Student Name: _____ **Student Number:**_____

Multiple Choice Questions:

Each of the following 46 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. How are Gibbs free energy, enthalpy and entropy related?

   a. $\Delta G = T - (\Delta H \Delta S)$
   b. $\Delta G = \Delta H - (T \Delta S)$
   c. $\Delta G = \Delta H/(T \Delta S)$
   d. $\Delta G = \Delta S/(T \Delta H)$
   e. Gibbs free energy, enthalpy and entropy are not related

3. How can ATP content of a cell or tissue be measured in a lab setting?

   a. Fluorescence microscopy (Luciferin)
   b. Spectrophotometry (Luciferin)
   c. Enzymatically (Luciferin + Luciferase)
   d. Using a glow-stick necklace
   e. None of the above

4. Reduction potentials are measured in units of:
   a) watts
   b) kJ or kcal
   c) volts
   d) Kelvin degrees
   e) None of the above

5. Which of the following statements about the relationships between K'_{eq}, $\Delta G'^{o}$ and the direction of chemical reactions **under standard conditions (with all components at 1 M)** is true?

   a) When K'eq, is less than one, $\Delta G'o$ is positive and the direction of chemical reaction will proceed in reverse.
   b) When K'_{eq}, is more than one, $\Delta G'^{o}$ is positive and the direction of chemical reaction will proceed in reverse.
   c) When K'_{eq}, is less than one, $\Delta G'^{o}$ is negative and the direction of chemical reaction will proceed in reverse.
   d) When K'_{eq}, is less than one, $\Delta G'^{o}$ is negative and the direction of chemical reaction will proceed in the forward direction.

e) None of the above

6. What is the purpose of a cross-over plot?

a. To identify the relative control of all enzymes in a pathway
b. To identify the mass action ratios (MAR) of each reaction in a pathway
c. To identify the rate-controlling step of a pathway
d. All of the above
e. None of the above

7. What is the major difference between metabolomics and traditional clinical chemistry?

a) Metabolomics is less expensive
b) Metabolomics is more precise
c) Equipment for metabolomics is generally cheaper than that for traditional clinical chemistry
d) Metabolomics will give you a greater number of metabolites measured in each analysis than the number of metabolites assessed in clinical chemistry
e) All of the above

8. Of the following techniques, which would give you the best results (in terms of sensitivity, throughput and comprehensiveness) for a metabolomics analysis?

a. Nuclear Magnetic Resonance (NMR) Spectroscopy
b. Infrared (IR) Spectroscopy
c. Liquid Chromatography Mass Spectrometry (LC-MS)
d. Gas Chromatography Mass Spectrometry (GC-MS)
e. All of the above are pretty similar

9. Which of the following is true regarding the definition of Metabonomics:

a) Metabonomics is just another word for metabolomics; you can use the terms interchangeably
b) Metabonomics is a subdiscipline of metabolomics that exclusively relies on the use of infra-red spectroscopy.
c) Metabonomics is just another word for metabolic 'fingerprinting'
d) Metabonomics is a term that is used to specifically to describe the comprehensive analysis of lipid metabolites.
e) Metabonomics refers to analyses that aim to assess the effects of a biological perturbation or of time.

10. During beta-oxidation, how many reducing equivalents are produced with one pass through the beta oxidation spiral (i.e., during the removal of one acetyl CoA molecule)?

a. 2 moles $FADH_2$ & 2 moles NADH
b. 1 mole $FADH_2$ & 2 moles NADH
c. 2 moles FADH2 & 1 mole NADH
d. 1 mole FADH2 & 1 mole NADH
e. None of the above is correct

11. Which auxiliary enzyme is required for the oxidation of polyunsaturated fatty acids but not for the oxidation of monounsaturated fatty acids?

a. 2,4-dienoyl-CoA reductase
b. Δ3,Δ2-enoyl-CoA isomerase
c. Enoyl-CoA hydratase
d. Acyl-CoA acetyltransferase
e. None of the above is correct

