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Multiple Choice Questions:

Each of the following 36 questions is worth one mark.

Select the best answer and mark your response on the pink computer sheet.

1. I have exam version: (a bonus mark to start you off!)
 - a. A
 - b. B

2. If you ate breakfast this morning, your body would be relying mainly on _____ metabolism to provide your cells with energy.
 - a. Carbohydrate
 - b. Free Fatty Acid
 - c. Triglyceride
 - d. Amino Acid
 - e. b & c

3. Type 1 diabetes mellitus is also called:
 - a. Late-onset diabetes
 - b. Non-insulin-dependent diabetes mellitus
 - c. Juvenile diabetes
 - d. NIDDM
 - e. Diabetes intrepidus

4. North Americans consume most of the energy in their diet in the form of:
 - a. Alcohol
 - b. Fat
 - c. Protein
 - d. Carbohydrate
 - e. Adenosine triphosphate (ATP)

5. The energy density of carbohydrate is _____ kcal/g, whereas the energy density of fat is _____ kcal/g.
 - a. 9; 4
 - b. 4; 9
 - c. 7; 4
 - d. 4; 7
 - e. 4; 4

6. Circulating levels of glucose (Glu), free fatty acids (FFA) and triglyceride (TG) (in kcal) have the following relationship:
 - a. $\text{Glu} < \text{FFA} < \text{TG}$
 - b. $\text{Glu} < \text{TG} < \text{FFA}$
 - c. $\text{FFA} < \text{TG} < \text{Glu}$
 - d. $\text{FFA} < \text{Glu} < \text{TG}$
 - e. $\text{TG} < \text{Glu} < \text{FFA}$

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7. The majority of the body's energy content is stored as:
 - a. Protein
 - b. Fat
 - c. Carbohydrate
 - d. ATP
 - e. Lactic Acid

8. A significant amount of _____ is required for the storage of carbohydrate in the body.
 - a. Connective tissue
 - b. ATP
 - c. Triglyceride
 - d. Adipose tissue
 - e. Water

9. Which of the following is true regarding niacin and riboflavin?
 - a. Niacin and riboflavin are water-soluble vitamins
 - b. Niacin and riboflavin act as co-factors in energy metabolism pathways
 - c. Niacin and riboflavin form the backbones for NAD and FAD, respectively
 - d. All of the above are true
 - e. None of the above are true

10. Which of the following approaches would you use to determine mRNA expression levels in a tissue?
 - a. Genome Database
 - b. DNA Microarray
 - c. Proteomics Analysis
 - d. Metabolomics Analysis
 - e. None of the above

11. In the field of metabolomics, how many metabolites can currently be studied simultaneously?
 - a. Only 1 metabolite at a time
 - b. A few dozen metabolites
 - c. Several hundreds of metabolites
 - d. Thousands of metabolites
 - e. Tens of thousands of metabolites

12. Which of the following does not occur in the mitochondria?
 - a. Pentose Phosphate Pathway
 - b. The Krebs Cycle
 - c. Oxidative Phosphorylation
 - d. Fatty Acid Oxidation
 - e. Amino Acid Catabolism

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13. Which of the following forms of regulatory control occurs in the shortest period of time?

- a. Transcriptional control
- b. Translational control
- c. Post-translational control
- d. Enzyme Turnover
- e. All forms of regulatory control occur within similar time-frames

14. In human cells, which of the following metabolic pathways has the highest metabolic flux?

- a. Glycolysis
- b. Beta-Oxidation
- c. Citric Acid Cycle
- d. Electron Transport Chain
- e. All of the above have similar metabolic flux

15. Inorganic fluoride inhibits enolase. In an anaerobic system that is metabolizing glucose as a substrate, which of the following compounds would you expect to increase in concentration following the addition of fluoride?

