

1. Most metabolic processes are controlled by all of the following **EXCEPT**:
 - A. Covalent modification of specific enzymes
 - B. Allostery
 - C. Formation of multi-enzymatic complexes
 - D. Regulation of transcription of specific genes
 - E. Reversible binding and release of prosthetic groups to the active site

2. The K_m of an enzyme for its substrate is usually:
 - A. Around the intracellular concentration of the substrate
 - B. Around the intracellular concentration of the enzyme
 - C. Far below the intracellular concentration of the substrate
 - D. Far below the intracellular concentration of the enzyme
 - E. There is no relationship between intracellular substrate concentration and K_m value

3. What kinds of enzymes may have pyridoxal phosphate as a prosthetic group?
 - A. Oxidoreductases
 - B. Transferases
 - C. Hydrolases
 - D. Lyases
 - E. Isomerases

4. Co-substrates:
 - A. Are part of the active site
 - B. Remain tightly bound to an enzyme.
 - C. Are recycled/reused by other enzymes
 - D. Are inorganic ions
 - E. Are continuously oxidized as a source of energy

5. Loosely-bound metals required in chemical reactions are known as:
 - A. Coenzymes
 - B. Cofactors
 - C. Activators
 - D. Metabolite cofactors
 - E. Repressors

6. Alcoholics may develop niacin deficiency. What kinds of enzymes would be affected by this syndrome?
 - A. Oxidoreductases
 - B. Transferases
 - C. Hydrolases
 - D. Lyases
 - E. Isomerases

7. Which of the following vitamins is actually synthesized in the body?
- A. A
 - B. B complex
 - C. C
 - D. D
 - E. E
8. What is an anomeric carbon in a sugar?
- A. The farthest chiral carbon from the carbonyl group
 - B. The carbonyl group after it is converted into a hemiacetal
 - C. The last carbon in the chain
 - D. A term used in sugar chemistry to define any chiral carbon
 - E. The carbon that determines whether a sugar is D- or L-
9. Which of the following prosthetic groups does not contain adenine in its structure?
- A. NAD
 - B. NADP
 - C. FAD
 - D. FMN
 - E. Coenzyme Q
10. Which of the following cytochrome-types has the same heme structure found in hemoglobin?
- A. Cytochrome a
 - B. Cytochrome b
 - C. Cytochrome c
 - D. All of the above
 - E. None of the above
11. Eggs contain a protein called avidin which binds biotin tightly. Thus, excessive intake of raw eggs may cause a rare biotin deficiency. Which of the following enzymes will be affected in these patients?
- A. Dehydrogenases
 - B. Aminotransferases (Transaminases)
 - C. Decarboxylases
 - D. Carboxylases
 - E. None of the above
12. Which of the following compounds **IS NOT** a polysaccharide?
- A. Chitin
 - B. Glycogen
 - C. Maltose
 - D. Amylose

- E. Cellulose
13. Chitin and cellulose are different in that:
- A. The sugars are bound through different glycosidic bonds (α for chitin and β for cellulose)
 - B. Cellulose contains acidic sugars
 - C. Chitin contains amino sugars
 - D. Chitin is branched
 - E. Cellulose is a polymer of glucose while chitin is a polymer of galactose
14. Cartilage is composed of collagen fibers imbedded in:
- A. Glycoproteins
 - B. Proteoglycans
 - C. Peptidoglycans
 - D. Disaccharides
 - E. Glycogen
15. The difference(s) between glycoproteins and gangliosides is(are) that:
- A. Glycoproteins only contain polymers of glucose
 - B. Gangliosides are always in the bloodstream
 - C. While gangliosides are always membrane component, glycoproteins may or not be associated with the membrane
 - D. All of the above
 - E. None of the above
16. Penicillin:
- A. Blocks synthesis of the bacterial wall
 - B. Inhibits a transpeptidase
 - C. Inhibits hydrolysis of a glycosidic bond
 - D. A and B are correct
 - E. A and C are correct
17. All of the following statements about of cholesterol are **TRUE, EXCEPT**:
- A. It affects membrane fluidity
 - B. It is a precursor of steroid hormones
 - C. It is a precursor of bile salts
 - D. It is a precursor of sphingomyelins
 - E. Is an alcohol
18. All the following statements apply to **BOTH** glycerophospholipids and sphingomyelins **EXCEPT**:
- A. Contain glycerol
 - B. Contain at least one fatty acids
 - C. Are amphipatic
 - D. May contain unsaturated fatty acids
 - E. Contain phosphate groups

