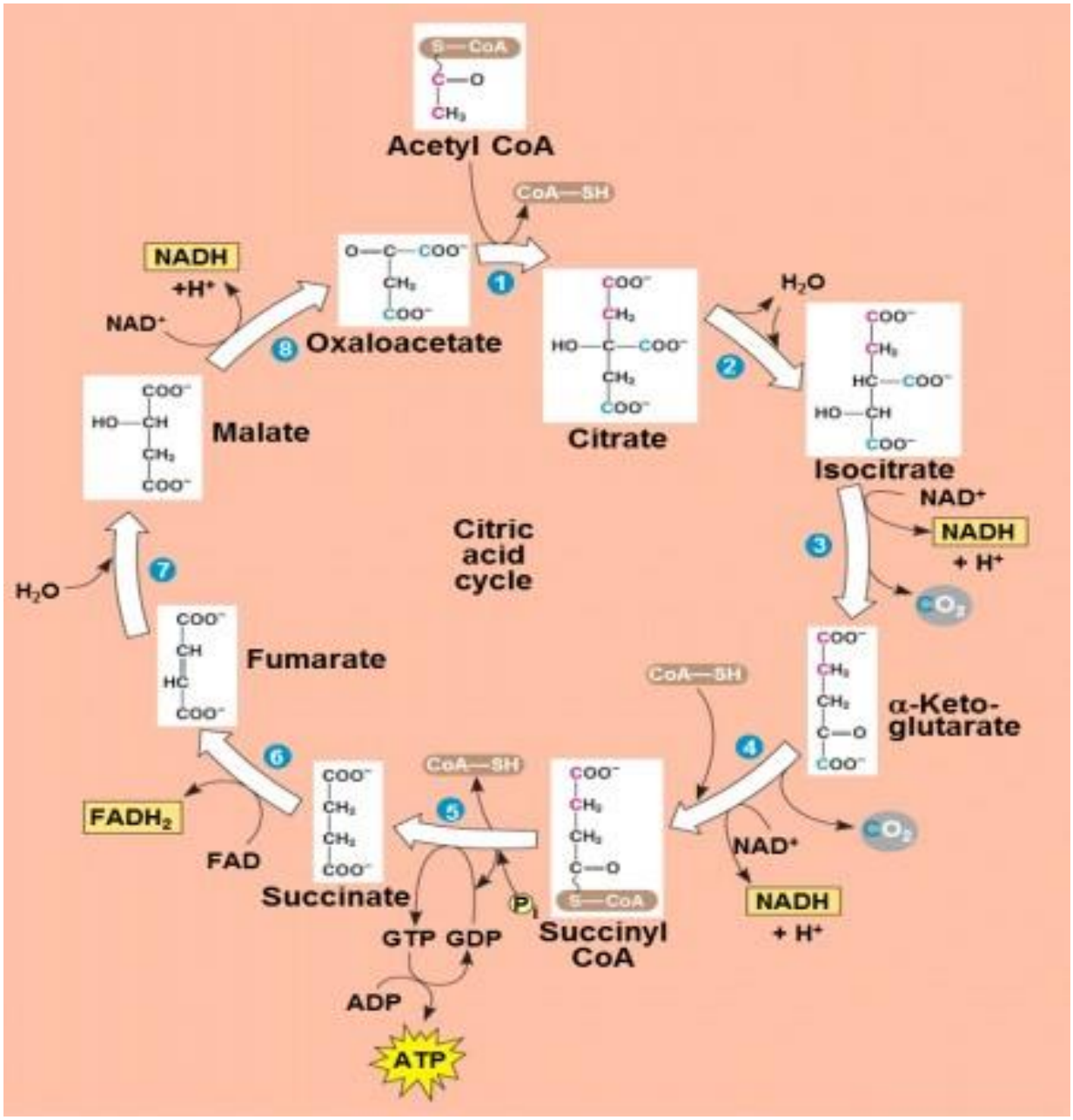
26. What is the NET energy yield per glucose molecule from Glycolysis?