- a. 2-phosphoglycerate
- b. Glucose
- c. Glyoxylate
- d. Phosphoenolpyruvate
- e. Pyruvate

16. In glycolysis, what are the total number of ATP molecules entering, the total number of molecules leaving, and the net production of ATP molecules per molecule of glucose?

- a. 2, 2, 0
- b. 2, 4, 6
- c. 4, 6, 2
- d. 2, 4, 1
- e. 2, 4, 2

17. The priming reactions of glycolysis occur at:

- a. Steps 1 and 2
- b. Steps 1 and 3
- c. Steps 2 and 3
- d. Steps 1 and 4
- e. Steps 2 and 4

18. The substrate-level phosphorylation reactions of glycolysis occur at:

- a. Steps 3 and 5
- b. Steps 5 and 7
- c. Steps 7 and 10
- d. Steps 8 and 9
- e. Steps 9 and 10

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19. Sucrose is a disaccharide made up of which 2 monosaccharides?

- i. glucose
 - ii. fructose
 - iii. lactose
 - iv. galactose
 - v. mannose
-
- a. i & i
 - b. i & ii
 - c. ii & iii
 - d. i & v
 - e. ii & iv

20. Which of the following is/are true with respect to lactic acid fermentation?

- i. Lactic acid fermentation occurs only in micro-organisms
 - ii. The conversion of pyruvate to L-lactate is catalyzed by lactate dehydrogenase
 - iii. The conversion of pyruvate to L-lactate is catalyzed by lactate reductase
 - iv. NAD⁺ is produced to fuel glycolysis
 - v. NADH is produced to fuel glycolysis
-
- a. None of the above are true
 - b. i, ii & v
 - c. ii & v
 - d. iii & iv
 - e. ii & iv

21. Which of the following is/are (a) product(s) of the oxidative phase of the pentose phosphate pathway?

- i. Pentose
 - ii. Hexose
 - iii. NADPH
 - iv. NADP⁺
 - v. Ribose 1,3,5-triphosphate
-
- a. i, iii & v
 - b. i, iv & v
 - c. i & iv
 - d. i & iii
 - e. ii & iii

22. Which of the following metabolites prevents the entry of glucose 6-phosphate into the pentose phosphate pathway, therefore shunting glucose 6-phosphate towards glycolysis?

- a. NADPH
- b. NADP⁺
- c. Ribose 5-phosphate
- d. Ribulose 5-phosphate

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- e. 6-phosphogluconate
23. The synthesis of glucose from non-carbohydrate precursors is called:
- Glycogenolysis
 - Glycogenesis
 - Glycolysis
 - Glucogenesis
 - Gluconeogenesis
24. Which of the following metabolites does not feed into gluconeogenesis?
- Lactate
 - Glycerol
 - Alanine
 - Lysine
 - Histidine
25. Which of the following is not an obligate glucose user?
- Pancreas
 - Brain
 - Some cells in the eye
 - Renal medulla (part of kidney)
 - Erythrocytes (red blood cells)
26. How much energy & reducing equivalents are required to form one molecule of glucose via gluconeogenesis?
- 2 ATP + 2 GTP + 2 NADH
 - 4 ATP + 2 GTP + 2 NADH
 - 4 ATP + 2 NADH
 - 2 ATP + 2 GTP + 4 NADH
 - None of the above
27. Which of the following tissues contain the most glycogen by weight?
- Muscle (up to 2%)
 - Muscle (up to 10%)
 - Heart (up to 25%)
 - Liver (up to 2%)
 - Liver (up to 10%)
28. How many molecules of glucose are found in a glycogen beta particle?
- 550
 - 5,500
 - 55,000
 - 550,000
 - 5,500,000

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29. Which of the following is not true?

