1. Cellular respiration is an example of:

A. Catabolic pathway
B. Anabolic pathway
C. Extracellular activity
D. Thermodynamics
E. Entropy

2. If 10 molecules of acetyl-CoA enter the citric acid cycle. How many molecules of ATP will be made by substrate level phosphorylation?

A. 18
B. 4
C. 20
D. 32
E. 10

3. Some enzymatic regulation is allosteric. In such cases, which of the following would usually be found?

A. Cooperativity
B. Feedback inhibition
C. Both activating and inhibitory activity
D. An enzyme with more than one subunit
E. The need for cofactors

4. Which of the following is an example of cooperativity?

A. The binding of an end product of a metabolic pathway to the first enzyme that acts in the pathway
B. Protein function at one site affected by binding at another of its active sites
C. A molecule binding at one unit of a tetramer allowing faster binding at each of the other three
D. The effect of increasing temperature on the rate of an enzymatic reaction
E. Binding of an ATP molecule along with one of the substrate molecules in an active site

5. What is the change in free energy of a system at chemical equilibrium?

A. slightly increasing
B. Greatly increasing
C. Slightly decreasing
D. Greatly decreasing
E. No net changes

6. Which of the following best describes enthalpy (H)?

A. The total kinetic energy of a system
B. The heat content of a chemical system
C. The system's entropy
D. The cell's energy equilibrium
E. The condition of a cell that is not able to react

7. Why is ATP an important molecule in metabolism?

A. Its hydrolysis provides an input of free energy for exergonic reactions.
B. It provides energy coupling between exergonic and endergonic reactions.
C. Its terminal phosphate group contains a strong covalent bond that when hydrolyzed releases free energy.
D. Its terminal phosphate bond has higher energy than the other two.
E. A, B, C, and D

8. Which of the following is most similar in structure to ATP?

A. an anabolic steroid
B. a DNA helix
C. an RNA nucleotide
D. an amino acid with three phosphate groups attached
E. a phospholipid

9. What term is used to describe the transfer of free energy from catabolic pathways to anabolic pathways?

A. feedback regulation
B. Bioenergetics
C. Energy coupling
D. Entropy
E. Cooperativity

10. Which of the following statements is true concerning catabolic pathways?

A. They combine molecules into more energy-rich molecules.
B. They are usually coupled with anabolic pathways to which they supply energy in the form of ATP.
C. They are endergonic.
D. They are spontaneous and do not need enzyme catalysis.
E. They build up complex molecules such as protein from simpler compounds.

11. When chemical, transport, or mechanical work is done by an organism, what happens to the heat generated?

A. It is used to power yet more cellular work.
B. It is used to store energy as more ATP.
C. It is used to generate ADP from nucleotide precursors.
D. It is lost to the environment.
E. It is transported to specific organs such as the brain.

12. Reactants capable of interacting to form products in a chemical reaction must first overcome a thermodynamic barrier known as the reaction's

A. Entropy
B. Activation energy
C. Endothermic level
D. Heat content
E. Free-energy content

13. True or false:

A catalyst is a chemical agent that speeds up a reaction without being consumed by the reaction.

14. A solution of starch at room temperature does not readily decompose to form a solution of simple sugars because

A. The starch solution has less free energy than the sugar solution.
B. The hydrolysis of starch to sugar is endergonic.
C. The activation energy barrier for this reaction cannot be surmounted.
D. Starch cannot hydrolyze in the presence of so much water.
E. Starch hydrolysis is nonspontaneous.

15. True or false

Cooperativity is a form of allosteric regulation

16. True or false

Oxidation of one NADH in the electron transport chain produces more H+-gradient than one FADH2

17. In tricarboxylic acid cycle:

A. One ATP is formed by oxidative phosphorylation
B. Two $FADH_2$ are produced by one glucose molecule
C. Acetyl CO-A is combined with succinate to form citric acid
D. Succinate is combined to CO_2 to produce $FADH_2$
E. One acetyl CO-A is oxidized to produce 3 CO_2

18. In electron transport chain FADH2 donates electrons to:

A. Complex I
B. Iron sulfur with complex II
C. NADH
D. Ubiquinone
E. Cytochrome C

19. High levels of citric acid inhibit phosphofructokinase. This is one example of:
A. Non-competitive inhibition
B. The specificity of enzyme to their substrates
C. Feedback inhibition
D. Feedforward inhibition
E. Competitive inhibition

20. Which of the following best describes the reaction of beta oxidation?
A. Anabolism of fatty acid
B. Catabolism of glucose
C. Anabolism of glucose
D. Catabolism of fatty acid
E. Catabolism of proteins

21. True or false:
In alcohol fermentation, NAD+ is regenerated from NADH through the reduction of pyruvate the form lactate.

22. True or false:
During glycolysis aldolase directly splits glucose 6-phosphate into two 3-carbon compounds.

23. During chemiosmosis in the mitochondria:
A. The PH in the matrix increases
B. Proton are pumped from the matrix to the intermembrane space
C. The electrons are transported from cytochrome to oxygen
D. Electrons are transported from complex I to complex III
E. Protons flow back from intermembrane space to the matrix

24. Which of the following statements regarding enzymes is true?
A. Enzymes decrease the free energy change of a reaction.
B. Enzymes increase the rate of a reaction.
C. Enzymes change the direction of chemical reactions.
D. Enzymes are permanently altered by the reactions they catalyze.
E. Enzymes prevent changes in substrate concentrations.