12. Absorption of dietary fat takes place in the:

a. Stomach in the form of triglyceride
b. Small Intestine in the form of triglyceride
c. Small Intestine in the form of fatty acids
d. Large Intestine in the form of triglyceride
e. Large Intestine in the form of fatty acids

13. Fatty acid oxidation takes place in

i. Mitochondria
ii. Peroxisomes
iii. Glyoxysomes
iv. Endoplasmic Reticulum
v. Cytoplasm

a. i only
b. i & ii only
c. I, ii & iv only
d. i, ii, iii, iv & v
e. None of the above combinations are correct

14. Which ketone body/bodies can be used by tissues for energy?

a. Acetone
b. Acetoacetate
c. Beta-hydroxybutyrate
d. b & c
e. a, b & c

15. In human energy metabolism, of the energy available in triacylglycerol, about what proportion of the energy is from the glycerol backbone?

a) 1%
b) 5%
c) 15%
d) 45%
e) 60%

16. Which B vitamin plays an important role in the oxidation of fatty acids having odd-numbered chain lengths?

a) B1
b) B2
c) B3
d) B6
e) B12

17. Exercise … Choose THE best answer.

a. promotes mitochondrial enlargement
b. promotes mitochondrial proliferation
c. promotes higher flux of electrons through electron chain transporters
d. A and b are correct
e. A, b and c are correct

18. Someone has consumed 10 liters of oxygen during an exercise. How many ATP were generated for the exercise?

a. About 2.5 moles of ATP
b. About 10 moles of ATP
c. About 15 moles of ATP
d. About 20 moles of ATP
e. None of the above is correct

19. How long does it take to a fit participant (1) to regenerate most of his intramuscular phosphocreatine pool and (2) to reconvert most of his blood lactate into glucose after a VO2max test?

a. About 20 seconds for (1) and about 30 minute for (2)
b. About 2-5 minutes for (1) and about 10 minute for (2)
c. About 20 minutes for (1) and about 1 minute for (2)
d. About 1 hour for (1) and about 1 minute for (2)
e. About 2-5 minutes for (1) and about 30 minutes for (2)

20. What's the main metabolic function for (1) pyruvate carboxylase and (2) acetate carboxylase?

a. Krebs cycle replenishing for (1) and the last step of beta fatty acid oxidation for (2)
b. Gluconeogenesis for (1) and the committing step for fatty acid synthesis for (2)
c. Synthesis of glutamate for (1) and an important control step for fatty acid oxidation for (2)
d. Activation of pyruvate for the fixation of the biotin cofactor for (1) and the last step of beta fatty acid oxidation for (2)
e. None of the above answers is correct

21. For this question, you should assume that all the metabolites listed are allosteric effectors of acetyl-CoA carboxylase. Which one(s) should be expected to enhance the activity of acetyl-CoA carboxylase? Choose THE best answer.

a. Malonyl-CoA, citrate
b. Malonyl-CoA, acetyl-CoA
c. Acyl-CoAs
d. Acetyl-CoA, citrate
e. None of the above

22. Choose the enzyme(s) that you would expect to be overexpressed in tumor cells.

a. Fatty acid Synthase
b. Pyruvate dehydrogenase kinase
c. Overall hexokinase activity
d. Acetyl-CoA carboxylase
e. All of the above

23. Choose THE correct statement relative to adipocytes.

a. The core of the lipid droplets within adipocytes are filled with cholesterol and triglycerides
b. Active glyceroneogenesis in adipocytes is correlated with active filling of adipocytes with triglycerides.
c. Glycerol kinase is expressed in adipocytes
d. All of the above are correct
e. A and B are correct

24. Presume that you are a medical doctor and one of your patient is suffering from cardiac ischemia. What should you prescribe?
a. Prescribe a diet rich in fatty acids
b. Prescribe a specific inhibitor of acetyl-CoA carboxylase
c. Prescribe a specific inhibitor of beta-hydroxymethylglutaryl synthase
d. Prescribe a specific inhibitor of pyruvate carboxylase
e. Prescribe a specific inhibitor of malonyl-CoA decarboxylase