19. Phospholipase ____ acts at the point indicated by the arrow:
- A. A₁
 - B. A₂
 - C. C
 - D. D
 - E. None of the above
20. The main difference between gangliosides and cerebroside is:
- A. Gangliosides contain phosphate
 - B. Only cerebroside contains sphingosine
 - C. Gangliosides contain branched polysaccharides
 - D. Gangliosides usually contain a single galactosamine
 - E. Cerebroside contains phosphate
21. A typical biological membrane contains:
- A. Only lipids
 - B. Only proteins
 - C. About 60 % proteins and 40 % lipids
 - D. About 90% lipids
 - E. About 90% proteins
22. Above the phase transition temperature:
- A. The membrane becomes thinner
 - B. There is less rotation around -C-C- bonds
 - C. Lateral diffusion increases
 - D. A and B are correct
 - E. A and C are correct
23. All of the following alcohols may be esterified with phosphate in glycerophospholipids **EXCEPT**:
- A. Serine
 - B. Inositol
 - C. Cholesterol
 - D. Choline
 - E. Ethanolamine
24. All of the following are characteristics of a phospholipid bilayer **EXCEPT**:
- A. The lipid composition in both sides of the bilayer is usually different
 - B. Lipids are free to move across the membrane
 - C. The lateral diffusion of many membrane proteins is not restricted
 - D. Integral proteins are located across the membrane.
 - E. Membrane glycoproteins face the inner side of the cell membrane

Figure

3. If you know the value of ΔG° in a redox reaction you also may calculate:
- A. K_{eq}
 - B. ΔE°
 - C. Q
 - D. A and B are correct
 - E. B and C
4. Which of the following is **CORRECT** for a reaction with a $\Delta G^{\circ} = 0$?
- A. Evolves in the direction of reagents
 - B. Evolves in the direction of products
 - C. Is in equilibrium
 - D. $K_{eq} < 0$
 - E. $K_{eq} = 1$
5. If the ΔE of a redox reaction is smaller than 0:
- A. $\Delta G > 0$
 - B. $\Delta G < 0$
 - C. The reaction is in equilibrium
 - D. A and C are correct
 - E. B and C are correct
4. The transport of one molecule of ATP outside the inner mitochondrial membrane requires the simultaneous movement of a molecule ADP inwards. This type of co-transporter is called:
- A. An uniport
 - B. An symport
 - C. Facilitated diffusion
 - D. A channel
 - E. None of the above
5. Glucagon receptors are an example of:
- A. Gs protein
 - B. Gi protein
 - C. Gq protein
 - D. Tyrosine kinase
 - E. Depends on the tissue where they are located
6. What determines the duration of a signal mediated by a G protein-dependent receptor?
- A. The affinity for the α subunit for the $\beta\gamma$ subunits
 - B. The rate of GTP hydrolysis by the α subunit
 - C. How long the γ subunit remains bound to GTP
 - D. The rate of GMP to GDP conversion
 - E. The time it takes for the α subunit to become phosphorylated

7. Processes mediated by Gq proteins involve all of the following **EXCEPT**:
- A. Phosphatidyl inositol
 - B. Phospholipase C
 - C. Ca^{+2}
 - D. Protein kinase C
 - E. cAMP
8. Fructose entry in the glycolytic pathway bypasses all the following points of regulation **EXCEPT**:
- A. Hexokinase
 - B. Glucokinase
 - C. PFK-1
 - D. PFK-2
 - E. Pyruvate kinase
9. Which of the following is a common intermediate in both glycogen synthesis and galactose metabolism?
- A. Fructose 1,6-bisphosphate
 - B. Fructose 2,6-bisphosphate
 - C. UDPG
 - D. Maltose
 - E. Fructose 1 phosphate
10. Yeast make ethanol in order to:
- A. Reoxidize NADH from glycolysis
 - B. Have fun
 - C. Make ATP in the process
 - D. Eliminate lactic acid
 - E. Reduce NAD for energy formation
11. Protein kinase A (stimulated by glucagon) has the following effects **EXCEPT**:
- A. Inhibits PFK-2
 - B. Stimulates glycogen phosphorylase
 - C. Inhibits glycogen synthase
 - D. Inhibits pyruvate dehydrogenase
 - E. Inhibits pyruvate kinase
12. Which of the following enzymes **DOES NOT** catalyze substrate level phosphorylation?
- A. Pyruvate kinase
 - B. Phosphoglycerate kinase
 - C. Succinyl CoA synthetase
 - D. PFK-1
 - E. All of them catalyze substrate level phosphorylation.