25. During a laboratory experiment, you discover that an enzyme-catalyzed reaction has a $\triangle G$ of -20 kcal/mol. If you double the amount of enzyme in the reaction, what will be the $\triangle G$ for the new reaction?
A. -40 kcal/mol
B. -20 kcal/mol
C. 0 kcal/mol
D. +20 kcal/mol
E. +40 kcal/mol

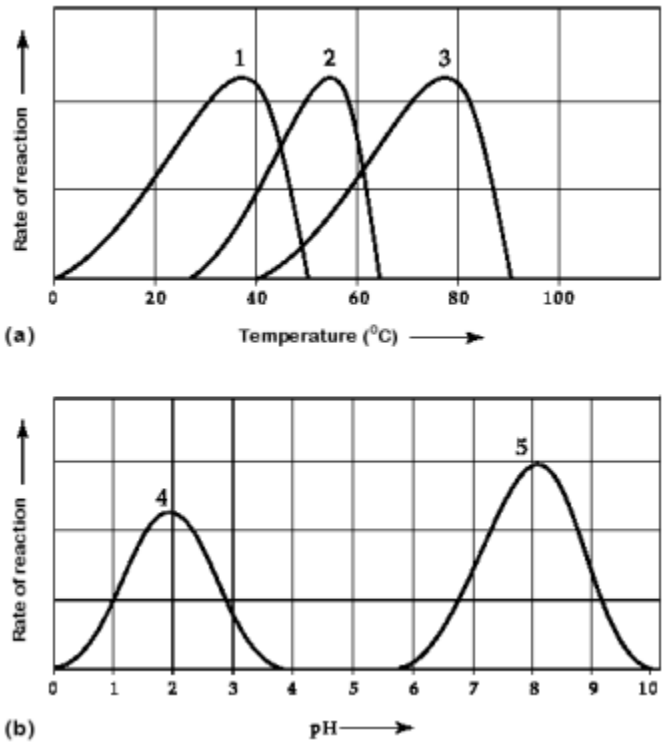
26. The active site of an enzyme is the region that

A. Binds allosteric regulators of the enzyme.
B. Is involved in the catalytic reaction of the enzyme.
C. Binds the products of the catalytic reaction.
D. Is inhibited by the presence of a coenzyme or a cofactor.

27. According to the induced fit hypothesis of enzyme catalysis, which of the following is correct?

A. The binding of the substrate depends on the shape of the active site.
B. Some enzymes change their structure when activators bind to the enzyme.
C. A competitive inhibitor can outcompete the substrate for the active site.
D. The binding of the substrate changes the shape of the enzyme's active site.
E. The active site creates a microenvironment ideal for the reaction

28. According to this figure:



A. Which curve represents the behavior of an enzyme taken from a bacterium that lives in hot springs at temperatures of 70°C or higher? 3
B. Which curve was most likely generated from analysis of an enzyme from a human stomach where conditions are strongly acid? 4
C. Which curve was most likely generated from an enzyme that requires a cofactor? Cannot be determined

29. Increasing the substrate concentration in an enzymatic reaction could overcome which of the following?

A. Denaturization of the enzyme
B. Allosteric inhibition
C. Competitive inhibition
D. Saturation of the enzyme activity
E. Insufficient cofactors

27. Which of the following is true of enzymes?

A. Enzymes may require a nonprotein cofactor or ion for catalysis to take speed up more appreciably than if the enzymes act alone.
B. Enzyme function is increased if the three-dimensional structure or conformation of an enzyme is altered.
C. Enzyme function is independent of physical and chemical environmental factors such as pH and temperature.
D. Enzymes increase the rate of chemical reaction by lowering activation energy barriers.

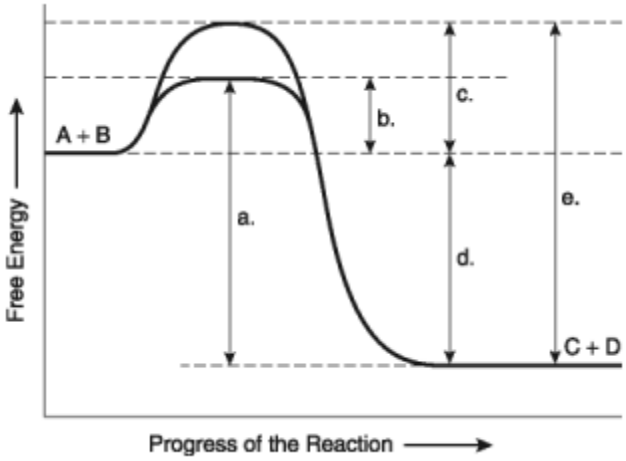
28. Zinc, an essential trace element for most organisms, is present in the active site of the enzyme carboxypeptidase. The zinc most likely functions as a(n)

A. Competitive inhibitor of the enzyme.
B. Noncompetitive inhibitor of the enzyme.
C. Allosteric activator of the enzyme.
D. Cofactor necessary for enzyme activity.
E. Coenzyme derived from a vitamin.

29. Which of the following statements describes enzyme cooperativity?

A. A multi-enzyme complex contains all the enzymes of a metabolic pathway.
B. A product of a pathway serves as a competitive inhibitor of an early enzyme in the pathway.
C. A substrate molecule bound to an active site affects the active site of several subunits.
D. Several substrate molecules can be catalyzed by the same enzyme.
E. A substrate binds to an active site and inhibits cooperation between enzymes in a pathway

30. According to this figure:



A. Which of the following terms best describes the reaction? Endergonic / exergonic / anabolic allosteric / nonspontaneous
B. Which of the following represents the △G of the reaction?
C. Which of the following would be the same in an enzyme-catalyzed or noncatalyzed reaction?
D. Which of the following bests describes the reaction?
E. Which of the following represents the difference between the free-energy content of the reaction and the free-energy content of the products?
F. Which of the following represents the activation energy required for the enzyme-catalyzed reaction?
G. Which of the following represents the activation energy required for a noncatalyzed reaction?

31. Catabolism is to anabolism as _____ is to _____.

A. Exergonic; spontaneous
B. Exergonic; endergonic
C. Free energy; entropy
D. Work; energy
E. Entropy; enthalpy

32. If an enzyme solution is saturated with substrate, the most effective way to obtain a faster yield of products is to

A. Add more of the enzyme.
B. Heat the solution to 90°C.
C. Add more substrate.
D. Add an allosteric inhibitor.
E. Add a noncompetitive inhibitor.

