**These review questions are for the Bio 1 cellular respiration topic. These questions were adapted from several sources, including the textbook’s review questions.**

**Multiple choice review questions:**

1) How many oxygen molecules (O2) are required for each molecule of glucose (C6H12O6) is completely oxidized to carbon dioxide and water via aerobic respiration?

A) 1

B) 3

C) 6

D) 12

E) 30

2) How many ATPs (the net gain) does the cell gain from one molecule of glucose going through aerobic respiration?

A) 1

B) 2

C) 4

D) 36

E) 60

3) Where does glycolysis take place in eukaryotic cells?

A) mitochondrial matrix

B) mitochondrial outer membrane

C) mitochondrial inner membrane

D) mitochondrial intermembrane space

E) cytoplasm

4) How many ATPs (the net gain) does the cell directly gain from one molecule of glucose going through glycolysis?

A) 1

B) 2

C) 4

D) 32

E) 36

5) How many ATPs (gross, not net) are directly made from one molecule of glucose going through glycolysis?

A) 1

B) 2

C) 4

D) 32

E) 36

6) In glycolysis, for each molecule of glucose broken down into pyruvate

A) two molecules of ATP are used and two molecules of ATP are produced.

B) two molecules of ATP are used and four molecules of ATP are produced.

C) four molecules of ATP are used and two molecules of ATP are produced.

D) two molecules of ATP are used and six molecules of ATP are produced.

E) six molecules of ATP are used and six molecules of ATP are produced.

7) Which intermediate molecule of the glycolysis metabolic pathway is also an intermediate molecule of the photosynthesis Calvin cycle?

A) PGAL

B) RuBP

C) Glucose

D) None. The two metabolic pathways have no molecules in common

8) During glycolysis, when each molecule of glucose is broken down in to two molecules of pyruvate, most of the potential energy contained in glucose is

A) transferred to ADP, forming ATP.

B) transferred directly to ATP.

C) retained in the two pyruvates.

D) stored in the NADH produced.

E) used to phosphorylate fructose to form fructose 6-phosphate.

9) In addition to ATP, what are the end products of glycolysis?

A) CO2 and H2O

B) CO2 and pyruvate

C) NADH and pyruvate

D) CO2 and NADH

E) H2O, FADH2, and citrate

10) Starting with one molecule of glucose, the net products of glycolysis are

A) 2 NAD+, 2 pyruvate, and 2 ATP.

B) 2 NADH, 2 pyruvate, and 2 ATP.

C) 2 FADH2, 2 pyruvate, and 4 ATP.

D) 6 CO2, 2 ATP, and 2 pyruvate.

E) 6 CO2, 30 ATP, and 2 pyruvate.

11) Which kind of metabolic poison would most directly interfere with glycolysis?

A) an agent that reacts with oxygen and depletes its concentration in the cell

B) an agent that binds to pyruvate and inactivates it

C) an agent that closely mimics the structure of glucose but is not metabolized

D) an agent that reacts with NADH and oxidizes it to NAD+

E) an agent that blocks the passage of electrons along the electron transport chain

12) High levels of citric acid inhibit the enzyme phosphofructokinase, a key enzyme in glycolysis. Citric acid binds to the enzyme at a different location from the active site. This is an example of

A) competitive inhibition.

B) allosteric regulation.

C) the specificity of enzymes for their substrates.

D) an enzyme requiring a cofactor.

E) positive feedback regulation.

13) Phosphofructokinase is an allosteric enzyme that catalyzes the conversion of fructose 6-phosphate to fructose 1,6-bisphosphate, an early step of glycolysis. Considering that ATP is an end product of the aerobic respiration pathway, an increase in the amount of ATP (to well above the normal level in the cell) would be expected to

A) inhibit the enzyme and thus slow the rates of glycolysis

B) activate the enzyme and thus slow the rates of glycolysis

C) inhibit the enzyme and thus increase the rates of glycolysis

D) activate the enzyme and increase the rates of glycolysis

The figure below illustrates some of the steps (reactions) of glycolysis in their proper sequence. Each step is lettered. Use these letters to answer the next four questions.

