

1. Which of the following crosses a lipid bilayer the fastest? That is, which has the highest permeability coefficient?

- A. H<sub>2</sub>O
- B. Na<sup>+</sup>
- C. isoleucine
- D. glucose
- E. aspartic acid

2. Which of the following is NOT a function of the Na<sup>+</sup>K<sup>+</sup> ATPase?

- A. maintaining high internal K<sup>+</sup>
- B. maintaining low internal Na<sup>+</sup>
- C. maintaining a transmembrane electrical potential
- D. maintaining a transmembrane electrochemical potential
- E. maintaining high internal Ca<sup>+2</sup>

Choose the single best answer for the following questions.

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3. If a cell has a transmembrane electrical potential of 100 mV, interior negative, how much energy does it take (in kcal/mole) to create a 1000-fold concentration gradient of calcium across the membrane (lower concentration inside).  $R = 1.99 \text{ cal degree}^{-1} \text{ mole}^{-1}$ ,  $T = 300^\circ\text{K}$ ,  $F = 23 \text{ cal mV}^{-1} \text{ mole}^{-1}$ .

A. 2.7

B. 3.7

C. 4.7

D. 5.7

E. 6.7

F. 7.7

G. 8.7

4. Which of the following is an intermediate in the pathway of serine biosynthesis?

A. cysteine

B. glutamate

C. phosphoenolpyruvate

D. 3-phosphoglycerate

E. tyrosine

Choose the single best answer for the following questions.

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5. Which cofactor do methylmalonyl CoA mutase and homocysteine methyltransferase have in common?

- A. NAD
- B. NADP
- C. biotin
- D. ATP
- E. B<sub>12</sub>

6. Heme breakdown involves which of the following sets of molecules?

- A. bilirubin, porphobilinogen, urobilinogen
- B. biliverdin, stercobilinogen, amino-levulinate
- C. bilirubin, stercobilinogen, urobilinogen
- D. porphobilinogen and bilirubin
- E. amino-levulinate and porphobilinogen

Choose the single best answer for the following questions.

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7. The two most abundant (highest concentration) amino acids in the blood are

- A. ala and ser
- B. asp and ser
- C. glu and ser
- D. ala and asn
- E. asp and asn
- F. glu and asn
- G. ala and gln
- H. asp and gln
- I. glu and gln

8. The genetic disease which produces citrullinemia results in an inability to synthesize which of the following

- A. ornithine
- B. aspartate
- C. arginine
- D. citrulline
- E. carbamoyl phosphate

Choose the single best answer for the following questions.

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9. Which of the following will increase the fluidity of membranes?
- A. removing double bonds from the fatty acids in the phospholipids
  - B. increasing the length of the fatty acids in the phospholipids
  - C. lowering the temperature
  - D. anchoring membrane-proteins to the cytoskeleton
  - E. increasing the degree of unsaturation of the fatty acids in the phospholipids
10. The primary forces which stabilize the bilayer structure of membranes are
- A. covalent bonds between the lipids
  - B. many weak interactions between component molecules
  - C. disulfide bonds between membrane proteins
  - D. ionic interactions with the cytoskeleton
  - E. asymmetric distribution of membrane components

11. What is a hydropathy plot?
- A. A plot used to measure the water content of the membrane
  - B. A plot used to predict the locations of transmembrane helices in integral membrane proteins
  - C. A plot used to measure the number of ionic bonds in a membrane protein
  - D. A plot of the rate of water movement across the bilayer as a function of the membrane fluidity
  - E. A plot of the locations of the charged amino acid residues in integral membrane proteins
12. An infant with an enlarged liver has a glucose 6-phosphatase deficiency. This infant
- A. cannot maintain blood glucose levels either by glycogenolysis or by gluconeogenesis
  - B. can use liver glycogen to maintain blood glucose levels
  - C. can use muscle glycogen to maintain blood glucose levels
  - D. can convert both alanine and glycerol to glucose to maintain blood glucose levels
  - E. can still hydrolyze glucose 6-phosphate in the endoplasmic reticulum

Choose the single best answer for the following questions.