33. If an enzyme is added to a solution where its substrate and product are in equilibrium, what would occur?

A. Additional product would be formed.
B. Additional substrate would be formed.
C. The reaction would change from endergonic to exergonic.
D. The free energy of the system would change.
E. Nothing; the reaction would stay at equilibrium.

34. Some bacteria are metabolically active in hot springs because

A. They are able to maintain a cooler internal temperature.
B. High temperatures make catalysis unnecessary.
C. Their enzymes have high optimal temperatures.
D. Their enzymes are completely insensitive to temperature.
E. They use molecules other than proteins or RNAs as their main catalysts.

35. Which metabolic pathway is common to both cellular respiration and fermentation?

A. The oxidation of pyruvate to acetyl CoA
B. The citric acid cycles
C. Oxidative phosphorylation
D. Glycolysis
E. Chemiosmosis

36. The ATP made during fermentation is generated by which of the following?

A. The electron transport chain
B. Substrate-level phosphorylation
C. Chemiosmosis
D. Oxidative phosphorylation
E. Aerobic respiration

37. Phosphofructokinase is an important control enzyme in the regulation of cellular respiration. Which of the following statements describes a function of phosphofructokinase?

A. It is activated by AMP (derived from ADP).
B. It is activated by ATP.
C. It is inhibited by citrate, an intermediate of the citric acid cycle.
D. It catalyzes the conversion of fructose-1,6-bisphosphate to fructose-6-phosphate, an early step of glycolysis.
E. It is an allosteric enzyme.

38. Phosphofructokinase is an allosteric enzyme that catalyzes the conversion of fructose -6-phosphate to fructose-1,6-bisphosphate, an early step of glycolysis. In the presence of oxygen, an increase in the amount ATP in a cell would be expected to:

A. Inhibit the enzyme and thus slow the rates of glycolysis and the citric acid cycle.
B. Activate the enzyme and thus slow the rates of glycolysis and the citric acid cycle.
C. Inhibit the enzyme and thus increase the rates of glycolysis and the citric acid cycle.
D. Activate the enzyme and increase the rates of glycolysis and the citric acid cycle.
E. Inhibit the enzyme and thus increase the rate of glycolysis and the concentration of citrate.

39. What is the purpose of beta oxidation in respiration?

A. Oxidation of glucose
B. Oxidation of pyruvate
C. Feedback regulation
D. Control of ATP accumulation
E. Breakdown of fatty acids

40. Where do the catabolic products of fatty acid breakdown enter into the citric acid cycle?

A. Pyruvate
B. Malate or fumarate
C. Acetyl CoA
D. α-ketoglutarate
E. Succinyl CoA

41. The immediate energy source that drives ATP synthesis by ATP synthase during oxidative phosphorylation is

A. The oxidation of glucose and other organic compounds.
B. The flow of electrons down the electron transport chain.
C. The affinity of oxygen for electrons.
D. The H+ concentration gradient across the inner mitochondrial membrane.
E. The transfer of phosphate to ADP.

42. Which metabolic pathway is common to both fermentation and cellular respiration of a glucose molecule?

A. The citric acid cycle
B. The electron transport chain
C. Glycolysis
D. Synthesis of acetyl CoA from pyruvate
E. Reduction of pyruvate to lactate

43. The final electron acceptor of the electron transport chain that functions in aerobic oxidative phosphorylation is:

A. Oxygen
B. Water
C. NAD+
D. Pyruvate

44. Most CO_2 from catabolism is released during:

A. Glycolysis
B. The citric acid cycle
C. Lactate fermentation
D. Electron transport
E. Oxidative phosphorylation

45. In alcohol fermentation, NAD^+ is regenerated from NADH during which of the following?

A. Reduction of acetaldehyde to ethanol (ethyl alcohol)
B. Oxidation of pyruvate to acetyl CoA
C. Reduction of pyruvate to form lactate
D. Oxidation of NAD+ in the citric acid cycle
E. Phosphorylation of ADP to form ATP

46. The totality of an organism's chemical reactions is called:

A. Catabolism
B. Anabolism
C. Metabolism
D. Cellular respiration

47. The free energy change is negative for which of the following sets of reactions?

A. Endergonic and spontaneous
B. Exergonic and spontaneous
C. Exergonic and non-spontaneous
D. Endergonic and non-spontaneous

48. How many FADH2 formed in each turn of Krebs cycle:

A. 1
B. 3
C. 6
D. 4

49. Which of the following is a co-enzyme?

A. Zn
B. Cu
C. Vitamins
D. Fe

50. The net number of ATP molecules produced in glycolysis per two glucose molecules are:

A. 2
B. 4
C. 8
D. 6

51. Which of the following enters Krebs cycle?

A. Pyruvate
B. NADH
C. Acetyl-CoA
D. Acetate

52. True or false:

ATP drives endergonic reactions by producing highly reactive phosphorylated intermediate.

53. True or false

In addition to ATP and pyruvate, NADH and H2O are other end products of glycolysis.

54. In the absence of oxygen, which of the following compounds will be formed by yeast to regenerate ATP through fermentation?

A. ATP, CO2 and acetyl-CoA
B. ATP only
C. ATP, CO2 and lactate
D. ATP, CO2 and ethanol
E. None of the above

55. In eukaryotic cells, the energy yield from the complete oxidation of one molecule of glucose:

A. Is always 32
B. Is 30 or 38 ATP
C. Can vary depending on whether NADH from glycolysis passes electrons to NAD+ or FAD
D. Is always 10 protons
E. Is less than the yield from fermentation

56. One function of both alcohol fermentation and lactic acid fermentation is to

A. Reduce NAD+ to NADH.
B. Reduce FAD+ to FADH2.
C. Oxidize NADH to NAD+.
D. Reduce FADH2 to FAD+.
E. None of the above

57. The immediate energy source that drives ATP synthesis by ATP synthase during oxidative phosphorylation is

A. The oxidation of glucose and other organic compounds.
B. The flow of electrons down the electron transport chain.
C. The affinity of oxygen for electrons.
D. The H+ concentration gradient across the inner mitochondrial membrane.
E. The transfer of phosphate to ADP

58. The free energy for the oxidation of glucose to CO2 and water is -686 kcal/mole and the free energy for the reduction of NAD+ to NADH is +53 kcal/mole. Why are only two molecules of NADH formed during glycolysis when it appears that as many as a dozen could be formed?

