## CHAPTER 9 Review

1. In respiration, is glucose oxidized or reduced? Oxidized
2. Explain why electrons lose energy when they are transferred to a more electronegative atom. They end up in a more stable state (lower potential energy)
3. What coenzyme is reduced during glycolysis? $NAD^+$
4. Where does glycolysis occur in the cell? Cytosol
5. Substrate-level phosphorylation occurs during which two processes?
   glycolysis + Krebs
6. Oxidative phosphorylation occurs during this process: ETC + chemiosmosis
7. Is NADH an oxidizing agent or a reducing agent? reducing agent
8. Why is glycolysis an anaerobic process? does not directly use $O_2$
9. How many ATPs are produced during glycolysis by substrate-level phosphorylation? 4 total
10. How many molecules of pyruvate are produced from every molecule of glucose during glycolysis? 2
11. What would occur if one of the enzymes of the Krebs cycle was inhibited?
    cycle would eventually stop, no more ETC either
12. In what part of the cell is pyruvate converted to acetyl Co A? matrix
13. What does Coenzyme A carry to the Krebs cycle? acetyl group
14. Pyruvate has 3 carbons, while the acetyl group on acetyl CoA has 2 carbons. What happened to the other carbon? lost as $CO_2$
15. What does it mean to say that the ET chain and chemiosmosis are "coupled?" What does an "uncoupler" do?
    "Coupled" = ETC creates proton gradient that drives chemiosmosis
    uncoupler = gets rid of proton gradient (see p. 177 book)
16. How many turns of the Krebs cycle occur for each glucose molecule? 2
17. For each turn of the Krebs cycle, two carbons enter in the form of Acetyl CoA and two carbons exit in the form of $CO_2$.
18. For each turn of the Krebs cycle, 3 molecules of NAD+ are reduced, 1 molecules of FAD+ is reduced, and 1 ATP is produced by substrate-level phosphorylation.
19. By the end of the Krebs cycle, what has happened to the six carbons of glucose?
    all lost as $CO_2$
20. By the end of the Krebs cycle, in what form is most of the extracted energy from glucose? NADH (high energy electrons)
21. How does the form of the cristae fit its function?
    more surface area for ETCs

22. ~~The flow~~ of electrons down the electron transport chain is an (exergonic/endergonic)________________ pathway.

23. What is the function of prosthetic groups in the electron transport chain?

to accept + pass on e⁻

24. Why does $FADH_2$ provide 2/3 the energy for ATP synthesis as NADH? passes off e⁻ lower in the ETC (is worth only 2 ATP instead of 3)

25. ___O2___ is the final electron acceptor at the end of the ET chain and it forms ___H2O___.

26. Where in the mitochondria is there a build-up of a H+ concentration gradient?

inner membranes

27. How is the H+ gradient created? by the ETC, shuttles H+ from matrix to inner mem space

28. At what places is the inner mitochondrial membrane permeable to H+ leaking down its gradient? ATP synthase

29. Would yeast consume more glucose under anaerobic or aerobic conditions?

anaerobic b/c to make same amt of ATP, more glucose is required

30. The ATP synthase complex looks like a lollipop in the inner membrane. Are the heads of the lollipops pointing toward the matrix or the inner membrane compartment? matrix

31. Each molecule of glucose upon combustion releases 686 Kcal/mol of energy. Each ATP contains 7.3 Kcal/mol of energy. How efficient is aerobic respiration (percent)

~41%

32. What happens to the energy that is not used to make ATP?

body heat

33. Why do eukaryotes produce less ATP per glucose (36) than prokaryotes (38)?

Their NADH from glycolysis doesn't have to cross a mit. membrane

34. Why is champagne bubbly and why does bread rise? $CO_2$ byproduct of fermentation

35. Why is it essential to oxidize NADH during fermentation?

to regenerate NAD+ for glycolysis

36. Lactate may accumulate in muscle cells because of an "oxygen debt." What later happens to lactate, and how is the oxygen debt paid?

must go back to blood stream, liver converts it to pyruvate + goes through cell respiration

37. Explain why are muscle cells behave as facultative anaerobes.

Can switch from aerobic resp to fermentation

38. Why is the allosteric enzyme phosphofructokinase called the "pacemaker of respiration?"

Sensitive to levels of citrate, ATP, ADP - can adjust rate of glycolysis

## Test Your Knowledge

**MULTIPLE CHOICE:** *Choose the one best answer.*

Catabolic and anabolic pathways are often coupled in a cell because

a. the intermediates of a catabolic pathway are used in the anabolic pathway.
b. both pathways use the same enzymes.
c. the free energy released from one pathway is used to drive the other pathway.
d. the activation energy of the catabolic pathway can be used in the anabolic pathway.
e. their enzymes are controlled by the same activators and inhibitors.

2. According to the first law of thermodynamics,

a. for every action there is an equal and opposite reaction.
b. every energy transfer results in an increase in disorder or entropy.
c. the total amount of energy in the universe is conserved or constant.
d. energy can be transferred or transformed, but disorder always increases.
e. potential energy is converted to kinetic energy, and kinetic energy is converted to heat.