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13. An adolescent patient with a deficiency of muscle phosphorylase was examined while exercising her forearm by squeezing a rubber ball. Compared to a normal person performing the same exercise, this patient

- A. could exercise for a longer period of time without fatigue
- B. had increased glucose levels in blood drawn from her forearm
- C. had decreased lactate levels in blood drawn from her forearm
- D. had lower levels of glycogen in biopsies of her forearm muscle
- E. had an increased insulin/glucagon ratio

14. The degradation of glycogen normally produces

- A. more glucose than glucose 1-phosphate
- B. more glucose 1-phosphate than glucose
- C. equal amounts of glucose and glucose 1-phosphate
- D. neither glucose nor glucose 1-phosphate
- E. only glucose 1-phosphate

15. Which of the following statements about liver phosphorylase kinase is true?

- A. It is present only in an inactive form when epinephrine is elevated
- B. It phosphorylates phosphorylase to an inactive form
- C. Unlike the muscle phosphorylase kinase it is not activated by AMP
- D. It is phosphorylated in response to elevated insulin
- E. It is not affected by cAMP

16. A patient had large deposits of liver glycogen, which, after an overnight fast, had shorter than normal branches. This abnormality could be caused by

- A. a deficiency of phosphorylase
- B. a defect in the glucagon receptor
- C. an inability to produce glycogenin
- D. a deficiency of amylo-1,6-glucosidase (debranching enzyme)
- E. a genetic deficiency of amylo-4,6-transferase (branching enzyme)

17. Which of the following glycolytic enzymes is used in gluconeogenesis?

- A. Glucokinase
- B. Phosphofructokinase 1
- C. Pyruvate kinase
- D. Aldolase
- E. pyruvate dehydrogenase

18. A common intermediate in the conversion of glycerol and lactate to glucose is
- A. pyruvate
  - B. oxaloacetate
  - C. malate
  - D. dihydroxyacetone phosphate
  - E. phosphoenolpyruvate
19. In the pentose phosphate pathway, thiamine pyrophosphate is required for the action of
- A. an epimerase
  - B. transaldolase
  - C. an isomerase
  - D. transketolase
  - E. a dehydrogenase
20. Free radicals (Reactive Oxygen Species, ROS) can be damaging to tissue DNA, protein and unsaturated lipids. Which of the following take part in the detoxification of ROS?
- A. NADPH and NAD
  - B. NADH and glucose 6-phosphatase
  - C. glutathione and NADPH
  - D. glucose 6-phosphate dehydrogenase and NADH
  - E. lactate dehydrogenase and NADH

Choose the single best answer for the following questions.

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21. Glycosaminoglycans

- A. lubricate joints
- B. consist of N-acetyl-sugars
- C. are negatively charged
- D. may accumulate in various tissues causing deformities
- E. all of the above are correct

22. Important for cell-cell recognition

- A. glycogen
- B. lectins
- C. chitin
- D. glucagon
- E. epinephrine

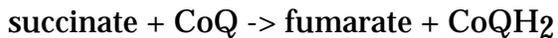
Choose the single best answer for the following questions.

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23. Given the standard reduction potentials for the redox couples below:

	$E^{\circ}$ (volts)
fumarate + 2e + 2H <sup>+</sup> -> succinate	0.03
CoQ + 2H <sup>+</sup> + 2e -> CoQH <sub>2</sub>	0.10

what can we deduce about the reaction below?



- A.  $\Delta E^{\circ} = +0.13\text{V}$
  - B.  $\Delta E^{\circ} = +0.07\text{V}$
  - C.  $\Delta E^{\circ} = -0.07\text{V}$
  - D.  $\Delta E^{\circ} = -0.13\text{V}$
  - E.  $\Delta G^{\circ}$  is positive
24. Which respiratory chain complex does NOT contain a pump capable of pumping protons from the mitochondrial matrix to the cytoplasm accompanying electron transfer?
- A. NADH-CoQ reductase
  - B. succinate-CoQ reductase
  - C. CoQ-cytochrome c reductase
  - D. cytochrome c oxidase

25. Barbiturates at elevated levels can inhibit the transfer of electrons from NADH to CoQ. An overdose of barbiturates might be expected to produce all of the changes EXCEPT

- A. a decreased rate of NADH oxidase activity
- B. an elevated level of intramitochondrial NADH:NAD<sup>+</sup>
- C. decreased whole body oxygen consumption
- D. a decrease in intracellular ATP:ADP ratios
- E. life-threatening hyperthermia