A. Most of the free energy available from the oxidation of glucose is used in the production of ATP in glycolysis.
B. Glycolysis is a very inefficient reaction, with much of the energy of glucose released as heat.
C. Most of the free energy available from the oxidation of glucose remains in pyruvate, one of the products of glycolysis.
D. There is no CO_2 or water produced as products of glycolysis.
E. Glycolysis consists of many enzymatic reactions, each of which extracts some energy from the glucose molecule

59. How many molecules of carbon dioxide (CO_2) would be produced by five turns of the citric acid cycle?

A. 2
B. 5
C. 10
D. 12
E. 60

60. Energy released by the electron transport chain is used to pump H+ ions into which location?

A. Cytosol
B. Mitochondrial outer membrane
C. Mitochondrial inner membrane
D. Mitochondrial intermembrane space
E. Mitochondrial matrix

61. Where is ATP synthase located in the mitochondrion?

A. Cytosol
B. Electron transport chain
C. Outer membrane
D. Inner membrane
E. Mitochondrial matrix

62. Besides turning enzymes on or off, what other means does a cell use to control enzymatic activity?

A. Cessation of all enzyme formation
B. Compartmentalization of enzymes into defined organelles
C. Exporting enzymes out of the cell
D. Connecting enzymes into large aggregates
E. Hydrophobic interactions

63. By beta-oxidation, fat is converted to acetyl Co-A, then acetyl CoA enters:

A. Glycolysis and pyruvate oxidation
B. Citric acid cycle
C. Pyruvate oxidation and the citric acid cycle
D. Citric acid cycle and fermentation
E. Glycolysis and chemiosmosis

64. When hydrogen ions are pumped across the inner mitochondrial membrane into the intermembrane space, this result is:

A. Creation of proton motive force
B. Reduction of NAD+
C. Lowering PH in mitochondrial matrix
D. Direct formation of 1atp
E. None of the above

65. True or false:

Spontaneous processes occur without energy input

66. True or false:

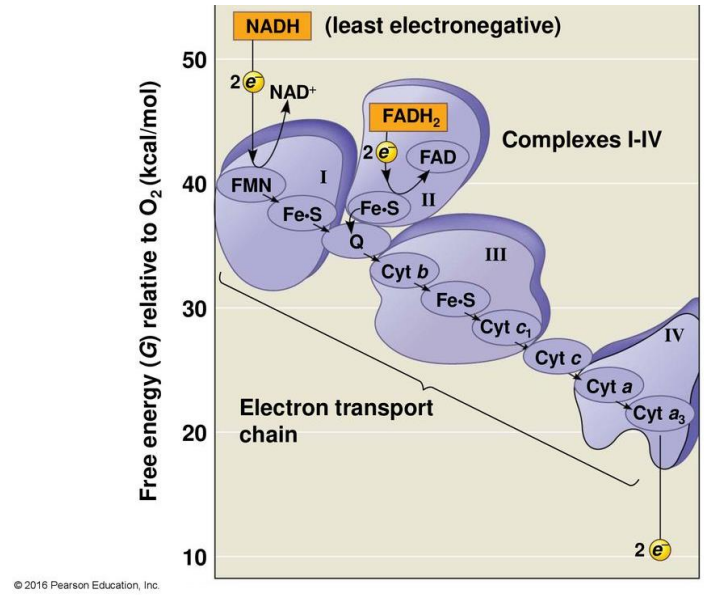
Exergonic reaction absorbs free energy from its surrounding

67. Chemiosmosis is described as an energy coupling mechanism that:

A. Uses the stored energy of the proton gradient to synthesized ATP
B. Inhibit electron transfer along ETC
C. Lower PH in the intermembrane space
D. Phosphorylates substrate molecules
E. None of the above

- Which of the following describes the sequence of electron carriers in the electron transport chain, starting with the least electronegative?

A. Ubiquinone (Q), cytochromes (Cyt), FMN, Fe•S
B. Cytochromes (Cyt), FMN, ubiquinone, Fe•S
C. Fe•S, FMN, cytochromes (Cyt), ubiquinone
D. FMN, Fe•S, ubiquinone, cytochromes (Cyt)
E. Cytochromes (Cyt), Fe•S, ubiquinone, FMN



- During aerobic respiration, which of the following directly donates electrons to the electron transport chain at the lowest energy level?

A. NAD+
B. NADH
C. ATP
D. ADP + Pi
E. $FADH_2$

- 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 hydrogen, forming water.
C. Combine with carbon, forming CO2
D. Combine with lactate, forming pyruvate.
E. Catalyze the reactions of glycolysis

- An electron loses potential energy when it

A. Shifts to a less electronegative atom.
B. Shifts to a more electronegative atom.
C. Increases its kinetic energy.
D. Increases its activity as an oxidizing agent.
E. Attaches itself to NAD+.

- Which of the following describes ubiquinone?

A. A protein in the electron transport chain
B. A small hydrophobic coenzyme
C. A substrate for synthesis of FADH
D. A vitamin needed for efficient glycolysis
E. An essential amino acid

- What is proton-motive force?