- a. UDP-glucose donates glucose residues to the non-reducing end of glycogen during glycogenesis
- b. Glycogen-branching enzyme creates the alpha 1,6-linkages at branch points during glycogenesis
- c. Glycogen-debranching enzyme has transferase and glucosidase functions
- d. Glycogenin catalyzes the addition of 7 glucose molecules before glycogen phosphorylase takes over during glycogenesis
- e. Vitamin B₆ is the precursor for pyridoxal phosphate, an essential cofactor in glycogenolysis

30. Which of the following stimulate(s) the conversion of fructose 6-phosphate to fructose 1,6-bisphosphate?

- i. ATP
 - ii. ADP
 - iii. AMP
 - iv. Citrate
 - v. Succinate
- a. i & iv
 - b. i, iv & v
 - c. ii & iii
 - d. ii, iii & v
 - e. None of the above combinations are correct

31. Which of the following positively regulates the conversion of glycogen synthase b to glycogen synthase a?

- a. Insulin
- b. Glucose 6-phosphate
- c. Glucose
- d. All of the above
- e. None of the above

32. E₁, E₂ and E₃, the three enzymes of the PDH complex are called (respectively):

- a. Pyruvate dehydrogenase (E₁), dihydrolipoyl dehydrogenase (E₂), dihydrolipoyl transacetylase (E₃)
- b. Dihydrolipoyl transacetylase(E₁), pyruvate dehydrogenase (E₂), dihydrolipoyl dehydrogenase (E₃)
- c. Pyruvate dehydrogenase (E₁), dihydrolipoyl transacetylase (E₂), dihydrolipoyl dehydrogenase (E₃)
- d. Dihydrolipoyl transacetylase (E₁), dihydrolipoyl dehydrogenase (E₂), pyruvate dehydrogenase (E₃)
- e. None of the above answers are correct

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33. Which of the following enzyme steps is not a point of regulation in the citric acid cycle?

- a. Pyruvate dehydrogenase complex (PDH)
- b. Succinate dehydrogenase
- c. Citrate Synthase
- d. Alpha-ketoglutarate dehydrogenase
- e. Isocitrate dehydrogenase

34. Who won the Nobel Prize in 1978 for his development of the Chemiosmotic Theory?

- a. Claude Bernard
- b. John E. Walker
- c. Peter Mitchell
- d. Joni Mitchell
- e. Gertrude Cori

35. Which of the following is a mobile carrier of electrons from complex II to complex III in the electron transport chain (ETC)?

- a. Succinate dehydrogenase
- b. Cytochrome c
- c. Ubiquinone
- d. ATP synthase
- e. Cytochrome b

36. In normal mitochondria, the rate of NADH consumption (oxidation) will:

- a. be increased in active muscle, decreased in inactive muscle.
- b. be very low if the ATP synthase is inhibited, but increase when an uncoupler is added.
- c. decrease if mitochondrial ADP is depleted.
- d. decrease when cyanide is used to prevent electron transfer through the cytochrome $a + a_3$ complex.
- e. All of the above are true.

True or False Questions: Mark "A" for True, and Mark "B" for False
Each of the following 20 questions is worth 1/2 mark.

37. Heterotrophs can synthesize complex molecules from simple precursors like CO₂ and ammonia. (True/False)

38. Mitochondria are static, oblong structures that function as the 'powerhouses' of cells. (True/False)

39. In animals, glucose can be stored as glycogen, or as starch. (True/False)

40. Protein restriction without malnutrition is the only experimental manipulation known to extend the lifespan of a variety of organisms. (True/False)