To enter the mitochondria and start the Krebs Cycle, pyruvate **(3C)** must first be converted to Acetyl CoA **(2C).** Acetyl CoA **(2C)** combines with the ***regenerated*** oxaloacetate **(4C)** to form citrate **(6C).**



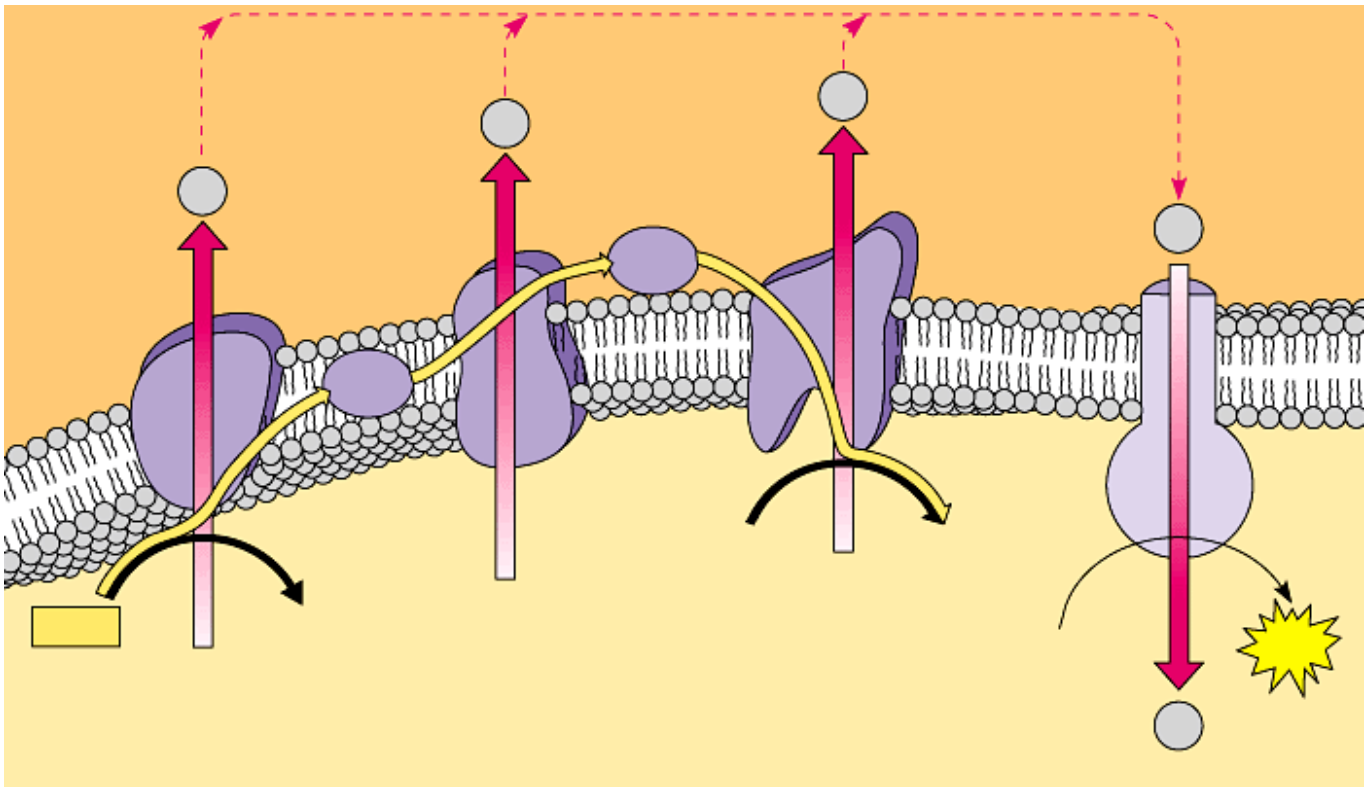
The
Krebs Cycle

(A closer look)



Phosphorylation (ADP ⟶ ATP) in cellular respiration involves two membrane components: the **electron transport chain** & **ATP synthase** (*just like in photosynthesis*). However, in photosynthesis the energy driving this reaction ultimately comes from the sun so it is termed **photophosphorylation**. In cellular respiration, this same ATP building process is called **oxidative phosphorylation** (*oxphos*) because the energy driving this process comes from the oxidation of glucose.

27. Figure 9.15 is a key to understanding the production of most of the ATP in the mitochondria. In the figure below, label all locations and molecules involved in the production of ATP via chemiosmosis.