25. Choose THE best statement related to the technology developed by Liponex.
a. It is efficient to lower HDL
b. It interferes with PKA-dependent signaling
c. It lowers cholesterol as well as LDL and VLDL levels in the blood
d. It increases VLDL
e. None of the above

26. Choose THE correct statement related to fatty acid synthase.
a. The last 2 carbon atoms of palmitate are directly derived from acetate.
b. The first 2 carbon atoms of palmitate are directly derived from acetate.
c. The biosynthesis of one palmitate molecule requires 8 molecules of malonyl-CoA
d. The biosynthesis of one palmitate molecule requires 7 molecules of malonyl-CoA
e. A and d are correct

27. Statins, which roughly represent_____ of worldwide annual sales, are specific inhibitors of _____ Choose the appropriate information to make a correct sentence.
a. 5 x 109$, b-hydroxy-b-methylglutaryl-CoA reductase
b. 50 x 109$, b-hydroxy-b-methylglutaryl-CoA reductase
c. 5 x 109$, b-hydroxy-b-methylglutaryl-CoA synthase
d. 50 x 109$, b-hydroxy-β-methylglutaryl-CoA synthase
e. None of the above

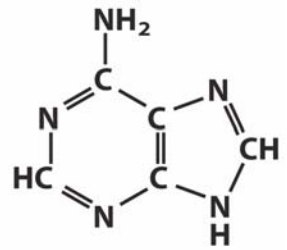
28. Choose the two types of cells in which acyl-CoA cholesterol acytransferase is expected to have the higher activity levels: (1) hepatocytes; (2) cardyomyocytes; (3) enterocytes; (4) adipocytes
a. 1 and 2
b. 1 and 3
c. 1 and 4
d. 2 and 3
e. 2 and 4

29. Choose THE correct statement about pancreatitis.
a. The presence of trypsinogen in the pancreas is correlated with pancreatitis
b. Pancreatitis is often related with an infection caused by Helicobacter pylori
c. Pancreatitis necessarily involves metabolic dysregulation
d. A and b are correct
e. A and c are correct

30. Choose THE correct statement about dietary proteins.
    a. Some small oligopeptides are absorbed by enterocytes
    b. Some dietary proteins can be absorbed by enterocytes
    c. Free amino acids can be absorbed by enterocytes
    d. A and b are correct
    e. A and c are correct

31. _____is the cofactor for most transaminases.
    a. NADPH
    b. Biotin
    c. FADH
    d. Phosphopentetheine
    e. None of the above

32. The name of this molecule is, _____.



    a. Adenine
    b. Cytosine
    c. Guanine
    d. Thymine
    e. none of the above

33. Choose THE correct statement relative to glutamatergic neurotransmission.

    a. Glutamate is transferred from the surrounding astrocyte into the glutamatergic neuron.
    b. Glutamate is converted to glutamine inside astrocytes.
    c. Glutamine is released within the synaptic cleft of glutamatergic neurons
    d. A and b are correct
    e. A and c are correct

34. Choose THE correct statement relative to the urea cycle.
    a. The committing step for the urea cycle is glutaminase
    b. Some steps of the urea cycle occur within the cytosol
    c. The two N atoms of urea are derived from carbamoyl phosphate and aspartate
    d. A and b are correct
    e. B and c are correct

35. Choose THE correct statement relative to catecholamines.
    a. Norepinephrine and epinephrine are derived from tyrosine
    b. Tetrahydrobiopterin is an essential cofactor for the biosynthesis of catecholamines
    c. The committing step for catecholamine biosynthesis is DOPA decarboxylase
    d. A and b are correct
    e. A and c are correct