14) Which step in the figure shows a split of one molecule into two smaller molecules?

A) A

B) B

C) C

D) D

E) E

15) In which step in the figure is an inorganic phosphate added to the reactant?

A) A

B) B

C) C

D) D

E) E

16) Which portion of the pathway in the figure involves an endergonic reaction?

A) A

B) B

C) C

D) D

E) E

17) Which portion of the pathway in the figure contains a phosphorylation reaction in which ATP is the phosphate source?

A) A

B) B

C) C

D) D

E) E

18) As pyruvate enters the mitochondria, it is changed into… (More than one answer)

A) ATP

B) Water

C) Carbon dioxide

D) Acetyl CoA

E) H+

19) Which of the following molecules (generated from pyruvate) enters the citric acid cycle?

A) lactate

B) PGAL

C) carbon dioxide

D) acetyl CoA

E) citrate

20) During cellular respiration, acetyl CoA enters the Krebs cycle in which location?

A) cytoplasm

B) mitochondrial outer membrane

C) mitochondrial inner membrane

D) mitochondrial intermembrane space

E) mitochondrial matrix

21) How many carbon atoms are fed into the citric acid cycle per each molecule of pyruvate that is made by glycolysis?

A) two

B) four

C) six

D) eight

E) ten

22) In the presence of oxygen, the three-carbon compound pyruvate can be catabolized in the citric acid cycle. First, however, the pyruvate (1) loses a carbon, which is given off as a molecule of CO2, (2) is oxidized to form a two-carbon compound called an acetyl group, and (3) is bonded to coenzyme A.

These three steps directly in result in the formation of

A) acetyl CoA, O2, and ATP.

B) acetyl CoA, FADH2, and CO2.

C) acetyl CoA, FAD, and CO2.

D) acetyl CoA, NADH, and CO2.

E) acetyl CoA, NAD+, ATP, and CO2.

23) How many carbon dioxide molecules (CO2) are produced for each molecule of glucose (C6H12O6) is completely oxidized to carbon dioxide and water via aerobic respiration?

A) 2

B) 4

C) 6

D) 32

E) 36

24) How many carbon dioxide molecules (CO2) are produced by the Krebs cycle for each molecule of glucose (C6H12O6) is completely oxidized to carbon dioxide and water via aerobic respiration?

A) 1

B) 2

C) 4

D) 32

E) 36

25) How many ATP molecules can be made directly by the Krebs cycle from one molecule of acetyl

Co-A?

A) 1

B) 2

C) 11

D) 12

E) 24

26) For each molecule of glucose (C6H12O6) oxidized by cellular respiration, how many molecules of ATP are made directly in the citric acid cycle?

A) 1

B) 2

C) 11

D) 12

E) 24

27) Which of the following combinations of products would result from three acetyl CoA molecules entering the citric acid cycle?

A) 1 ATP, 2 CO2, 3 NADH, and 1 FADH2

B) 2 ATP, 2 CO2, 3 NADH, and 3 FADH2

C) 3 ATP, 3 CO2, 3 NADH, and 3 FADH2

D) 3 ATP, 6 CO2, 9 NADH, and 3 FADH2

E) 38 ATP, 6 CO2, 3 NADH, and 12 FADH2

28) The molecule NADH (nicotinamide adenine dinucleotide) is used by cells to carry…

A) carbon atoms

B) glucose

C) ribose

D) nicotine

E) electrons

29) In mitochondria, when ATP is made, H+ moves from the \_\_\_\_\_ to the \_\_\_\_\_\_.

A) Matrix, Cytoplasm

B) Cytoplasm, Intermembrane space

C) Intermembrane space, Matrix

D) Intermembrane space, Cytoplasm

E) Cytoplasm, Matrix.

30) Where are the proteins of the electron transport system located?

A) cytoplasm

B) mitochondrial outer membrane

C) mitochondrial inner membrane

D) mitochondrial intermembrane space

E) mitochondrial matrix

31) In cellular respiration, the energy that directly drives most ATP synthesis is supplied by

A) high energy phosphate bonds in organic molecules.