A. The force required to remove an electron from hydrogen
B. The transmembrane proton concentration gradient
C. Movement of hydrogen into the intermembrane space
D. Movement of hydrogen into the mitochondrion
E. The addition of hydrogen to NAD+

- Phosphofructokinase is an allosteric enzyme that catalyzes the conversion of fructose-6-phosphate to fructose1,6-bisphosphate, an early step of glycolysis. In the presence of oxygen, an increase in the amount ATP in a cell would be expected to

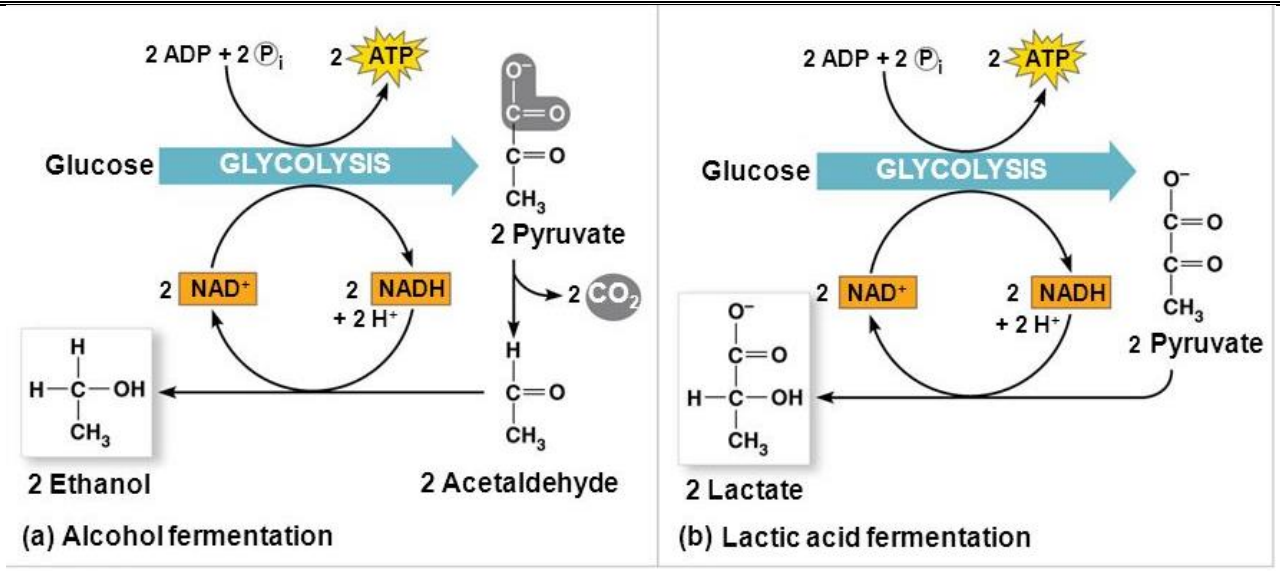
A. inhibit the enzyme and thus slow the rates of glycolysis and the citric acid cycle.
B. activate the enzyme and thus slow the rates of glycolysis and the citric acid cycle.
C. inhibit the enzyme and thus increase the rates of glycolysis and the citric acid cycle.
D. activate the enzyme and increase the rates of glycolysis and the citric acid cycle.
E. inhibit the enzyme and thus increase the rate of glycolysis and the concentration of citrate

- Which process in eukaryotic cells will proceed normally whether oxygen (O_2) is present or absent?

A. Electron transport
B. Glycolysis
C. The citric acid cycle
D. Oxidative phosphorylation
E. Chemiosmosis

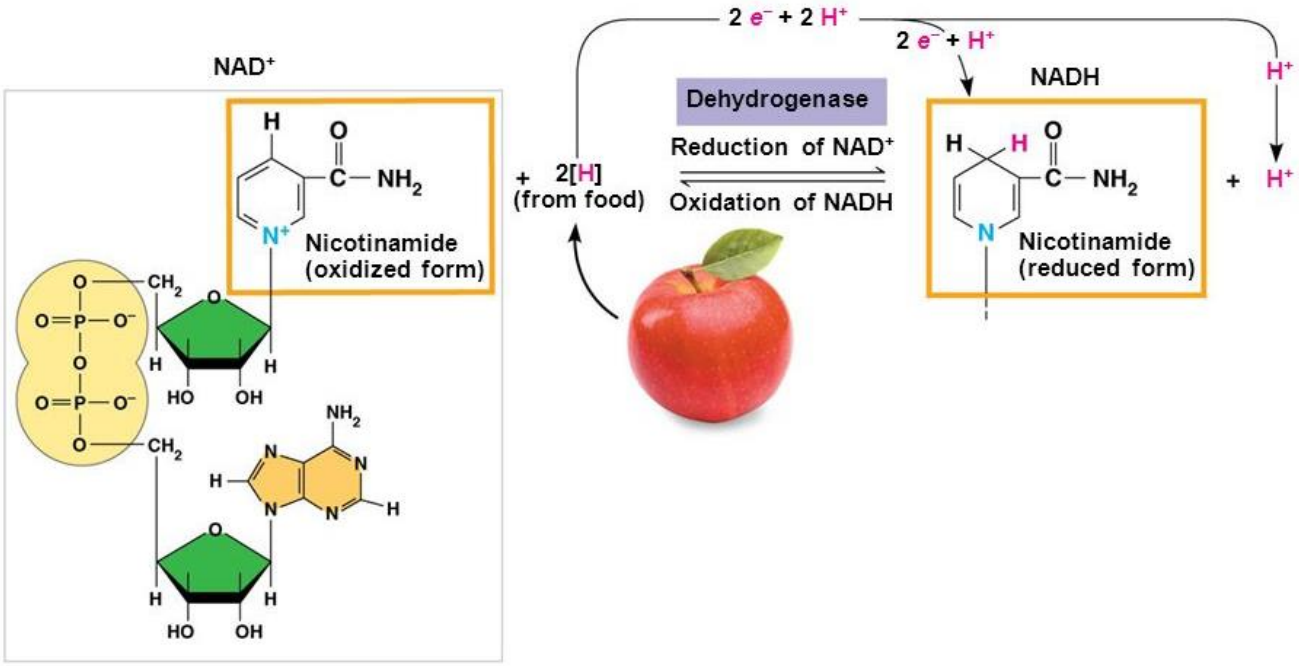
- Why are carbohydrates and fats considered high energy foods?