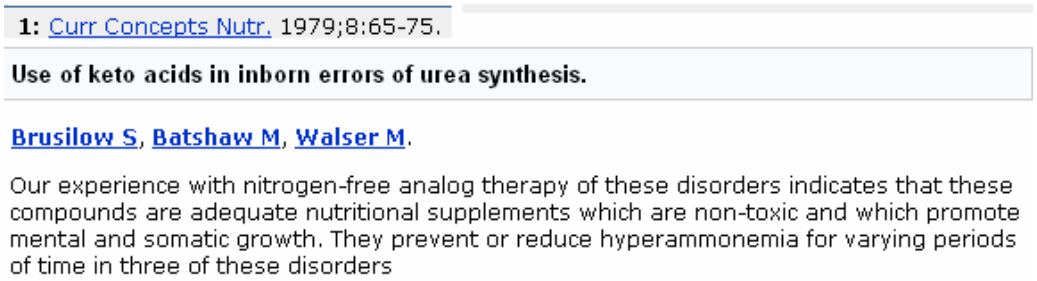
36. Serotonin, histamine and dopamine are respectively derived from …
    a. Tryptophan, tyrosine and histidine
    b. Histidine, tryptophan and tyrosine
    c. Tryptophan, histidine and tyrosine
    d. Phenylalanine, histidine and tyrosine
    e. None of the above is correct

37. Choose THE best statement relative to gastric cancer.
    a. Dysregulated secretion of cholecystokinin is related with gastric cancer.
    b. It is often caused by an infection of the stomach with *Helicobacter pylori* that triggers an excessive release of HCl
    c. The proper regulatory control of gastrin remains unaffected in most individuals affected by gastric cancer.
    d. A and b are correct
    e. None of the above is correct

38. Knock out mice for the gene … would be typically affected by … Choose THE best answer.
    a. Acetyl-CoA carboxylase, pancreatitis
    b. SAT2, dyslipidemia
    c. PSTI, pancreatitis
    d. A and b are correct
    e. None of the above is correct

39. Choose THE best statement relative to the urea cycle.
    a. The urea cycle is controlled independently of the Krebs cycle
    b. The committing step for the urea cycle is argininosuccinate synthetase
    c. The removal of one urea molecule allows a net excretion of 1.5 ammonia molecules
    d. A and b are correct
    e. None of the above is correct

40. Choose THE best answer to explain the underlying principle by which dietary keto acids are beneficial for the treatment of hyperammonemia.



1: Curr Concepts Nutr. 1979;8:65-75.

Use of keto acids in inborn errors of urea synthesis.

Brusilow S, Batshaw M, Walser M.

Our experience with nitrogen-free analog therapy of these disorders indicates that these compounds are adequate nutritional supplements which are non-toxic and which promote mental and somatic growth. They prevent or reduce hyperammonemia for varying periods of time in three of these disorders

a. Keto acids can act as antioxidants to prevent oxidative stress within mitochondria
b. Keto acids can accept the amino group to form amino products
c. Keto acids change the blood pH
d. A and b are correct
e. None of the above is correct

41. Some individuals can survive despite mutations in one of the key enzymes of the pentose phosphate pathway. Choose THE best answer relative to the alternative sources or pathways that might be activated in those individuals to supply the metabolic demand of (1) ribose and (2) NADPH.

a. (1) adenylation/ribosylation shuttle and (2) pyruvate transaminase
b. (1) salvage pathway and (2) dietary NADPH
c. (1) dietary ribose and (2) malic enzyme
d. B and C are correct
e. None of the above is correct

42. Choose THE best statement relative to selective serotonin reuptake inhibitors (SSRIs).

a. SSRIs bind on the serotonin receptors located on either the pre- or postsynaptic serotoninergic neurons.
b. SSRIs can be used to reduce aggressiveness
c. The second generation of SSRIs is preferable to the first generation of SSRIs as it minimizes side effects.
d. b and c are correct
e. a, b and c are correct

43. Choose THE best statement relative to the cofactors essential to one-carbon transfer reactions.

a. Folic acid
b. S-adenosylmethionine
c. Pyridoxal
d. a and b are correct
e. a, b and c are correct