B) an H+ gradient across a membrane.

C) converting oxygen to ATP.

D) transferring electrons from organic molecules to pyruvate.

E) generating carbon dioxide and oxygen in the electron transport chain.

32) Which of the following donates electrons that move through only two of the three H+ pumps of the electron transport chain?

A) NAD+

B) NADH

C) ATP

D) ADP + i

E) FADH2

33) The primary role of oxygen in cellular respiration is to

A) yield energy in the form of ATP as it is passed down the respiratory chain.

B) act as an acceptor for electrons and H+ , forming water.

C) combine with carbon, forming CO2.

D) combine with lactate, forming pyruvate.

E) catalyze the reactions of glycolysis.

34) During aerobic respiration, H2O is formed. Where does the oxygen atom for the formation of the water come from?

A) carbon dioxide (CO2)

B) glucose (C6H12O6)

C) molecular oxygen (O2)

D) pyruvate (C3H3O3-)

E) lactate (C3H5O3-)

35) The energy of the electrons that move through the electron transport system is directly used to make…

A) ATP.

B) NADH

C) Water

D) an H= gradient

E) O2

36) The electron energy that moves through the electron transport chain is used to pump H+ into which location in eukaryotic cells?

A) cytoplasm

B) mitochondrial outer membrane

C) mitochondrial inner membrane

D) mitochondrial intermembrane space

E) mitochondrial matrix

37) Where is ATP synthase enzyme located in the mitochondrion?

A) cytoplasm

B) electron transport chain

C) outer membrane

D) inner membrane

E) mitochondrial matrix

38) The synthesis of ATP using the energy released by movement of H+ across the membrane down their concentration gradient, is an example of

A) active transport.

B) facilitated diffusion.

C) competitive inhibition.

D) osmosis.

E) allosteric regulation.

39) Which of the following is the list of molecules that directly donate or remove electrons from the proteins of the electron transport system?

A) oxygen, carbon dioxide, and water

B) NAD+, FAD, and electrons

C) NADH, FADH2, and H+

D) NADH, FADH2, and O2

E) oxygen and H+

40) What happens at the end of the electron transport system?

A) 2 electrons combine with H+ and a molecule of NAD+.

B) 2 electrons combine with an oxygen atom and two H+.

C) 4 electrons combine with a molecule of CO2 and 4 H+.

D) 4 electrons combine with four H+ and two ATP molecules.

E) 1 electron combines with a molecule of O2 and a H+.

41) Exposing inner mitochondrial membranes to ultrasonic vibrations will disrupt the membranes. However, the fragments will reseal "inside out" into tiny vesicles. The little vesicles that result still have a functioning electron transport chain and can still synthesize ATP. When electron transfer and ATP synthesis still occur, what must be present?

A) all of the electron transport proteins as well as ATP synthase

B) all of the electron transport system and the ability to add CoA to acetyl groups

C) only the ATP synthase system

D) only the electron transport system

E) plasma membranes like those bacteria use for respiration

42) The inside-out membrane vesicles described in the problem above…

A) will become acidic inside the vesicles when NADH is added.

B) will become alkaline inside the vesicles when NADH is added.

C) will make ATP from ADP and i if transferred to a pH 4 buffered solution after incubation in a pH 7

 buffered solution.

D) will hydrolyze ATP to pump protons out of the interior of the vesicle to the exterior.

E) will reverse electron flow to generate NADH from NAD+ in the absence of oxygen.

43) The *immediate* energy source that drives ATP synthesis by ATP synthase enzyme is

A) oxidation of glucose and other organic compounds.

B) flow of electrons down the electron transport chain.

C) affinity of oxygen for electrons.

D) H+ concentration across the membrane holding ATP synthase.

E) transfer of phosphate to ADP.

44) The final electron acceptor of the electron transport system is…

A) oxygen.

B) water.

C) NAD+.

D) pyruvate.

E) ADP.