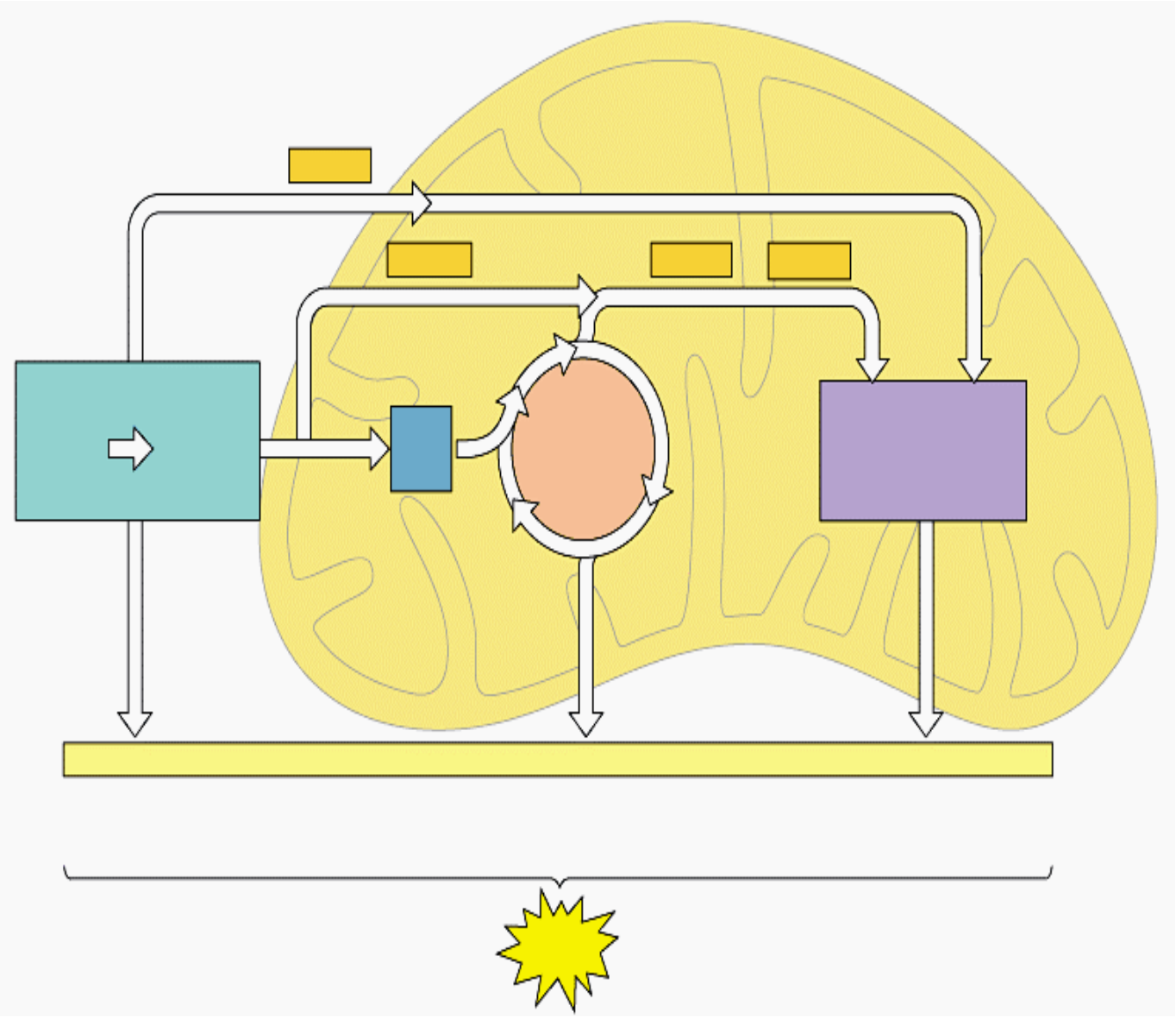


28. The 2 electron carriers that feed electrons into the ETC are _____ and _____.

29. What is the role of the ETC in forming the H+ gradient across the inner mitochondrial membrane?

30. What is the role of ATP synthase?

31. Use figure 9.16 and the diagram below to help you account for the location, major events and total number ATP molecules formed during aerobic cellular respiration.