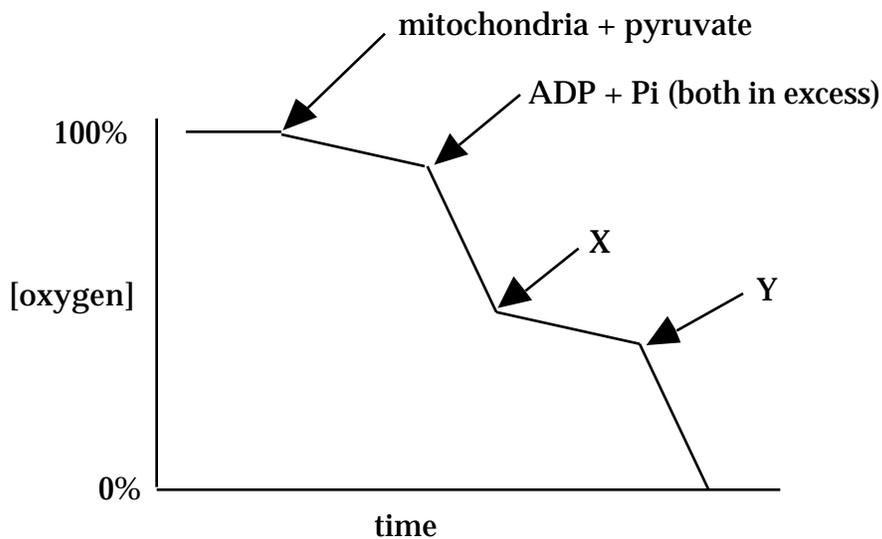
26. Which of the following IS NOT a feature of the chemi-osmotic coupling hypothesis?

- A. the existence of 2 aqueous phase separated by a proton-impermeable membrane
- B. the ability of 2,4-dinitrophenol to dissolve in the mitochondrial inner membrane and to dissipate the proton electrochemical gradient across the inner membrane
- C. the phosphorylation of thioesters generated by redox reactions within the inner membrane, leading to the formation of acyl phosphates and ultimately to ATP
- D. the existence of a reversible proton-translocating ATPase in the inner mitochondrial membrane
- E. the existence of specific carrier proteins in the inner membrane that serve to transport solutes such as carboxylic acids across the inner membrane

27. Which pair of compounds would be expected to give the same ATP yield (on a mol basis) when oxidized completely to CO<sub>2</sub> and water within the cell?

- A. glucose and sucrose
- B. fumarate and succinate
- C. pyruvate and oxaloacetate
- D. lactate and pyruvate
- E. citrate and malate

28. The figure shows an oxygen electrode trace of oxygen consumption against time. Identify the compounds X and Y that could produce the effects shown in the figure.



- A. X = cyanide and Y = dinitrophenol
- B. X = oligomycin and Y = dinitrophenol
- C. X = dinitrophenol and Y = atractylate
- D. X = atractylate and Y = succinate
- E. X = cyanide and Y = oligomycin

29. All of the following help to ensure that during fasting there is a sufficient level of blood glucose to meet the demands of the brain EXCEPT

- A. a decreased level of blood insulin
- B. a decreased level of hepatic fructose 2,6-bisphosphate
- C. the phosphorylation of L-type pyruvate kinase
- D. a decreased rate of conversion of glucose to glucose 6-phosphate
- E. an adaptive change in brain biochemistry during fasting that favors glucose consumption over that of ketone bodies as a fuel source

30. In some clinical situations, e.g. infection, a patient may respond by increasing his/her rate of gluconeogenesis. What could be an undesirable consequence of this protective response if the individual also had an impaired urea cycle activity?

- A. none -- the two metabolic processes are unrelated
- B. loss of the amino acid tyrosine in the urine in the form of phenylacetyl glutamine
- C. hyperammonemia
- D. the patient would go into positive nitrogen balance because that rate of protein synthesis would exceed that of protein breakdown
- E. uremia (elevated blood urea)

31. All of the following are involved in the ability of adipose cells to use glucose for fat synthesis following a meal rich in carbohydrates EXCEPT
- A. stimulation by insulin of glucose uptake into adipocytes
  - B. the formation of alpha-glycerol phosphate from glucose in the adipocyte
  - C. the release of glycerol from adipocytes for use in gluconeogenesis by the liver
  - D. an antilipolytic effect exerted by insulin on adipocytes
  - E. the ability of glucose to provide the acetyl CoA needed for fatty acid synthesis in the liver
32. Which of the following provides carbon-6 in the fatty acid palmitate (C16:0)?
- A. carbonyl carbon of acetyl CoA
  - B. carbonyl carbon of malonyl CoA
  - C. methyl carbon of acetyl CoA
  - D. bicarbonate
  - E. carboxylate carbon of malonyl CoA
33. Which of the following is involved in the committed step for fatty acid synthesis?
- A. cobalamin
  - B. ACP
  - C. NADPH
  - D. FADH<sub>2</sub>
  - E. citrate

34. Arrange the following partial reactions of palmitate (C16:0) synthesis in the correct order:

I. formation of  $\beta$ -ketone intermediate

II. release of  $\text{CO}_2$

III. formation of trans- $\Delta^2$ -enoyl intermediate  
A. I  $\rightarrow$  II  $\rightarrow$  III

B. II  $\rightarrow$  I  $\rightarrow$  III

C. II  $\rightarrow$  III  $\rightarrow$  I

D. III  $\rightarrow$  II  $\rightarrow$  I

E. III  $\rightarrow$  I  $\rightarrow$  II

35. Which of the following will yield a net of 23 ATP when oxidized to acetyl CoA in the  $\beta$ -oxidation pathway?  
A.  $\text{CH}_3(\text{CH}_2)_{14}\text{COO}^-$