45) When electrons flow along the electron transport system of mitochondria, which of the following changes occurs?

A) The pH of the matrix increases.

B) ATP synthase pumps protons by active transport.

C) The electrons gain energy.

D) The electron carriers use ADP to form ATP.

E) NADH is generated.

46) Prokaryotes as well as eukaryotes, can perform aerobic respiration. Where would you guess that the respiratory electron transport system is located in prokaryotic cells?

A) in the mitochondrial inner membrane.

B) in the mitochondrial outer membrane.

C) in the plasma membrane.

D) in the cytoplasm.

E) in the bacterial cell wall.

47) Which of the following produces the most ATP when glucose (C6H12O6) is completely oxidized to carbon dioxide (CO2) and water?

A) glycolysis proteins

B) fermentation

C) the transition step (oxidation of pyruvate to acetyl CoA) proteins

D) citric acid cycle proteins

E) the proteins in the inner membrane

48) Which number below is closest to the number of ATP molecules produced from the complete oxidation of one molecule of glucose (C6H12O6) in aerobic cellular respiration?

A) 2

B) 4

C) 15

D) 30-32

E) 60-64

49) During aerobic respiration, electrons travel downhill (to lower energy levels) in which sequence?

A) food → citric acid cycle → ATP → NAD+

B) food → NADH → electron transport chain → oxygen

C) glucose → pyruvate → ATP → oxygen

D) glucose → ATP → electron transport chain → NADH

E) food → glycolysis → citric acid cycle → NADH → ATP

50) Carbon dioxide (CO2) is released during which of the following stages of cellular aerobic respiration?

A) glycolysis and the oxidation of pyruvate to acetyl CoA

B) oxidation of pyruvate to acetyl CoA and the citric acid cycle

C) the citric acid cycle and ATP production

D) ATP production and the electron transport system

E) alcohol production

51) Most CO2 from aerobic respiration is released during

A) glycolysis.

B) the citric acid cycle.

C) lactate fermentation.

D) electron transport.

E) activity of ATP synthase enzyme

52) The oxygen consumed during cellular respiration is involved directly in which process or event?

A) glycolysis

B) accepting electrons at the end of the electron transport chain

C) the citric acid cycle

D) changing pyruvate to acetyl CoA

E) the phosphorylation of ADP to form ATP

53) Which process in eukaryotic cells will proceed normally whether oxygen (O2) is present or absent?

A) electron transport

B) glycolysis

C) the citric acid cycle

D) the electron transport chain

E) the transition step

54) Why are carbohydrates and fats considered high energy foods?

A) They have a lot of oxygen-carbon bonds.

B) They have no nitrogen in their makeup.

C) They can have very long carbon skeletons.

D) They have a lots of hydrogen-carbon bonds.

E) They have lots of nitrogen-carbon bonds.

55) If a cell is able to synthesize 36 ATP molecules when one molecule of glucose is completely oxidized into carbon dioxide and water, how many ATP molecules can the cell synthesize from one molecule of pyruvate completely oxidized to carbon dioxide and water?

A) 0

B) 1

C) 12

D) 14

E) 15

56) Brown fat cells produce a protein called thermogenin in their mitochondrial inner membrane. Thermogenin is a channel for facilitated diffusion of H+ across the membrane. What will occur in the brown fat cells when they produce thermogenin?

A) ATP synthesis and heat generation will both increase.

B) ATP synthesis will increase, and heat generation will decrease.

C) ATP synthesis will decrease, and heat generation will increase.

D) ATP synthesis and heat generation will both decrease.

E) ATP synthesis and heat generation will stay the same.

57) For each molecule of glucose that is metabolized by aerobic respiration, what is the total number of NADH molecules produced?

A) 2

B) 4

C) 6

D) 10

E) 12

58) For each molecule of glucose that is metabolized by aerobic respiration, what is the total number of FADH2 molecules produced?

A) 2

B) 4

C) 6

D) 10

E) 12

59) You have a friend who lost 7 kg (about 15 pounds) of fat on a regimen of strict dieting. How did the atoms of the fat molecules leave her body?