32. Why is the total count about 36 or 38 ATP molecules rather than a specific number?

Related Metabolic Processes

(Fermentation – making ATP without oxygen)

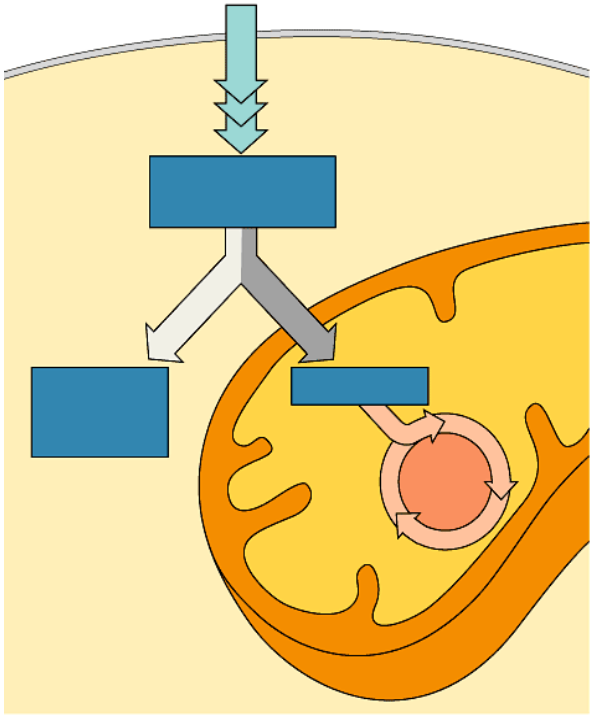
33. For aerobic respiration to continue, the cell must be supplied with oxygen - the ultimate electron acceptor. What is the electron acceptor in fermentation?**)**

34. Explain how alcohol fermentation starts with glucose and yields ethanol. Be sure to stress how NAD+ is recycled.

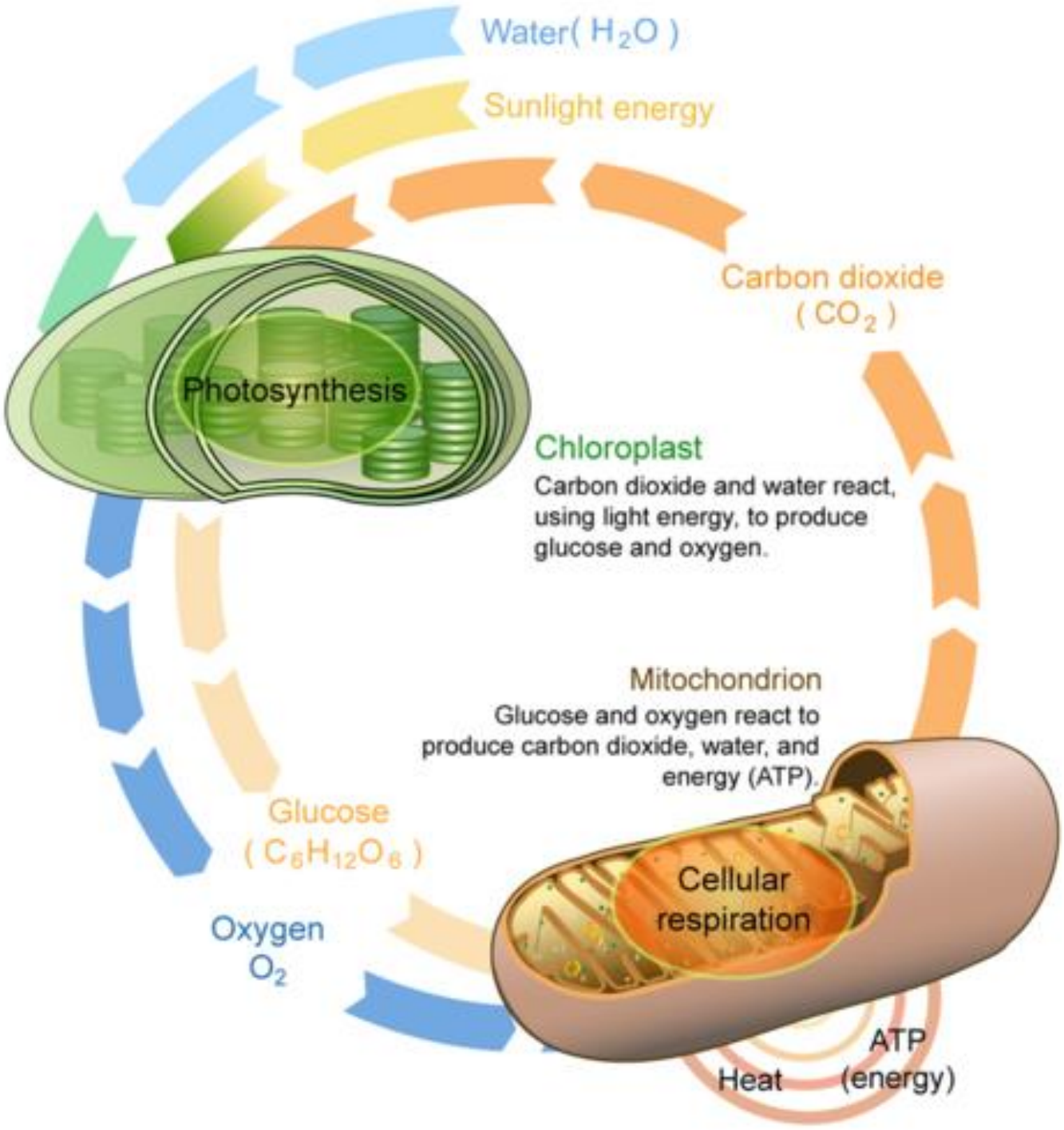
35. Explain how lactic acid fermentation starts with glucose and yields lactate. Be sure to stress how NAD+ is recycled.