13. Protein phosphatase-1, which reverses the action of protein kinase A, is activated by:
- A. cAMP
 - B. UDPG
 - C. Free glucose
 - D. Fructose-1-P
 - E. None of the above
14. Which of the following enzymes normally catalyze the re-oxidation of NADH produced in glycolysis?
- A. Pyruvate dehydrogenase
 - B. Glyceraldehyde-3-phosphate dehydrogenase
 - C. Lactate dehydrogenase
 - D. Isocitrate dehydrogenase
 - E. α -ketoglutarate dehydrogenase
15. How many ATP molecules are produced thorough substrate-level and oxidative phosphorylation as a result of the conversion of 1,3-bisphosphoglycerate into α -ketoglutarate?
- A. 2
 - B. 4.5
 - C. 7
 - D. 9.5
 - E. 12
16. All the following enzymes are critical in the regulation of glucose oxidation to CO₂, **EXCEPT**:
- A. PFK-1
 - B. pyruvate kinase
 - C. Glyceraldehyde-3-phosphate dehydrogenase
 - D. Pyruvate dehydrogenase
 - E. Isocitrate dehydrogenase
17. All the following vitamins/coenzymes are needed in the reactions catalyzed by the pyruvate dehydrogenase complex **EXCEPT**:
- A. Niacin (needed for NAD)
 - B. Pyridoxal phosphate
 - C. Riboflavin
 - D. Thiamine pyrophosphate (TPP)
 - E. pantothenic acid (CoA)
18. Which of the enzymes in the pyruvate dehydrogenase complex **IS NOT** allosterically regulated?
- A. E₁
 - B. E₂
 - C. E₃
 - D. Kinase

- E. Phosphatase
19. The pyruvate dehydrogenase and α -ketoglutarate dehydrogenase complexes are similar in that:
- A. Both contain a kinase
 - B. Both complexes involve 3 enzymes in for the reaction
 - C. Both are inhibited by CO_2
 - D. Both are regulated by covalent modification
 - E. Both contain FMN as the prosthetic group of E_3
20. The formation of UDPG requires:
- A. Glucose-6-P + UTP
 - B. Glucose 6-P + UDP
 - C. Glucose-1-P + UTP
 - D. Glucose-1-P + UDP
 - E. Glucose + UTP
21. How are the α 1 \rightarrow 6 branches in glycogen synthesized?
- A. By addition of a free glucose through an α 1 \rightarrow 6 glycosidic bond
 - B. By addition of glucose using UDPG as a substrate
 - C. By addition of glucose using glucose-1-phosphate as a substrate
 - D. By transferring an oligosaccharide from the non reducing end to create an α 1 \rightarrow 6 branch
 - E. By transferring an oligosaccharide from the reducing end to create an α 1 \rightarrow 6 branch
22. Which of the following enzymes is found in liver but not in muscle?
- A. Hexokinase
 - B. Glucose-6- phosphatase
 - C. Phosphoglucomutase
 - D. Glycogen phosphorylase
 - E. Glycogen synthase
23. Which of the following hormones binds more than one type of receptor in the liver?
- A. Insulin
 - B. Glucagon
 - C. Epinephrine
 - D. None of the above
 - E. All of the above

TRUE/FALSE:

24. Epinephrine decreases the affinity of insulin for its receptor
25. The carboxylation of pyruvate to make oxaloacetate is one of the anaplerotic reactions
26. Glycogen is only stored in muscle and liver

27. The oxidative step (NADH formation) during glycolysis occurs simultaneously with incorporation of inorganic phosphate.
28. Insulin stimulates GLUT4 fusion in the brain cell membranes.

ESSAYS

29. Insulin has to be injected in order to be effective. Recently a newly discovered product seems to mimic insulin action when taken orally, and could become the first oral treatment for Type I diabetes. Explain its proposed mechanism of action.
30. Which is the effect of glucagon in the following activities? Answer: 9, 8 or none.
- Glycolysis in the liver
 - glycogen synthesis in the muscle
 - glycogen synthesis in the liver
 - glycogen degradation in the muscle
 - glycogen degradation in the liver
 - glucose concentration in plasma
31. Which are the main differences between glycogen degradation in liver and muscle? What is the advantage of phosphorylase instead of hydrolyase during this process in the muscle?
32. The equilibrium between di-hydroxyacetone phosphate (DHAP) and glyceraldehyde-3-phosphate (G-3-P) favors the accumulation of DHAP. Explain why does glycolysis continue if the next reaction needs G-3-P.
33. Explain in a few sentences the process of signal transduction. What is the main difference between the glucagon and insulin receptors?