A) They were released as CO2 and H2O.

B) They were converted to heat and then released.

C) They were converted to ATP, which weighs much less than fat.

D) They were broken down to amino acids and eliminated from the body.

E) They were broken down to amino acids and converted into muscle protein.

60) In vertebrate animals, brown fat tissue's color is due to abundant blood vessels and capillaries. White fat tissue, on the other hand, is specialized for fat storage and contains relatively few blood vessels or capillaries. Brown fat cells have a specialized membrane transport protein that allows the H+ gradient to diffuse through the mitochondrial membrane without making any ATP. Which of the following might be the function of the brown fat tissue?

A) to increase the rate of oxidative phosphorylation from its few mitochondria

B) to allow the animals to regulate their metabolic rate when it is especially hot

C) to increase the production of ATP

D) to allow other membranes of the cell to perform mitochondrial functions

E) to regulate temperature by converting most of the energy from NADH oxidation to heat

61) When fatty acids are used as the fuel for aerobic respiration (instead of glucose, the normal fuel), each fatty acid molecule is broken apart by enzymes into several two-carbon molecules. Which aerobic respiration intermediate molecule do these two-carbon molecules become?

A) glucose

B) pyruvate

C) PGAL

D) ATP

E) Acetyl-CoA

62) Where do the catabolic products of fatty acid breakdown enter into the aerobic respiration pathway?

A) glycolysis

B) ATP production by ATP synthase enzyme

C) the transition step (oxidation of pyruvate to acetyl CoA)

D) citric acid cycle

E) the electron transport system

63) A spaceship is designed to support animal life for a multiyear voyage to the outer planets of the solar system. Plants will be grown to provide oxygen and to recycle carbon dioxide. Since the spaceship will be too far from the sun for photosynthesis, an artificial light source will be needed. If the light source stops functioning, what will happen to CO2 levels?

A) CO2 will rise as a result of both animal and plant respiration.

B) CO2 will rise as a result of animal respiration only.

C) CO2 will remain balanced because plants will continue to fix CO2 in the dark.

D) CO2 will fall because plants will increase CO2 fixation.

E) CO2 will fall because plants will cease to respire in the dark.

64) In a plant cell, where are the ATP synthase complexes (the enzyme that makes ATP from a H+ gradient) located?

A) thylakoid membrane only

B) plasma membrane only

C) inner mitochondrial membrane only

D) thylakoid membrane and inner mitochondrial membrane

E) thylakoid membrane and plasma membrane

65) Which of the following statements best describes the relationship between photosynthesis and respiration?

A) Respiration runs the biochemical pathways of photosynthesis in reverse.

B) Photosynthesis stores energy in glucose molecules, whereas respiration releases it.

C) Photosynthesis occurs only in plants and respiration occurs only in animals.

D) ATP molecules are produced in photosynthesis and used up in respiration.

E) Respiration is anabolic and photosynthesis is catabolic.

66) Where are electron transport systems found in plant cells? (More than one answer)

A) thylakoid membranes of chloroplasts

B) stroma of chloroplasts

C) outer membrane of mitochondria

D) cell membrane

E) inner membrane of mitochondria

67) Plants photosynthesize only in the light. Plants do cellular respiration…

A) in the dark only.

B) in the light only.

C) both in light and dark.

D) never–they get their ATP from photophosphorylation.

E) only when excessive light energy induces photorespiration.

68) In photosynthetic cells, synthesis of ATP occurs during

A) photosynthesis only.

B) respiration only.

C) both photosynthesis and respiration.

D) neither photosynthesis nor respiration.

69) In plants, formation of water molecules from O2, H+, and electrons occurs…

A) photosynthesis only.

B) respiration only.

C) both photosynthesis and respiration.

D) neither photosynthesis nor respiration.

70) The splitting of carbon dioxide to form oxygen gas and carbon compounds occurs during

A) photosynthesis.

B) respiration.

C) both photosynthesis and respiration.

D) neither photosynthesis nor respiration.