5. When amino acids join to form a protein, which of the following energy and entropy changes apply?

a. $-\Delta H, +\Delta S, +\Delta G$
b. $-\Delta H, -\Delta S, +\Delta G$
c. $+\Delta H, +\Delta S, +\Delta G$
d. $+\Delta H, -\Delta S, +\Delta G$
e. $+\Delta H, +\Delta S, -\Delta G$

protein more ordered, takes energy to build

6. A negative $\Delta G$ means that

a. the quantity G of energy is available to do work.
b. the reaction is spontaneous.
c. the reactants have more free energy than the products.
d. the reaction is exergonic.
e. all of the above are true.

7. One way in which a cell maintains metabolic disequilibrium is to

a. siphon products of a reaction off to the next step in a metabolic pathway.
b. provide a constant supply of enzymes for critical reactions.
c. use feedback inhibition to turn off pathways.
d. use allosteric enzymes that can bind to activators or inhibitors.
e. use the energy from anabolic pathways to drive catabolic pathways.

8. At equilibrium,

a. no enzymes are functioning.
b. free energy is decreasing.
c. the forward and backward reactions have stopped.
d. the products and reactants have equal values of *H*.
e. $\Delta G$ is 0.

11. What is meant by an induced fit?

a. The binding of the substrate is an energy-requiring process.
b. A competitive inhibitor can outcompete the substrate for the active site.
c. The binding of the substrate changes the shape of the active site, which can stress or bend substrate bonds.
d. The active site creates a microenvironment ideal for the reaction.
e. The binding of an activator to an allosteric site induces a more active form of the subunits of an enzyme.

12. In an experiment, changing the pH from 7 to 6 resulted in an increase in product formation. From this we could conclude that

a. the enzyme became saturated at pH 6.
b. the enzyme's optimal pH is 6.
c. this enzyme works best at a neutral pH.
d. the temperature must have increased when the pH was changed to 6.
e. the enzyme was in a more active shape at pH 6.

13. When substance A was added to an enzyme reaction, product formation decreased. The addition of more substrate did not increase product formation. From this we conclude that substance A could be

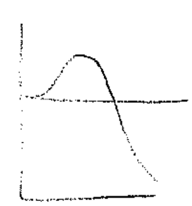
a. product molecules.
b. a cofactor.
c. an allosteric enzyme.
d. a competitive inhibitor.
e. a noncompetitive inhibitor.

14. Which of the following characteristics is most directly responsible for the specificity of a protein enzyme?

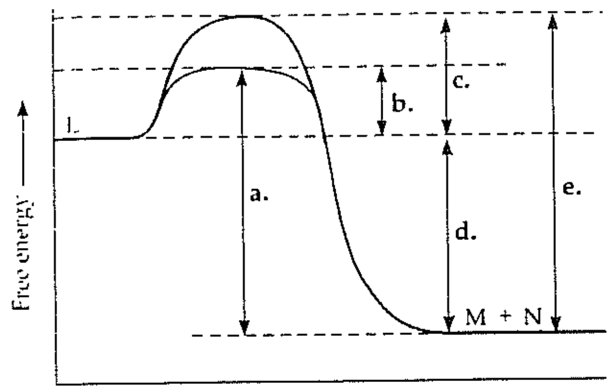
a. its primary structure
b. its secondary and tertiary structures
c. the shape and characteristics of its allosteric site
d. its cofactors
e. the R groups of the amino acids in its active site

16. Zinc, an essential trace element, may be found bound to the active site of some enzymes. Such zinc ions most likely function as

a. a coenzyme derived from a vitamin.
b. a cofactor necessary for catalysis.
c. a substrate of the enzyme.
d. a competitive inhibitor of the enzyme.
e. an allosteric activator of the enzyme.



*Use the following diagram to answer questions 17–19.*




17. Which line in the diagram indicates the ΔG of the enzyme-catalyzed reaction L → M + N? D

18. Which line in the diagram indicates the activation energy of the noncatalyzed reaction? C

19. Which of the following terms best describes this reaction?
    a. nonspontaneous
    (b.) −ΔG
    c. endergonic
    d. coupled reaction
    e. anabolic reaction

21. In the metabolic pathway A → B → C → D → E, what effect would molecule E likely have on the enzyme that catalyzes A → B?
    (a.) allosteric inhibitor
    b. allosteric activator
    c. competitive inhibitor
    d. feedback activator
    e. coenzyme

## FILL IN THE BLANKS

Metabolism 1. the totality of an organism's chemical processes

anabolic 2. pathways that use energy to synthesize complex molecules

potential 3. the energy resulting from location or structure

heat ~~entropy~~ 4. the most random form of energy

entropy 5. term for the measure of disorder or randomness

activ. energy 6. the energy that must be absorbed by molecules to reach the transition state