6. Which of the following **IS NOT** a gluconeogenic substrate
- A. Acetoacetate
 - B. Pyruvate
 - C. Oxaloacetate
 - D. Glycerol-P
 - E. Malate
7. Which enzyme(s) is(are) required to convert pyruvate into phosphoenol pyruvate?
- A. Pyruvate carboxylase
 - B. Pyruvate kinase
 - C. Phosphoenol-pyruvate carboxykinase
 - D. A and B are correct
 - E. A and C are correct
8. Conversion of PFK-2 to fructose 2,6 bisphosphatase by protein kinase A:
- A. Activates PFK-1
 - B. Activates fructose 1,6 bisphosphatase
 - C. Increases the intracellular concentration of fructose 2,6 bisphosphate
 - D. Activates glucose-6-phosphatase
 - E. Is inhibited by cAMP
9. How many ATP molecules are required to make glucose from malate?
- A. 1
 - B. 2
 - C. 3
 - D. 4
 - E. 6
10. Several irreversible steps in glycolysis must be bypassed in gluconeogenesis by specific enzymes. The glycolytic steps include all of the following **EXCEPT**:
- A. Phosphorylation of glucose to G-6-P
 - B. Formation of fructose 1,6 bisphosphate
 - C. Substrate level phosphorylation of ADP from 1,3-bisphosphoglycerate
 - D. Substrate level phosphorylation of ADP from phosphoenol pyruvate
 - E. No exceptions. All these steps are irreversible
11. Which of the following dehydrogenases also catalyzes a decarboxylation?
- A. NADH dehydrogenase
 - B. Succinate dehydrogenase

- C. Pyruvate carboxylase
- D. Glucose-6-phosphate dehydrogenase
- E. 6-phosphogluconolactone dehydrogenase

12. Which is the prosthetic group of mitochondrial glycerol phosphate dehydrogenase?

- A. Heme
- B. FMN
- C. FAD
- D. NAD^+
- E. Cu

13. How many ATPs are generated as a result of the oxidation of cytoplasmic NADH via the glycerol-P-shuttle?

- A. 1
- B. 1.5
- C. 2
- D. 2.5
- E. 5

14. Which respiratory complex **DOES NOT** carry H^+ in any direction?

- A. Complex I
- B. Complex II
- C. Complex III
- D. Complex IV
- E. Complex V

15. Which of the following Complexes **DOES NOT** contain Fe-S proteins?

- A. Complex I
- B. Complex II
- C. Complex III
- D. Complex IV
- E. They all contain Fe-S proteins

16. How many redox centers are there in Complex IV?

- A. 0
- B. 1
- C. 2
- D. 3
- E. 4

17. In addition to Complex I and II, which other flavoproteins transfer electrons to Coenzyme Q?

- A. Fatty acyl CoA dehydrogenase
- B. β -hydroxyacyl CoA dehydrogenase
- C. Glycerol-P-dehydrogenase
- D. A and B are correct
- E. A and C are correct

18. Cyanide stops electron transfer from cytochrome a_3 to oxygen. Which of the following processes is also blocked as a result of this inhibition:
- A. Proton pumping stops
 - B. NADH oxidation
 - C. ATP formation
 - D. Krebs cycle
 - E. All of the above
19. The **TOTAL** amount of ATP resulting from the complete oxidation of glucose to 6 CO_2 (if the glycerol phosphate shuttle is operating) is:
- A. 10
 - B. 20
 - C. 27
 - D. 30
 - E. 32
20. The enzyme translocase (ATP/ADP antiport)
- A. Co-transport H^+ bound to ADP
 - B. Takes negative charges from the matrix, at the expense of $\Delta\psi$
 - C. Requires P_i
 - D. Utilizes the F_o component of Complex V
 - E. Is a flavoprotein
21. What is the role of apoprotein C-II?
- A. To recognize LDL receptors
 - B. To recognize receptors for chylomicron remnants
 - C. To activate the pancreatic lipase
 - D. To activate LPL (lipoprotein lipase)
 - E. To carry free fatty acids
22. Digested lipids in the intestine are packed and delivered as:
- A. Chylomicrons
 - B. VLDL
 - C. LDL
 - D. IDL
 - E. HDL
23. Arrange the following lipoproteins in order of increasing density:
- A. VLDL > Chylomicrons > IDL > LDL
 - B. Chylomicrons > VLDL > IDL > LDL
 - C. IDL > Chylomicrons > VLDL > LDL
 - D. VLDL > IDL > LDL > Chylomicrons
 - E. Chylomicrons > LDL > IDL > VLDL