B.  $\text{CH}_3(\text{CH}_2)_{14}\text{CO-CoA}$

C.  $\text{CH}_3(\text{CH}_2)_{12}\text{COO}^-$

D.  $\text{CH}_3(\text{CH}_2)_{10}\text{COO}^-$

E.  $\text{CH}_3(\text{CH}_2)_{10}\text{CO-CoA}$

36. Which of the following conditions is correlated with increased levels of fatty acid  $\beta$ -oxidation?  
A. polymerization of acetyl CoA carboxylase

B. inhibition of isocitrate dehydrogenase

C. high concentrations of malonyl CoA

D. high NADH/NAD<sup>+</sup> ratio

E. high levels of glucagon

37. Which of the following reactions occurs in the  $\beta$ -oxidation pathway? A. a trans-2-enoyl intermediate is formed following a dehydration reaction
- B. the formation of a  $\beta$ -hydroxyl intermediate precedes the formation of a  $\beta$ -ketone intermediate
- C. an NAD<sup>+</sup>-linked step puts a double bond in the fatty acid
- D. water is used to cleave off the acetyl CoA product from the fatty acid chain that is being oxidized
- E. all of the above
38. The reaction of phospholipase C with phosphatidylcholine will yield A. 1,2-diacylglycerol
- B. choline
- C. arachidonic acid (C20:4(5,8,11,14))
- D. stearic acid (C18:0)
- E. phosphatidate

In each group, for each numbered question select the best lettered answer. Each lettered answer may be selected once, more than once, or not at all.

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39. Which TCA cycle intermediate is a direct product of a urea cycle enzyme?  
40. The keto acid derivative of alanine

41. The keto acid derivative of glutamate

42. The keto acid derivative of aspartate

A. pyruvate

B. citrate

C. cis-aconitate

D.  $\alpha$ -ketoglutarate

E. succinate

F. fumarate

G. malate

H. oxaloacetate

In each group, for each numbered question select the best lettered answer. Each lettered answer may be selected once, more than once, or not at all.

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43. The regulated enzyme in the pentose phosphate pathway
44. The enzyme which is activated by epinephrine binding to its hepatic receptor
45. The mitochondrial enzyme required for the ultimate conversion of lactate and alanine to glucose
- A. pyruvate carboxylase
  - B. pyruvate kinase
  - C. phosphoenolpyruvate carboxykinase
  - D. glucose 6-phosphate dehydrogenase
  - E. phosphorylase "b"
  - F. transketolase
  - G. transaldolase
  - H. glutathione reductase
  - I. glycogen synthase

In each group, for each numbered question select the best lettered answer. Each lettered answer may be selected once, more than once, or not at all.

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46. Suppose an individual has a mitochondrial defect in skeletal muscle that resulted in a reduced ability of the cytochrome c oxidase complex to transfer electrons from cytochrome c reduced to oxygen, what might you expect to observe in the patients muscle with respect to that of a normal individual?47.

Supposing you found a way to treat the above patient that allowed electrons to bypass the block and to be transferred from cytochrome c to O<sub>2</sub> and you also improved the patients muscle strength. What might you logically expect to find in the treated patient using noninvasive nmr to study muscle metabolism?

- A. ATP/ADP elevated
- B. PCr/Pi elevated
- C. NADH/NAD<sup>+</sup> elevated
- D. Krebs cycle activity elevated
- E. P/O ratio elevated
- F. blood pyruvate/lactate elevated
- G. basal metabolic rate elevated

48. A compound used to treat hepatic encephalopathy by promoting the excretion of ammonium salts of organic acids in the feces

49. A compound administered orally to facilitate the excretion of nitrogen in the urine in a patient with a urea cycle deficiency

- A. glycine
- B. glutamine
- C. lactulose
- D. sorbitol
- E. phenyl acetate
- F. hippuric acid

In each group, for each numbered question select the best lettered answer. Each lettered answer may be selected once, more than once, or not at all.

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50. Intermediate common to both ganglioside GM<sub>2</sub> and phosphatidyl choline biosynthesis

51. Immediate precursor to 1,2-diacylglycerol in the *de novo* pathway for triacylglycerol synthesis in human adipose tissue

- A. phosphatidate
- B. CDP-diacylglycerol
- C. malonyl CoA
- D. L-serine
- E. 2-monoacylglycerol