Competitive 7. inhibitors that decrease an enzyme's activity by binding to the active site

coenzymes 8. organic molecules that bind to enzymes and are necessary for their functioning

feedback inhib 9. regulatory device in which the product of a pathway binds to an enzyme early in the pathway

phosphorylated intermediate 10. more reactive molecules created by the transfer of a phosphate group from ATP

I didn't include all the inputs, just main idea

| Process | Main Function | Inputs | Outputs |
|---|---|---|---|
| Glycolysis | split glucose to make pyruvate | glucose NAD+, ADP + Pi | pyruvate 2ATP 2NADH |
| Pyruvate to acetyl CoA | Create acetyl fragment | pyruvate | acetyl |
| Citric acid cycle | completely break down acetyl CoA | acetyl | NADH, $FADH_2$ $CO_2$, ATP |
| Oxidative phosphorylation | Create ATP | ↑ energy electrons, $O_2$ → | ATP $H_2O$ |
| Fermentation | Regenerate NAD+ to keep glycolysis going | pyruvate | NAD+, alcohol + $CO_2$ ~~or lactic acid~~ |

## Test Your Knowledge

MULTIPLE CHOICE: *Choose the one best answer.*

1. When electrons move closer to a more electronegative atom,
   a. energy is released.
   b. energy is consumed.
   c. a proton gradient is established.
   d. water is produced.
   e. ATP is synthesized.

2. In the reaction $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$,
   a. glucose becomes reduced.
   b. oxygen becomes reduced. to $H_2O$
   c. oxygen becomes oxidized.
   d. water is a reducing agent.
   e. oxygen is a reducing agent.

4. Which of the following reactions is *incorrectly* paired with its location?
   a. ATP synthesis—inner membrane of the mitochondrion, mitochondrial matrix, and cytosol
   b. fermentation—cell cytosol
   c. glycolysis—cell cytosol
   d. substrate-level phosphorylation—cytosol and mitochondrial matrix
   e. citric acid cycle—cristae of mitochondrion (takes place in matrix)

6. Which of the following compounds produces the most ATP when oxidized?
   a. acetyl CoA
   b. glucose Start of process
   c. pyruvate
   d. fructose-1,6-bisphosphate
   e. glyceraldehyde-3-phosphate

7. When pyruvate is converted to acetyl CoA,
   a. $CO_2$ and ATP are released.
   b. a multienzyme complex removes a carboxyl group, transfers electrons to $NAD^+$, and attaches a coenzyme.
   c. one turn of the citric acid cycle is completed.
   d. $NAD^+$ is regenerated so that glycolysis can continue to produce ATP by substrate-level phosphorylation.
   e. phosphofructokinase is activated and glycolysis continues.

8. How many molecules of $CO_2$ are generated for each molecule of acetyl CoA introduced into the citric acid cycle?
   a. 1 c. 3 e. 6
   b. 2 d. 4
   one turn of krebs

9. Which of the following statements correctly describes the role of oxygen in cellular respiration?
   a. It is reduced in glycolysis as glucose is oxidized.
   b. It combines with $H^+$ diffusing through ATP synthase to produce $H_2O$.
   c. It provides the activation energy needed for oxidation to occur.
   d. It is the final electron acceptor for the electron transport chain.
   e. It combines with the carbon removed during the citric acid cycle to form $CO_2$.

10. In the chemiosmotic mechanism,
    a. ATP production is linked to the proton gradient established by the electron transport chain.
    b. the difference in pH between the intermembrane space and the cytosol drives the formation of ATP.
    c. the flow of $H^+$ through ATP synthases rotates a rotor and rod, driving the hydrolysis of ADP.
    d. the energy released by the reduction and subsequent oxidation of electron carriers transfers a phosphate to ADP.
    e. the production of water in the mitochondrial matrix by the reduction of oxygen leads to a net flow of water out of a mitochondrion.

15. Fermentation produces less ATP than cellular respiration because
    a. $NAD^+$ is regenerated by alcohol or lactate production, without the electrons of NADH passing through the electron transport chain.
    b. pyruvate still contains most of the "hilltop" electrons that were present in glucose.
    c. its starting reactant is pyruvate and not glucose.
    d. a and b are correct.
    e. a, b, and c are correct.

17. Muscle cells in oxygen deprivation gain which of the following from the reduction of pyruvate?
    a. ATP
    b. ~~ATP~~ and $NAD^+$
    c. $CO_2$ and $NAD^+$
    d. ATP, alcohol, and $NAD^+$
    e. ATP and $CO_2$

19. Glycolysis is considered one of the first metabolic pathways to have evolved because
    a. it relies on fermentation, which is characteristic of archaea and bacteria.
    b. it is found only in prokaryotes, whereas eukaryotes use mitochondria to produce ATP.
    c. it produces much less ATP than does the electron transport chain and chemiosmosis.
    d. it produces ATP only by substrate phosphorylation and does not involve redox reactions.
    e. it is nearly universal, is located in the cytosol, and does not involve $O_2$.

1st evolved in prokaryotes, early Earth, no $O_2$ in atm.