24. Ketone bodies in the liver result indirectly from a combination of all the following processes **EXCEPT**:
- A. Gluconeogenesis
 - B. Energy is only provided by β -oxidation
 - C. Accumulation of citrate
 - D. Protein kinase A activation
 - E. Increased cAMP
25. The formation of acetoacetyl-CoA from acetoacetate in peripheral tissues requires:
- A. ATP
 - B. GTP
 - C. Succinyl CoA
 - D. Free CoA
 - E. All of the above
26. What is the role of carnitine?
- A. Transports CoA
 - B. Transports acyl-CoA
 - C. Transports acyl groups
 - D. Transports acetyl CoA
 - E. Transports malate
27. In the heart and the muscle, the reaction: **stearoyl-CoA (18 C) + palmitoyl-CoA (16 C) + 2 CO₂**, results in the formation of _____ molecules of ATP:
- A. 2
 - B. 4
 - C. 8
 - D. 14
 - E. 28
28. Which of the following lipases is activated by phosphorylation?
- A. Pancreatic lipase
 - B. Lipoprotein lipase
 - C. Pancreatic phospholipase A₂
 - D. None of the above
 - E. All of the above

TRUE/FALSE

29. All Krebs' cycle intermediates may be used for gluconeogenesis
30. Ketone bodies are carried out as part of VLDL
31. Fatty acid oxidation is the main source of energy for gluconeogenesis

32. Cytochromes are always integral membrane proteins
33. The three active sites in ATP synthase are, at any given time, in three different configurations

ESSAYS:

34. Explain how is the energy from NADH oxidation converted into ATP during oxidative phosphorylation.
35. Explain why ketone bodies cannot be oxidized in the liver.
36. Explain why uncouplers stimulate oxygen consumption.
37. Describe the chemical reactions in common between the Krebs' cycle and β -oxidation of fatty acids.
38. Regarding VLDL: a) where are they made; b) what is their fate; c) why are they called VLDL and d) mention an apoprotein present in VLDL

1. According to the 2nd law of thermodynamics for a chemical reaction to be spontaneous:
 - A. The change in enthalpy (ΔH) must be < 0
 - B. The change in the entropy of the universe (ΔS_u) must be < 0
 - C. The change in free energy (ΔG) must be < 0
 - D. The equilibrium constant (K_{eq}) must be < 0
 - E. The change in standard free energy (ΔG°) must be < 0

2. Which of the following vitamins is required for the function of transaminases?
 - A. Biotin
 - B. Pyridoxal
 - C. Vitamin D
 - D. Riboflavin
 - E. Niacin

3. All of the following are functions of carbohydrates **EXCEPT**:
 - A. Structural
 - B. Bacterial wall
 - C. Energy storage
 - D. Antigens
 - E. Hormones

4. What is the major component of the exoskeleton of crustaceans and insects?
 - A. Collagen
 - B. Chitin
 - C. Cellulose
 - D. Hyaluronic acid
 - E. Heparin

5. Lysozyme is a natural antibiotic present in tears and saliva. Its mechanism of action involves:
 - A. Cleavage of a peptide bond in peptidoglycans
 - B. Cleavage of a peptide bond in proteoglycans
 - C. Inhibition of an enzyme involved in the synthesis of the bacterial wall
 - D. Hydrolysis of a glycosidic bond
 - E. None of the above

6. The anomeric carbon in a sugar comes from:
 - A. Always the first carbon
 - B. The last chiral carbon
 - C. It depends on whether the sugar is a pentose or an hexose
 - D. The carbonyl group
 - E. It depends on whether the sugar is a pyranose or a furanose