41. The process of fermentation resulting in ethanol and carbon dioxide production occurs in all organisms. (True/False)

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42. The phosphorylation of glucose prevents its exit from the cell. (True/False)
43. Fructose can enter glycolysis as either fructose 6-phosphate or as fructose 1,6-bisphosphate. (True/False)
44. Starch makes up the largest component of dietary carbohydrate (as opposed to simple sugars or fibre). (True/False)
45. On a per molecule basis, fructose is sweeter than both sucrose and glucose. (True/False)
46. During the Cori cycle, lactate is converted to glucose in muscle cells. (True/False)
47. Vertebrate tissues do not contain pyruvate decarboxylase. (True/False)
48. Skeletal muscle can release glucose back into the bloodstream whereas liver cannot. (True/False)
49. The active form of glycogen phosphorylase is the "A" version, which is phosphorylated. (True/False)
50. The high membrane potential of mitochondria is a result of the inner and outer mitochondrial membranes being highly selectively permeable. (True/False)
51. Glycolysis takes place in the cytoplasm whereas the citric acid cycle, the electron transport chain and oxidative phosphorylation all take place in the mitochondria (True/False)
52. Aconitase is an iron-sulfur protein whose activity is used as a marker for oxidative damage in tissues. (True/False)
53. A synthetase catalyzes condensation reactions in which no nucleoside triphosphate is needed. (True/False)
54. Uncoupling protein-1 (UCP1) is expressed exclusively in brown adipose tissue (BAT). (True/False)
55. Vertebrates convert acetate to glucose via the glyoxylate cycle. (True/False)
56. Substrate level phosphorylation is dependent on oxygen availability. (True/False)

Fill in the blanks: Each blank is potentially worth 1 mark. The total number of marks for this section is 35. *Please avoid abbreviations*

57. The unique isoform of hexokinase expressed in the liver is called: _____.
58. What is the elemental co-factor that is required in many of the reactions of glycolysis?

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59. Fill in the names of the enzymes that catalyze each of the steps of glycolysis. Use the long form names (as opposed to acronyms) for the enzymes. Be careful of your spelling! (3 marks in total for this question)

Fructose 6-phosphate to fructose 1,6-bisphosphate
enzyme: _____

Fructose 1,6-bisphosphate to glyceraldehyde 3-phosphate + dihydroxyacetone phosphate
enzyme: _____

phosphoenolpyruvate to pyruvate
enzyme: _____

60. Although both hormones are produced from the same gene and secreted by the stomach, _____ stimulates hunger and food intake, whereas _____ inhibits hunger and food intake.

61. The inability to digest significant amounts of _____, the major sugar in milk, results in nausea, cramps, bloating, gas and diarrhea.

62. _____ has a similar structure to succinate and can therefore act to inhibit succinate dehydrogenase via competitive inhibition.

63. The two types of enzymes required for the non-oxidative phase of the pentose phosphate pathway are _____ and _____.

64. Glycolysis contains three irreversible steps. List the four enzymes that catalyze the reverse reactions in gluconeogenesis to get around these steps: _____,
_____, _____,
and _____.