36. **THE FATE OF PYRUVATE.**

Using Figure 9.19 as a guide to label the diagram to the right and explain why pyruvate is a key juncture in metabolism.



The Carbon/Oxygen Cycle



Chapter 9: Summary of Key Concepts

ATP functions as the *energy currency* for cells. It allows the cell to store energy briefly and transport it within the cell to support **endergonic** chemical reactions. The structure of ATP is that of an RNA nucleotide with three phosphates attached. As ATP is used for energy, a phosphate group or two are detached, and

either ADP or AMP is produced. Energy derived from glucose catabolism is used to convert ADP into ATP. When ATP is used in a reaction, the third phosphate is temporarily attached to a substrate in a process called **phosphorylation**.

Glycolysis is the first pathway used in the breakdown of glucose to extract energy. *It was probably one of the earliest metabolic pathways to evolve and is used by nearly all of the organisms on earth.* Glycolysis consists of two parts: The first part prepares the six-carbon ring of glucose for cleavage into two three-carbon sugars. ATP is invested in the process during this half to energize the separation. The second half of glycolysis extracts ATP and high-energy electrons from hydrogen atoms and attaches them to NAD^+. Two ATP molecules are invested in the first half and four ATP molecules are formed by substrate phosphorylation during the second half. This produces a net gain of two ATP and two NADH molecules for the cell.

In the presence of oxygen, **pyruvate** is transformed into an acetyl group attached to a carrier molecule of **coenzyme A**. The resulting acetyl CoA can enter several pathways, but most often, the acetyl group is delivered to the **Krebs** or **citric acid cycle** for further catabolism. During the conversion of pyruvate into the acetyl group, a molecule of carbon dioxide and two high-energy electrons are removed. The carbon dioxide accounts for two (*conversion of two pyruvate molecules*) of the six carbons of the original glucose molecule. The electrons are picked up by **NAD^+**, and the **NADH** carries the electrons to a later pathway for ATP production. At this point, the glucose molecule that originally entered cellular respiration has been completely oxidized. Chemical potential energy stored within the glucose molecule has been transferred to electron carriers or has been used to synthesize a few ATPs.