A. They have a lot of oxygen atoms.
B. They have no nitrogen in their makeup.
C. They can have very long carbon skeletons.
D. They have a lot of electrons associated with hydrogen.
E. They are easily reduced



- Where do the reactions of the citric acid cycle occur in eukaryotic cells?

A. the cytosol
B. the intermembrane space of the mitochondrion
C. the matrix of the mitochondrion
D. the cristae of the mitochondrion
E. across the inner membrane of the mitochondrion

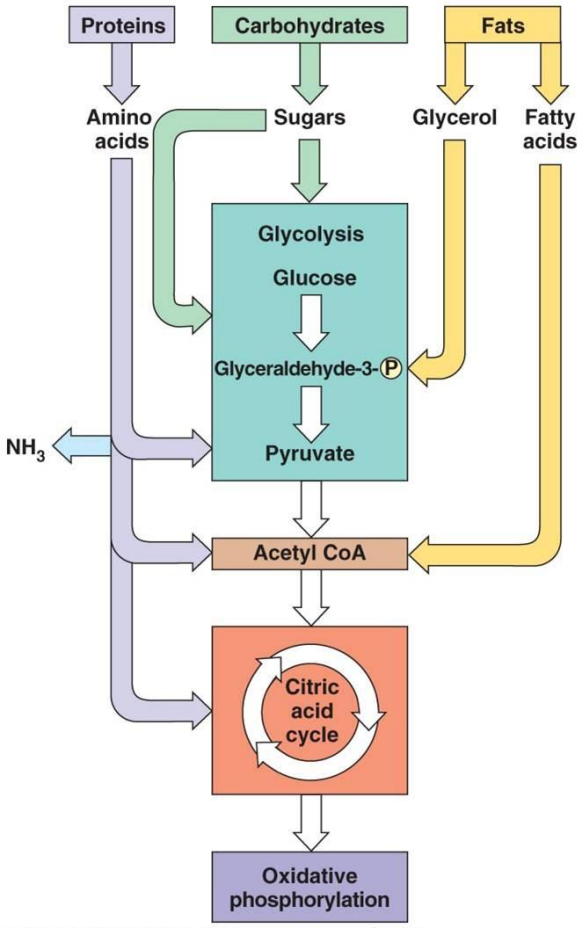


- Most CO_2 from catabolism is released during

A. lactate fermentation.
B. oxidative phosphorylation.
C. the citric acid cycle.
D. electron transport.
E. Glycolysis

- When electrons move closer to a more electronegative atom, what happens?

A. The more electronegative atom is reduced, and energy is released.
B. The more electronegative atom is reduced, and energy is consumed.
C. The more electronegative atom is oxidized, and energy is consumed.
D. The more electronegative atom is oxidized, and energy is released.
E. The more electronegative atom is reduced, and entropy decreases



- When glucose monomers are joined together by glycosidic linkages to form a cellulose polymer, the changes in free energy, total energy, and entropy are as follows:

A. +ΔG, +ΔH, +ΔS.
B. +ΔG, +ΔH, -ΔS.
C. +ΔG, -ΔH, -ΔS.
D. -ΔG, +ΔH, +ΔS.
E. -ΔG, -ΔH, -ΔS

- The mechanism in which the end product of a metabolic pathway inhibits an earlier step in the pathway is most precisely described as

A. metabolic inhibition.
B. feedback inhibition.
C. allosteric inhibition.
D. noncooperative inhibition.
E. reversible inhibition

- Besides turning enzymes on or off, what other means does a cell use to control enzymatic activity?

A. cessation of cellular protein synthesis
B. localization of enzymes into specific organelles or membranes
C. exporting enzymes out of the cell
D. connecting enzymes into large aggregates E. hydrophobic interactions

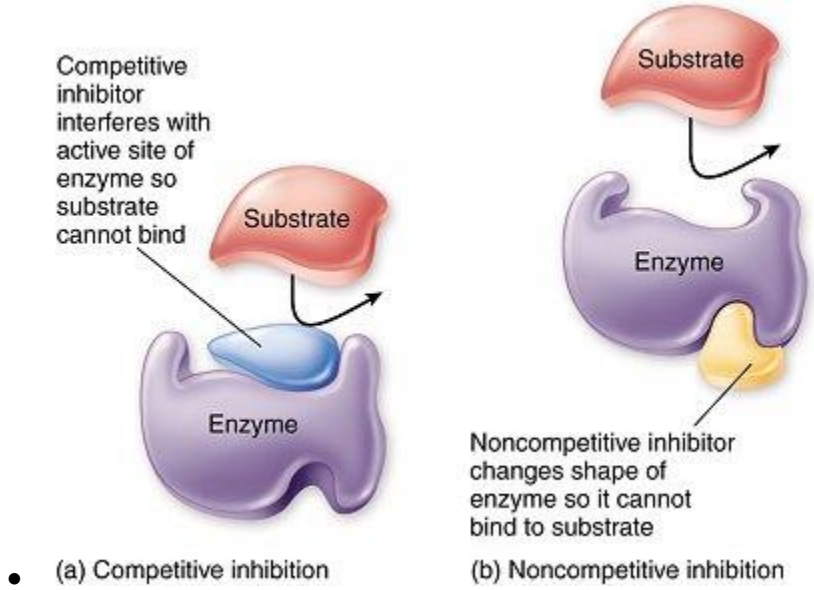
- The end product of citric acid cycle includes all the following except:

A. NADH
B. ATP
C. Pyruvic acid
D. FADH2
E. CO2

- The net products of breaking down of one acetyl-CoA in citric acid cycle is:

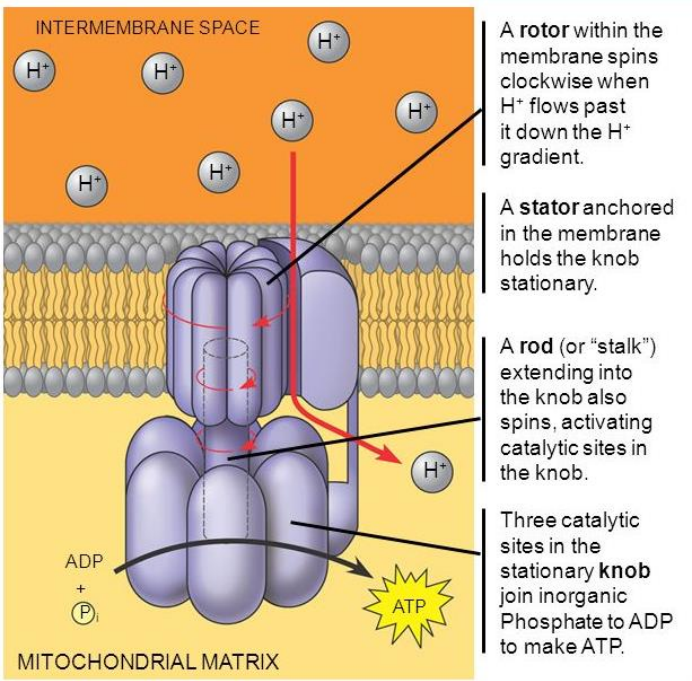
- Which stage of cellular respiration requires ATP?

A. Chemiosmosis
B. Citric acid cycle
C. None of the above
D. Electron transport chain
E. Glycolysis



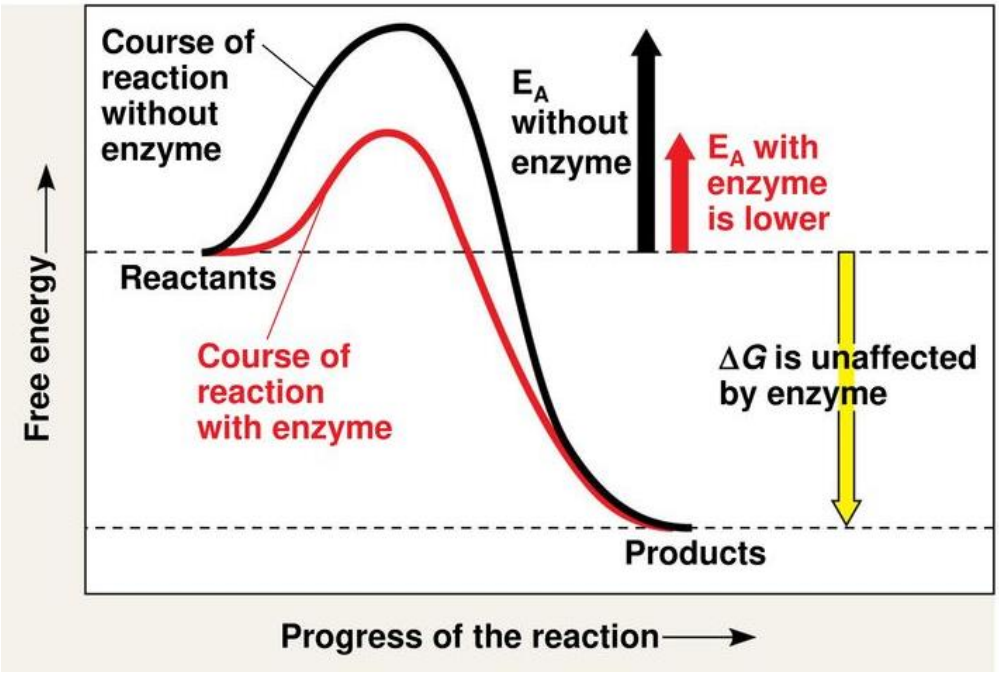
- Which of the following is a result of glycolysis?

A. Conversion to NADH to NAD+
B. Production of CO2
C. Conversion to FAD to FADH2
D. Conversion of glucose to two three carbon compounds
E. A net loss of 2 ATP molecules per glucose molecule

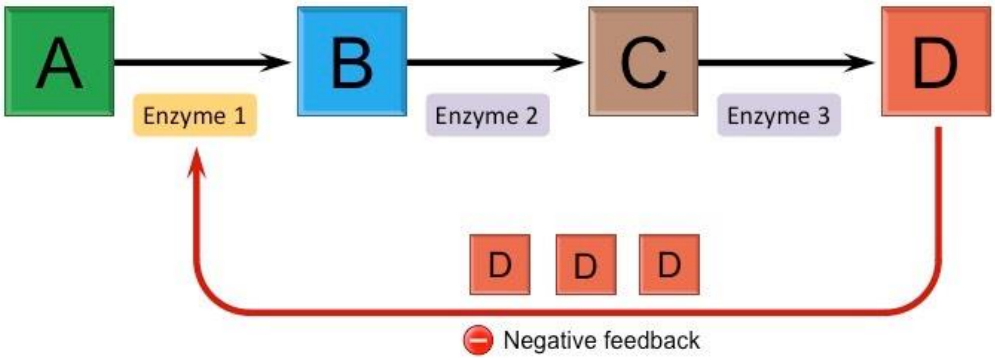


- True or false:

A. Oxygen is used during Krebs cycle.
B. Glycolysis is the first phase of cell respiration and occurs in the mitochondria.
C. Glycolysis requires 4 ATP to start the reaction.
D. Enzymes speeds up chemical reaction by increasing activation energy
E. Enzymes can convert endergonic reaction to exergonic one