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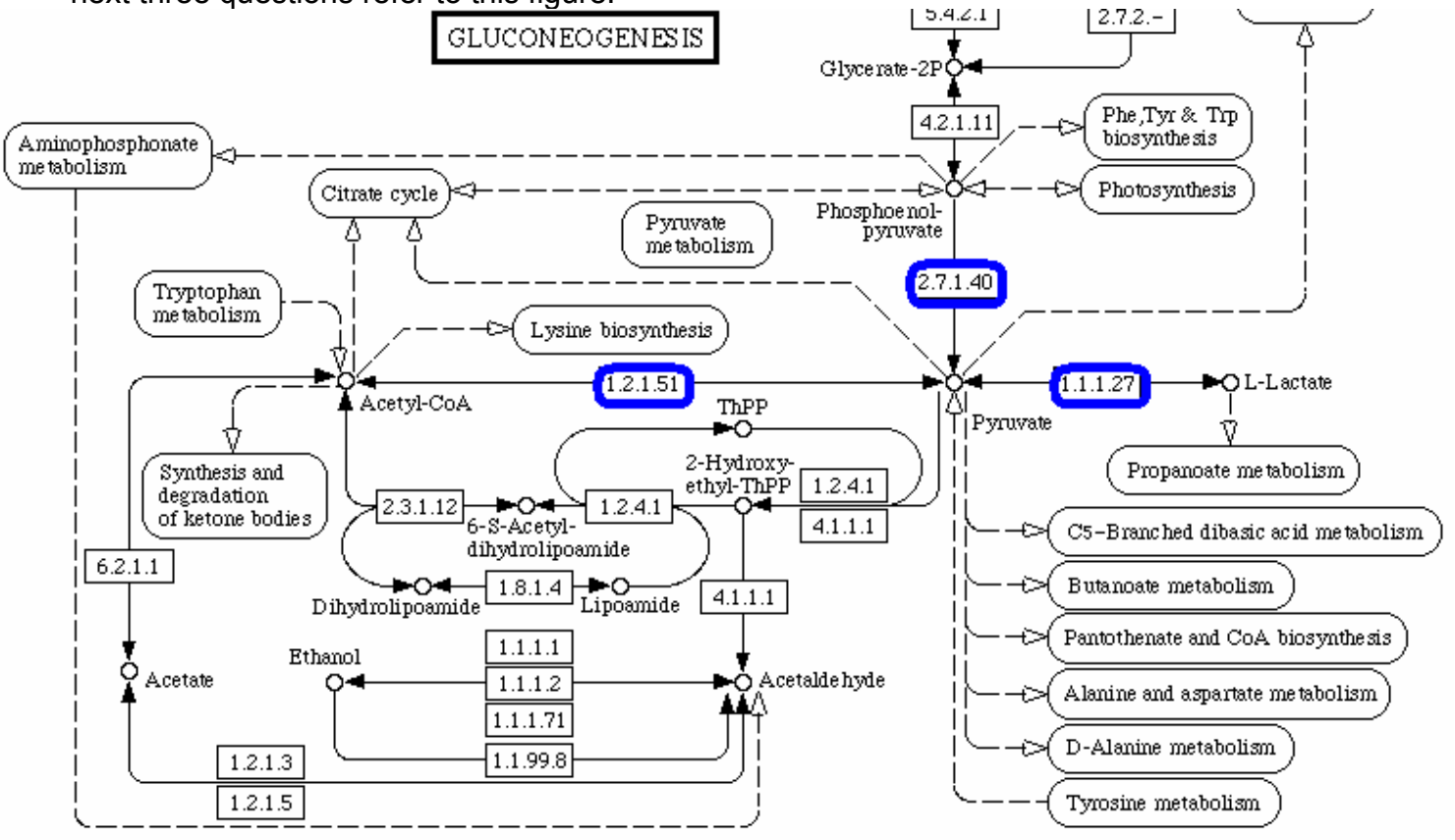
The figure below was obtained from the glycolysis/gluconeogenesis KEGG pathway. The next three questions refer to this figure.