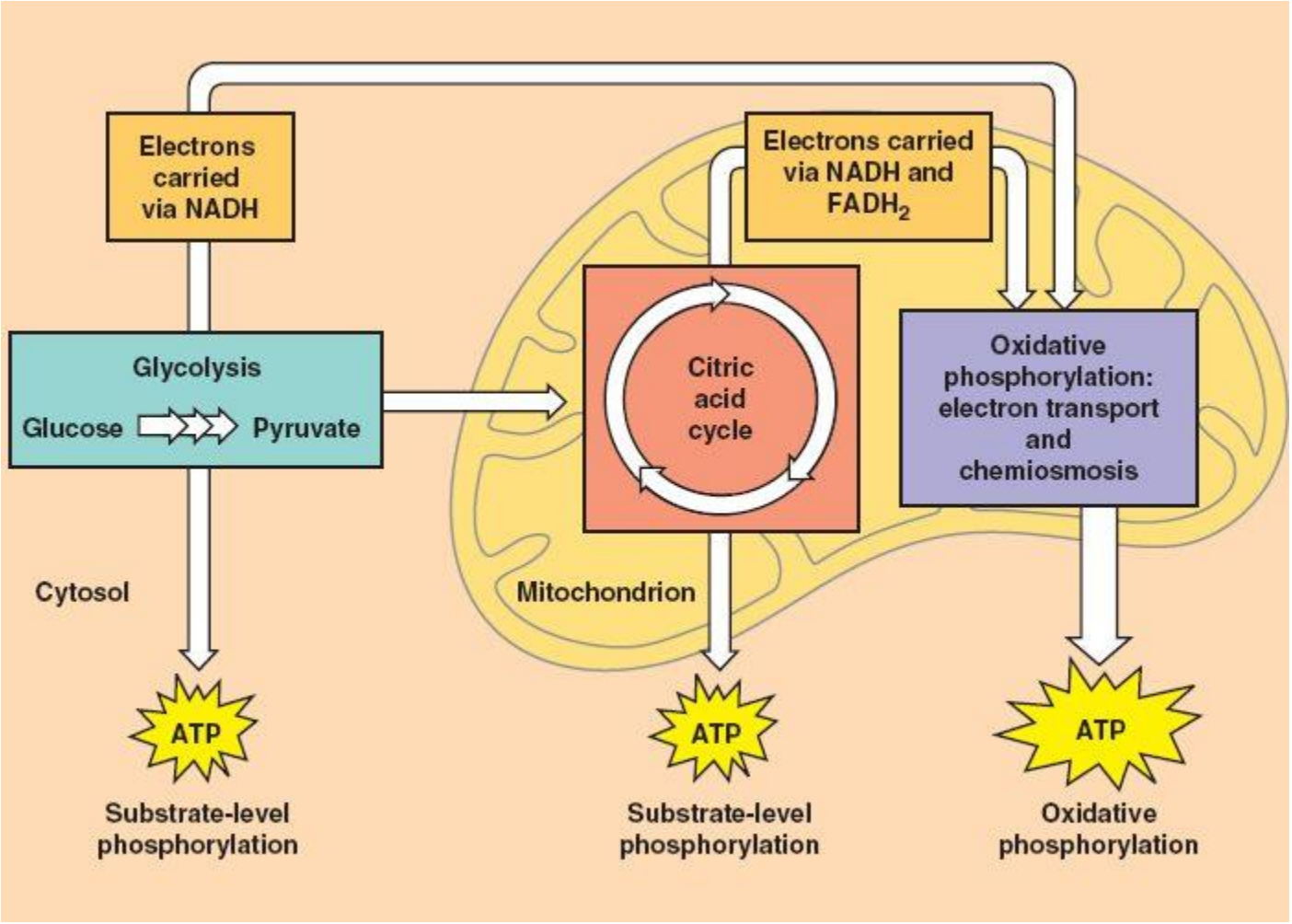
The **Krebs** or **citric acid cycle** is a series of *redox* and *decarboxylation* reactions that remove high-energy electrons and carbon dioxide. The electrons temporarily stored in molecules of NADH and $FADH_2$ are used to generate ATP in a subsequent pathway. One molecule of ATP is produced by on each turn of the cycle.