71) Generation of an H+ gradient across a membrane occurs during

A) photosynthesis.

B) respiration.

C) both photosynthesis and respiration.

D) neither photosynthesis nor respiration.

E) photorespiration.

72) Even though plants carry on photosynthesis, plant cells still use their mitochondria to produce ATP. When and where will this occur?

A) Only in photosynthetic cells in the light, while photosynthesis occurs concurrently

B) Only in nonphotosynthesizing cells

C) Only in the roots

D) in all cells all the time

E) in photosynthesizing cells in the light and in other tissues in the dark

73) Which of the following occurs in the cytoplasm of a eukaryotic cell?

A) glycolysis and anaerobic respiration

B) anaerobic respiration and ATP production by ATP synthase enzyme

C) conversion of pyruvate to acetyl CoA

D) citric acid cycle

E) the electron transport system

74) Which metabolic pathway is common to both anaerobic and aerobic cellular respiration of a glucose molecule?

A) the citric acid cycle

B) the electron transport system

C) glycolysis

D) synthesis of acetyl CoA from pyruvate

E) conversion of pyruvate to lactate

75) What is the fuel molecule that yeast cells metabolize to make ATP from ADP under anaerobic conditions?

A) glucose

B) ethanol

C) pyruvate

D) lactic acid

E) either ethanol or lactic acid

76) In the absence of oxygen, yeast cells can obtain energy by anaerobic respiration, resulting in the production of which end product molecules?

A) ATP, CO2, and ethanol (ethyl alcohol).

B) ATP, CO2, and lactate.

C) ATP, NADH, and pyruvate.

D) ATP, pyruvate, and oxygen.

E) ATP, pyruvate, and acetyl CoA.

77) How many ATPs (the net gain) does the cell gain from one molecule of glucose going through anaerobic respiration?

A) 1

B) 2

C) 4

D) 36

E) 60

78) How many lactic acid molecules does the cell make from one molecule of glucose going through anaerobic respiration?

A) 1

B) 2

C) 4

D) 36

E) 60

79) How many ethanol molecules does a yeast cell make from one molecule of glucose going through anaerobic respiration?

A) 1

B) 2

C) 4

D) 36

E) 60

80) How many CO2 molecules does a yeast cell make from one molecule of glucose going through anaerobic respiration?

A) 1

B) 2

C) 4

D) 36

E) 60

81) During intense exercise, skeletal muscle cells switch from using aerobic respiration to using anaerobic respiration. This results in…

A) More glucose being used in each muscle cell (compared to using aerobic respiration).

B) Less glucose being used in each muscle cell (compared to using aerobic respiration).

C) No change in the glucose being used in each muscle cell.

D) More oxygen being used in each muscle cell.

82) When skeletal muscle cells undergo anaerobic respiration, they become fatigued and painful. This is now known to be caused by

A) buildup of pyruvate.

B) buildup of lactic acid.

C) increase in sodium ions.

D) increase in potassium ions.

E) increase in ethanol.

**Answers to multiple choice questions:**

1 = C

2 = D

3 = E

4 = 2

5 = C

6 = B

7 = A

8 = C

9 = C

10 = B

11 = C

12 = B

13 = A

14 = B

15 = C

16 = A

17 = A

18 = C and D

19 = D

20 = E

21 = A

22 = D

23 = C

24 = C

25 = A

26 = B

27 = D

28 = E

29 = C

30 = C

31 = B

32 = E

33 = B

34 = C

35 = D

36 = D

37 = D

38 = B

39 = D

40 = B

41 = A

42 = A

43 = D

44 = A

45 = A

46 = C

47 = E

48 = D

49 = B

50 = B

51 = B

52 = B

53 = B

54 = D

55 = D

56 = C

57 = D

58 = A

59 = A

60 = E

61 = E

62 = D

63 = A

64 = D

65 = B

66 = A and E

67 = C

68 = C

69 = B

70 = D

71 = C

72 = D

73 = C

74 = C

75 = A

76 = A

77 = B

78 = B

79 = B

80 = B

81 = A

82 = B