Feedback inhibition



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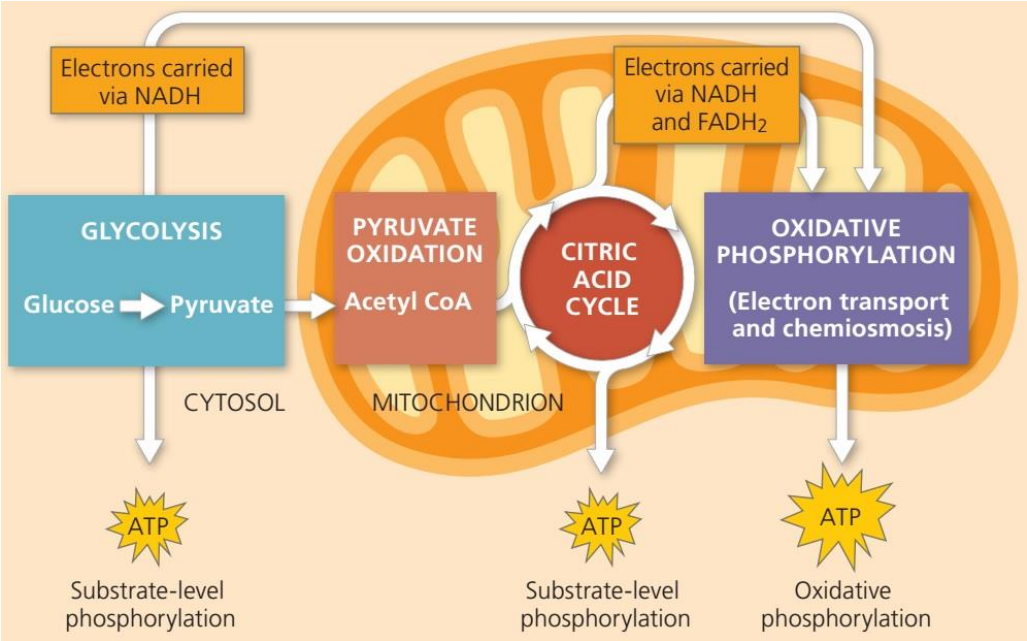

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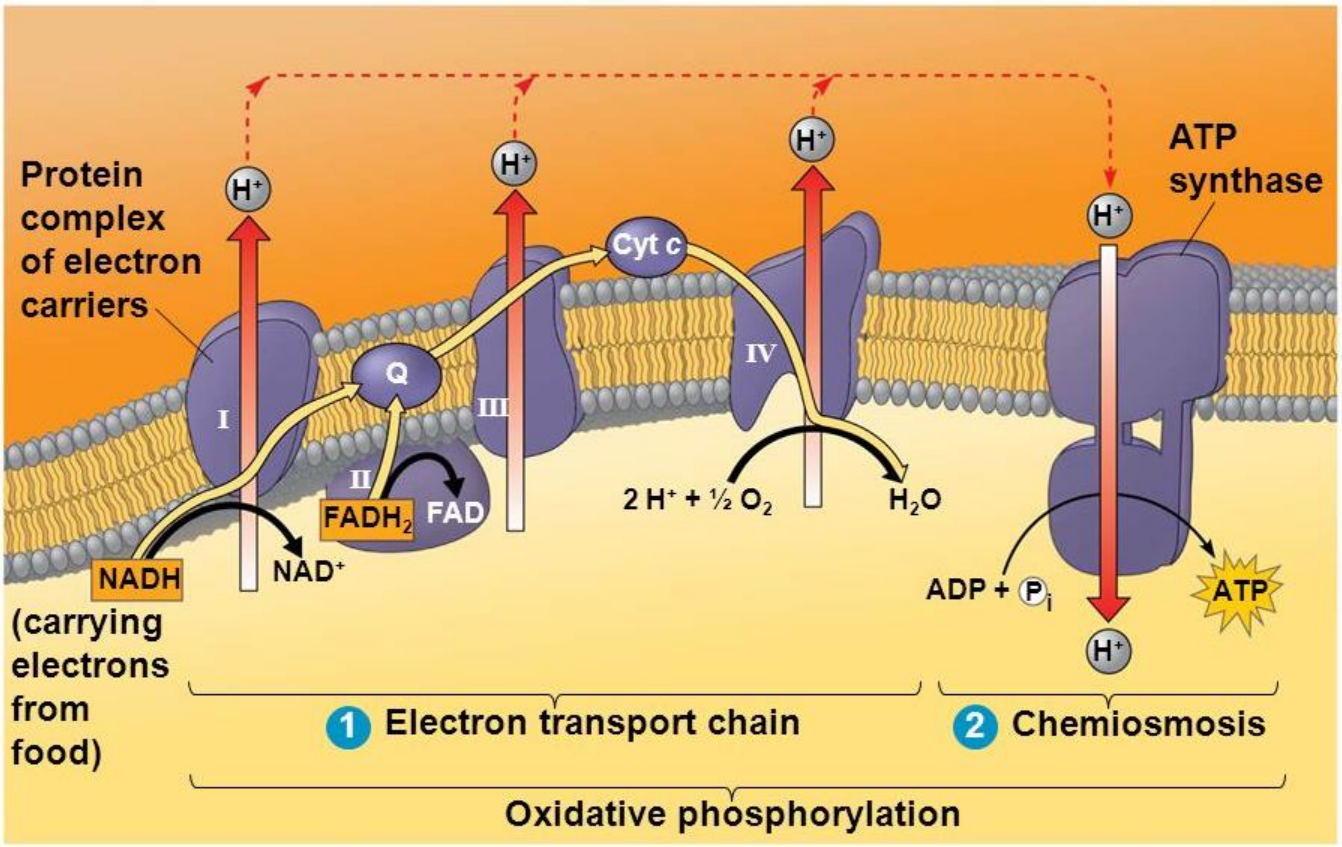
A. Most of the free energy available from the oxidation of glucose is used in the production of ATP in glycolysis.
B. Glycolysis is a very inefficient reaction, with much of the energy of glucose released as heat.
C. Most of the free energy available from the oxidation of glucose remains in pyruvate, one of the products of glycolysis.
D. There is no CO_2 or water produced as products of glycolysis.
E. Glycolysis consists of many enzymatic reactions, each of which extracts some energy from the glucose molecule

- Chemiosmosis is described as an energy coupling mechanism that:

A. Uses the stored energy of the proton gradient to synthesized ATP
B. Inhibit electron transfer along ETC
C. Lower PH in the intermembrane space
D. Phosphorylates substrate molecules
E. None of the above



- Energy flow during respiration ----------
- Electron flow during respiration ----------