44. The names for the three enzymes circled with a thick line are …

a. 1.2.1.51 acetyl-CoA carboxylase; 1.1.1.27 pyruvate dehydrogenase; 2.7.1.40 pyruvate kinase
b. 1.2.1.51 acetyl-CoA carboxylase; 1.1.1.27 lactate dehydrogenase; 2.7.1.40 pyruvate kinase
c. 1.2.1.51 acetyl-CoA carboxylase; 1.1.1.27 pyruvate dehydrogenase; 2.7.1.40 pyruvate kinase
d. 1.2.1.51 pyruvate dehydrogenase; 1.1.1.27 lactate dehydrogenase; 2.7.1.40 pyruvate kinase
e. None of the above is correct

45. Among the three enzymes circled with a thick line, which one(s) is(are) functionally reversible in humans?

a. 1.2.1.51
b. 1.1.1.27
c. 2.7.1.40
d. 1.2.1.51 and 1.1.1.27
e. 1.2.1.51, 1.1.1.27 and 2.7.1.40

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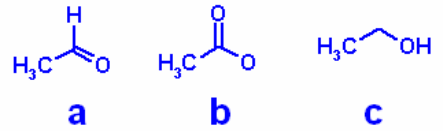
46. Choose the proper sequence of metabolites describing the catabolism of ethanol.



a **b** **c**

a. c, a, b
b. a, b, c
c. b, c, a
d. b, a, c
e. c, b, a

True/False Questions: Mark "A" for True, and Mark "B" for False
Each of the following 12 questions is worth ½ mark. The total number of marks for this section is 6.

47. In addition to being a common source of free energy for biological systems, ATP also has a high phorphoryl group transfer potential. (a. True; b. False)

48. Control of a metabolic pathway generally occurs towards the end of the pathway to prevent the wastage of energy. (1. True; b. False)

49. Phosphocreatine is an important energy source in skeletal muscle during endurance activity. (a. True; b. False)

50. Highly endergonic reactions tend to have a high degree of control over a pathway. (a. True; b. False)

51. All controlling reactions are far from K'eq, but not all reactions that are far from K'eq are controlling. (a. True; b. False)

52. The application of metabolic control analysis to industrial chemistry and biotechnology has demonstrated that the overexpression of a single rate-controlling enzyme can result in very significant increases in the production of commercially important products. (a. True; b. False)

53 The sum of all flux control coefficients is 1, even for branched pathways. (a. True; b. False)

54. A metabolite is defined as any biological molecule that has a molecular weight of less than 1000 kDa. (a. True; b. False)

55. Metabolic fingerprinting analyses in metabolomics can provide a lot of valuable information about metabolic mechanisms. (a. True; b. False)

56 In adipocytes, perilipin protects lipid droplet when it is unphosphorylated (a. True; b. False)

57. Fatty acids that are 'liberated' from adipose tissue are transported in the blood attached to albumin, and approximately 1000 molecules of fatty acid are bound to each molecule of albumin. (a. True; b. False)

58. The Krebs 'bi-cycle' is a term used to describe the interactions between the citric acid cycle and mitochondrial fatty acid oxidation. (a. True; b. False)

FILL-IN-THE-BLANKS QUESTIONS:
Each blank is worth 1 mark. The total number of marks for this section is 3
***Please avoid abbreviations***

59. Which type of metabolic control analysis (MCA) requires the use of specific inhibitors for each enzyme in the pathway? _____

60. _____ is the total number of occurrences of disease in a population at a given point in time where as _____ is the number of new cases that occur in a population over a specified period of time.

61. Fatty acids with _____ or more carbons must enter the mitochondria through the _____ shuttle.

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62. Fill this summary table relative to different basic pathways of intermediary metabolism. (10 MARKS)

Pathway	Cofactor(s)	Substrate(s)	Product	One important regulatory enzymatic step
Glycolysis				
Fatty acid synthesis				
Beta oxidation				
Cholesterol biosynthesis				
Glyceroneogenesis in adipocytes				

63. Use a diagram to illustrate the enzymatic reaction(s) by which one of the intermediate of the Krebs cycle can be converted into glutamine. Make sure to include (1) the names and (2) structures of all metabolites involved as well as (3) the enzyme names. The name and the molecular structure of the Krebs cycle intermediate from which glutamine is derived should be included also. (6 MARKS: 2 MARKS FOR NAMES OF METABOLITES; 2 MARKS FOR MOLECULAR STRUCTURES; 2 MARKS FOR ENZYME NAMES)