The **electron transport chain** is the portion of aerobic respiration that *uses free oxygen as the final electron acceptor of the electrons* removed from the intermediate compounds in glucose catabolism. The **electron transport chain** is composed of four large, multiprotein complexes embedded in the inner mitochondrial membrane and two small diffusible electron carriers shuttling electrons between them. The electrons are passed through a series of **redox** reactions, with a small amount of free energy used at three points to transport hydrogen ions across a membrane. This process contributes to the gradient used in **chemiosmosis**. The electrons passing through the electron transport chain gradually lose energy, High-energy electrons donated to the chain by either **NADH** or **$FADH_2$** complete the chain, as low-energy electrons reduce oxygen molecules and form water. The end products of the electron transport chain are water and ATP. A number of intermediate compounds of the citric acid cycle can be diverted into the anabolism of other biochemical molecules, such as nonessential amino acids, sugars, and lipids. These same molecules can serve as energy sources for the glucose pathways.

If **NADH** cannot be oxidized through **aerobic respiration**, another electron acceptor is used. Most organisms will use some form of **fermentation** to accomplish the regeneration of NAD^+, ensuring the continuation of **glycolysis**. The regeneration of **NAD^+** in fermentation is not accompanied by ATP production; therefore, the potential of **NADH** to produce **ATP** using an electron transport chain is not utilized.

The breakdown and synthesis of carbohydrates, proteins, and lipids connect with the pathways of glucose catabolism. The simple sugars are galactose, fructose, glycogen, and pentose. These are catabolized during glycolysis. The amino acids from proteins connect with glucose catabolism through pyruvate, acetyl CoA, and components of the citric acid cycle. Cholesterol synthesis starts with acetyl groups, and the components of triglycerides come from **glycerol-3-phosphate** from glycolysis and acetyl groups produced in the mitochondria from pyruvate.

Cellular respiration is controlled by a variety of means. The entry of glucose into a cell is controlled by the transport proteins that aid glucose passage through the cell membrane. Most of the control of the respiration processes is accomplished through the control of specific enzymes in the pathways. This is a type of negative feedback, turning the enzymes off. The enzymes respond most often to the levels of the available nucleosides ATP, ADP, AMP, NAD^+, and FAD. Other intermediates of the pathway also affect certain enzymes in the systems.



Chapter 9 - Review Questions

___ 1. The overall equation for the cellular respiration of glucose is -

A) $C_5H_{12}O_6 + 6\ O_2 \rightarrow 5\ CO_2 + 6\ H_2O$ + energy.
B) $5\ CO_2 + 6\ H_2O \rightarrow C_5H_{12}O_6 + 6\ O_2$ + energy.
C) $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$ + energy.
D) $C_6H_{12}O_6$ + energy $\rightarrow 6\ CO_2 + 6\ H_2O + 6\ O_2$.

___ 2. Oxidation is the _____, and reduction is the _____.
A) gain of electrons . . . loss of electrons
B) loss of electrons . . . gain of electrons
C) gain of oxygen . . . loss of oxygen
D) gain of protons . . . loss of protons

___ 3. Which of the following statements concerning the role of redox reactions in photosynthesis and cellular respiration is *true*?
A) Photosynthesis involves only reductions, while respiration involves only oxidations.
B) Photosynthesis involves only oxidations, while respiration involves only reductions.
C) In photosynthesis, C02 is oxidized to form sugar, while in respiration, sugar is reduced to form CO2.
D) In photosynthesis, CO2 is reduced to form sugar, while in respiration, sugar is oxidized to form CO2.

___ 4. Mitochondria transfer _____ energy from _____ to ATP;
chloroplasts transform _____ energy into the chemical energy of ATP.
A) chemical . . . food . . . light
B) light . . . food . . . kinetic
C) food . . . light . . . chemical
D) food . . . light . . . nuclear

___ 5. Photosynthetic organisms derive their carbon from -
A) carbon monoxide.
B) carbon dioxide.
C) hydrocarbons.
D) methane.

___ 6. Which of the following statements regarding photosynthesis and cellular respiration is *true*?
A) Photosynthesis occurs in chloroplasts, and cellular respiration occurs in mitochondria.
B) Photosynthesis occurs in mitochondria, and cellular respiration occurs in chloroplasts.
C) Photosynthesis occurs in mitochondria and in chloroplasts.
D) Cellular respiration occurs in mitochondria and in chloroplasts.