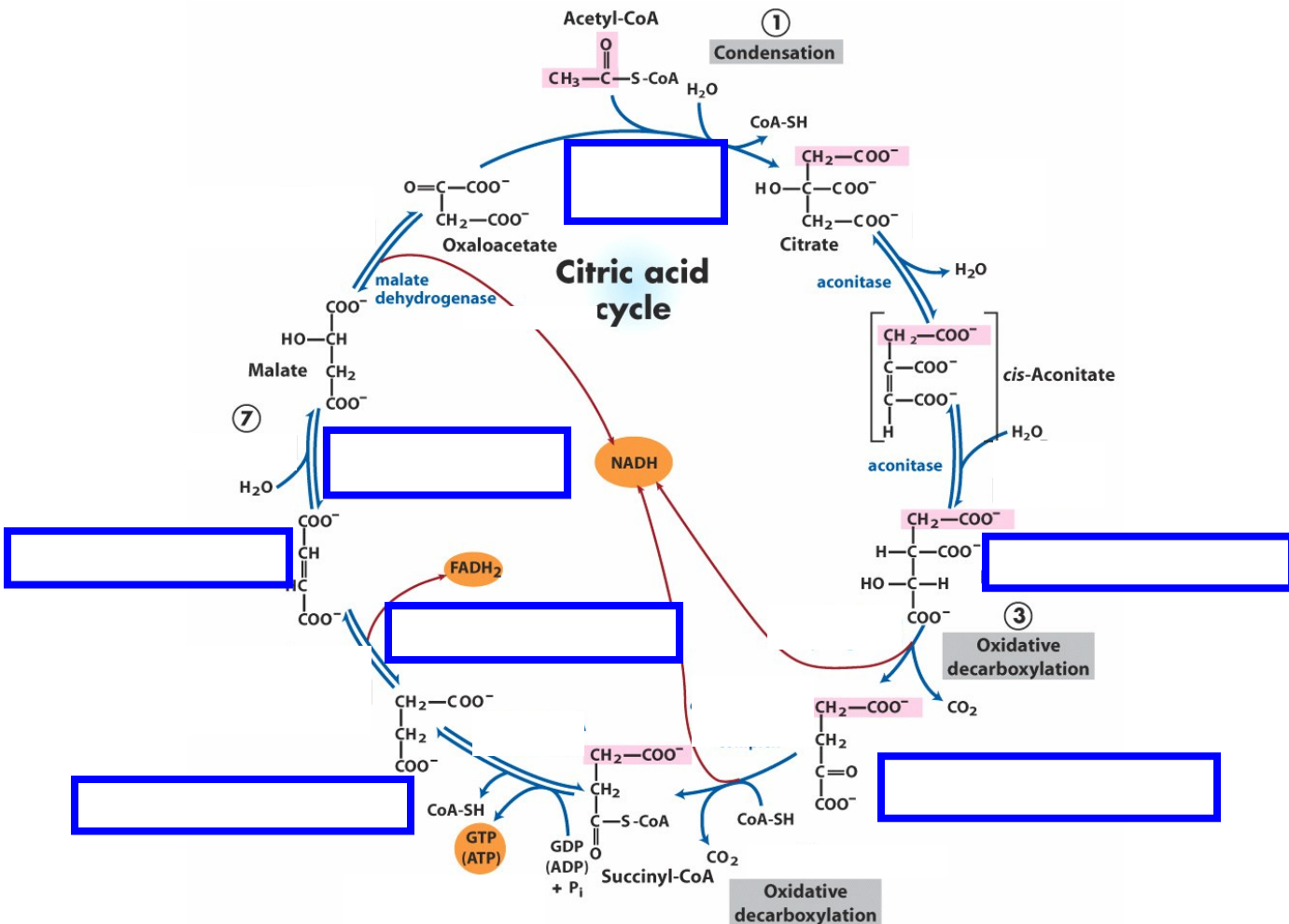
65. Draw the structure of pyruvate:

66. The two mitochondrial shuttles used to transport reducing equivalents into the mitochondria are called the _____ shuttle and the _____ shuttle. (Please do not use abbreviations.)

67. When _____ enters the electron transport chain (ETC) at complex I, a total of _____ protons can be pumped out into the intermembrane space. When succinate enters the ETC at complex _____, a total of _____ protons can be pumped out into the intermembrane space.

68. Name the uncoupling protein that is expressed in muscle (e.g., UCP1 or UCP2 or UCP3 or UCP4 or UCP5): _____

69. The Krebs cycle is referred to as the major metabolic node in intermediary metabolism. The following diagram of the Krebs cycle is missing the names of some metabolites and enzymes. Provide the names of these metabolites (M) and enzymes (E) in the empty spaces. (7 marks total for this question)



70. The return of protons to the matrix from the intermembrane space by any means other than through ATP synthase is called _____.

71. Fill in the inhibitors of the electron transport chain (ETC). (Do not use abbreviations.)
 Complex I _____ Complex IV _____
 Complex V _____

72.. In ischemia (*i.e.*, a hypoxic condition in which [O₂] drops) ATP synthase does not operate in reverse due to the binding of a specific molecule to ATP synthase. This is important so that ATP synthase does not consume ATP under these conditions. Name this molecule: _____