7. The individual components of fat include:
- A. Glycerol and fatty acids
 - B. Glycerol, fatty acids, phosphate and an alcohol
 - C. Sphingosin
 - D. Cholesterol
 - E. All of the above
8. The main difference between amylopectin and glycogen is:
- A. Frequency of branching
 - B. Types of glycosidic bonds
 - C. Amylopectin does not have α 166 glycosidic bonds
 - D. One of them has β -glycosidic bonds
 - E. One of them is a structural polysaccharide
9. Functions of cholesterol include the following **EXCEPT**:
- A. Disrupts packing of phospholipids
 - B. Changes the transition phase temperature
 - C. Energy storage
 - D. Hormone precursor
 - E. Precursor of Vitamin D
10. Passive diffusion of a solute across the membrane results in:
- A. Equal concentrations in both sides of the membrane
 - B. Higher concentration outside the membrane
 - C. Energy spent in the movement of the solute
 - D. Formation of a gradient across the membrane
 - E. All of the above
11. Which of the following enzymes catalyze substrate-level-phosphorylation:
- A. ATP synthase
 - B. Succinyl CoA synthetase (thiokinase)
 - C. Pyruvate kinase
 - D. A and B are correct
 - E. B and C are correct
12. How many molecules of NADH are produced during one turn of the Krebs' cycle?
- A. 0
 - B. 1
 - C. 2
 - D. 3
 - E. 4

13. Which of the following enzymes of the Krebs' cycle catalyze a reaction similar to the conversion of pyruvate to acetyl CoA?
- A. Isocitrate dehydrogenase
 - B. α -ketoglutarate dehydrogenase
 - C. Malate dehydrogenase
 - D. Succinate dehydrogenase
 - E. None of the above
14. Which of the following enzymes in the Krebs' cycle is also part of one of the electron shuttles?
- A. Isocitrate dehydrogenase
 - B. α -ketoglutarate dehydrogenase
 - C. Malate dehydrogenase
 - D. Succinate dehydrogenase
 - E. None of the above
15. Which of the following enzymes is/are involved in the regulation of the Krebs' cycle?
- A. Malate dehydrogenase
 - B. Isocitrate dehydrogenase
 - C. α -ketoglutarate dehydrogenase
 - D. A and B are correct
 - E. B and C are correct
16. Acetyl CoA is either a product or a substrate in all the following pathways **EXCEPT**:
- A. β -oxidation
 - B. Gluconeogenesis
 - C. Citric acid cycle
 - D. Fatty acid synthesis
 - E. Cholesterol synthesis
17. Respiration is inhibited by all of the following **EXCEPT**:
- A. Uncouplers
 - B. Cyanide
 - C. Inhibitors of the ATP synthase complex
 - D. Inhibitors of the ADP/ATP translocase
 - E. All of the above block respiration
18. How many ATPs are produced as a result of the oxidation of glycerol phosphate by the respiratory chain?
- A. 1
 - B. 1.5
 - C. 2
 - D. 2.5

- E. 3
19. The energy for the synthesis of phosphoenol-pyruvate during gluconeogenesis comes from:
- A. GTP
 - B. ATP
 - C. GTP and a decarboxylation
 - D. ATP and a decarboxylation
 - E. A H^+ gradient
20. Each cycle in the β -oxidation of fatty acids produces all of the following **EXCEPT**:
- A. NADPH
 - B. Acetyl CoA
 - C. $FADH_2$
 - D. A molecule of acyl CoA which is two carbons shorter
 - E. All of the above are correct
21. Malonyl CoA:
- A. Stimulates glycolysis
 - B. Inhibits carnitine-acyl transferase I
 - C. Is a ketone body
 - D. Is a precursor in cholesterol synthesis
 - E. Is decarboxylated to acetyl CoA during fatty acid synthesis
22. Which of the following dehydrogenases contains FMN and Fe-S clusters?
- A. Malate dehydrogenase
 - B. Glycerol-3-P dehydrogenase
 - C. Fatty acyl CoA dehydrogenase complex
 - D. Succinate dehydrogenase
 - E. NADH-dehydrogenase
23. All the following enzymes are inhibited by the action of protein kinase A **EXCEPT**:
- A. PFK-2
 - B. Pyruvate kinase
 - C. Pyruvate dehydrogenase
 - D. Glycogen synthase
 - E. Malonyl CoA synthetase
24. Which of the following enzymes is activated by free glucose?
- A. Glycogen synthase
 - B. Protein phosphatase-1
 - C. PFK-1
 - D. PFK-2
 - E. None of the above