___ 7. How do cells capture the energy released by cellular respiration?
A) They produce ATP.
B) They produce glucose.
C) They store it in molecules of carbon dioxide
D) The energy is coupled to oxygen.

___ 8. The processes of photosynthesis and cellular respiration are complementary.
During these energy conversions, some energy is -
A) lost in the form of heat.
B) used to create light.
C) destroyed when the chemical bonds of glucose are made.
D) saved in the chemical bonds of water, CO_2 and O_2.

___ 9. Respiration _____, and cellular respiration _____.
A) produces ATP . . . is gas exchange
B) is gas exchange . . . produces ATP
C) produces glucose . . . produces oxygen
D) uses glucose . . . produces glucose

___ 10. Which of the following are products of cellular respiration?
A) oxygen and carbon dioxide
B) energy to make ATP and carbon dioxide
C) oxygen and glucose
D) oxygen and energy to make AT

___ 11. Which of the following statements regarding cellular respiration is *false*?
A) Cellular respiration is a single chemical reaction with just one step.
B) Cellular respiration produces water.
C) Cellular respiration produces carbon dioxide.
D) Cellular respiration releases heat.

___ 12. Which of the following metabolic pathways is common in aerobic and anaerobic metabolism?
A) the citric acid cycle
B) oxidative phosphorylation
C) glycolysis
D) electron transport chain

___ 13. As a result of glycolysis there is a net gain of _____ ATPs.
A) 0 B) 1 C) 2 D) 36

___ 14. Which of the following is a result of glycolysis?
A) production of CO_2
B) conversion of NADH to NAD^+
C) a net loss of two ATPs per glucose molecule
D) conversion of glucose to two three-carbon compounds

___ 15. The end products of glycolysis include -
A) NADH. B) acetyl CoA. C) citric acid. D) O_2.

___ 16. During chemiosmosis,-
A) energy is released as H^+ ions move freely across mitochondrial membranes.
B) ATP is synthesized when H^+ ions move through a channel in ATP synthase.
C) a concentration gradient is generated when large numbers of H^+ ions are passively transported from the matrix of the mitochondrion to the mitochondrion's intermembrane space.
D) H^+ ions serve as the final electron acceptor.

___ 17. The mitochondrial cristae are an adaptation that -
A) permits the expansion of mitochondria as oxygen accumulates in the mitochondrial matrix.
B) helps mitochondria divide during times of greatest cellular respiration.
C) increases the surface area for more electron transport chain proteins and ATP synthase complexes.
D) carefully encloses the DNA housed within the mitochondrial matrix.

___ 18. By-products of cellular respiration include -
A) oxygen and heat.
B) carbon dioxide and water.
C) $FADH_2$ and NADH.
D) NADH and ATP.

___ 19. In the electron transport chain of mitochondria, the final electron acceptor is -
A) an oxygen atom.
B) a molecule of carbon dioxide.
C) a molecule of water.
D) ADP.

___ 20. In yeast cells,-
A) lactic acid is produced during anaerobic respiration.
B) lactic acid is produced during glycolysis.
C) alcohol is produced during the citric acid cycle.
D) alcohol is produced after glycolysis.

___ 21. If you consume 1 g of each of the following, which will yield the most ATP?
A) fat B) glucose C) protein D) starch

___ 22. Which of the following statements regarding glycolysis is *false*?
A) Glycolysis is considered to be an ancient metabolic process because it does not require oxygen.
B) Glycolysis is considered to be an ancient metabolic process because it is not located in a membrane-bound organelle.
C) Glycolysis is considered to be an ancient metabolic system because it occurs universally.

D) Glycolysis is considered to be an ancient metabolic system because it is the most efficient metabolic pathway for ATP synthesis.

___ 23. To obtain energy from starch and glycogen, the body must begin by -
A) hydrolyzing the starch to glucose and the glycogen to amino acids.
B) hydrolyzing both starch and glycogen to glucose.
C) converting both starch and glycogen to fatty acids.
D) removing one glucose at a time with a condensation reaction.

___ 24. If ATP accumulates in a cell -
A) the cell receives a signal that there is a need for more energy.
B) feedback inhibition speeds up cellular respiration.
C) feedback inhibition slows down cellular respiration.
D) the rate of cellular respiration does not change.