25. All the following statements concerning insulin are correct **EXCEPT**:
- A. It has receptors in adipose tissue
 - B. Stimulates tyrosine kinase
 - C. Causes its receptor to self-phosphorylate
 - D. Increases the expression of GLUT4 in muscle
 - E. Stimulates the release of free fatty acid
26. Anabolic processes:
- A. Cannot be allosterically modulated
 - B. Involve oxidations
 - C. Consume ATP
 - D. Consume oxygen
 - E. Are not subjected to hormonal control
27. All of the following enzymes are found in the liver but not in adipose tissue **EXCEPT**:
- A. Glycogen phosphorylase
 - B. Glycerol kinase
 - C. Malonyl CoA synthetase
 - D. Glucokinase
 - E. Glutaminase
28. Roles of citrate include all of the following **EXCEPT**:
- A. Precursor in the synthesis of fatty acids
 - B. Precursor in the synthesis of cholesterol
 - C. Precursor in the synthesis of ketone bodies
 - D. Inhibitor of PFK-1
 - E. Carrier of mitochondrial acetyl CoA to the cytoplasm
29. The energy for the addition of 2 carbons during fatty acid synthesis is provided by:
- A. GTP
 - B. ATP
 - C. CTP
 - D. A decarboxylation
 - E. Hydrolysis of CoA
30. Alanine is an example of a _____ amino acid:
- A. Gluconeogenic
 - B. Essential
 - C. Aromatic
 - D. Branched
 - E. None of the above

31. Which of the following amino acids is used in the urea cycle and for the synthesis of nitric oxide?
- A. Alanine
 - B. Citrulline
 - C. Aspartic acid
 - D. Arginine
 - E. Glutamine
32. Albinism is caused by a deficiency in:
- A. Branched amino acid dehydrogenase
 - B. Tyrosinase
 - C. Phenylalanine hydroxylase
 - D. A transaminase
 - E. A decarboxylase
33. Which of the following organs does not have a significant number of receptors for glucagon:
- A. Liver
 - B. Adipose tissue
 - C. Muscle
 - D. A and B
 - E. B and C
34. Which of the following enzymes **IS NOT** are produced by the pancreas for digestion?
- A. Sucrase
 - B. Amylase
 - C. Lipase
 - D. Phospholipase A
 - E. HMG CoA reductase
35. In the long term fasting state, a large proportion of the energy in the muscle is derived from:
- A. Glucose
 - B. acetone
 - C. beta-hydroxybutyrate
 - D. oxalacetate
 - E. malonic acid
36. The following pathways are equally active in both starving and uncontrolled diabetic patients **EXCEPT**:
- A. Gluconeogenesis
 - B. Loss of muscle protein
 - C. Fatty acid oxidation
 - D. Ketone bodies formation
 - E. Urea cycle

37. Which of the following metabolic states is most likely to lead to ketoacidosis?
- A. Type I diabetes
 - B. Type II diabetes
 - C. Fed state
 - D. Overnight fasting
 - E. None of the above

TRUE/FALSE

38. The K_m of hexokinase is lower than the K_m of glucokinase
39. Lipoprotein lipase activity is stimulated by apoprotein C-II and insulin
40. The polysaccharides found in all glycoproteins have the same structure
41. Cerebrosides are glycosphingolipids
42. Phospholipase A_2 is required to release IP_3
43. The release of epinephrine alters the effect of insulin

ESSAY QUESTIONS:

44. List three mechanisms of metabolic control
45. Which of the following metabolic pathways increase/decrease/remain the same during overnight fasting?

Glycogen synthesis

Urea formation

Fatty acid synthesis

β -oxidation of fatty acids by the heart

Oxidation of ketone bodies by the brain

Glycolysis in the brain

46. Explain the general mechanism of signal transduction through G proteins.
47. Explain why we measure glycosylated hemoglobin in diabetic patients. Why is it produced?

48. Why can't diabetics take insulin orally? A new drug is being developed which will mimic insulin action but can be taken orally. How does it work?

49. Match the following enzymes with their allosteric modulators (some enzymes may have more than one) (4 points)

PFK-1

AMP

Hexokinase

ATP

the protein kinase of pyruvate dehydrogenase

Fructose 2,6 bis phosphate

glucose-6-phosphate

citrate

isocitrate dehydrogenase

NADH

pyruvate carboxylase/acetyl CoA

Acetyl CoA