

Exam #3 INFORMATION THAT MAY BE USEFUL FOR THE EXAM

Abbreviations for Amino Acids				Ionizable Group	pKa
Amino Acid	3-Letter Abbreviation	Amino Acid	3-Letter Abbreviation		
Alanine	Ala	Leucine	Leu	α -COOH of any aa	2
Arginine	Arg	Lysine	Lys	β -COOH of Asp	4
Asparagine	Asn	Methionine	Met	γ -COOH of Glu	4
Aspartic Acid	Asp	Phenylalanine	Phe	imidazole of His	6
Cysteine	Cys	Proline	Pro	SH of Cys	8
Glutamine	Gln	Serine	Ser	α -NH ₂ of any aa	9
Glutamic Acid	Glu	Threonine	Thr	phenolic OH of Tyr	10
Glycine	Gly	Tryptophan	Trp	ϵ -NH ₂ of Lys	10
Histidine	His	Tyrosine	Tyr	guanidino of Arg	12
Isoleucine	Ile	Valine	Val		

Tables of Logarithmic Relationships

Number	Decimal									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1.	.00	.04	.08	.11	.15	.18	.20	.23	.26	.28
2.	.30	.32	.34	.36	.38	.40	.41	.43	.45	.46
3.	.48	.49	.51	.52	.53	.54	.56	.57	.58	.59
4.	.60	.61	.62	.63	.64	.65	.66	.67	.68	.69
5.	.70	.71	.72	.72	.73	.74	.75	.76	.76	.77
6.	.78	.79	.79	.80	.81	.81	.82	.83	.83	.84
7.	.85	.85	.86	.86	.87	.88	.88	.89	.89	.90
8.	.90	.91	.91	.92	.92	.93	.93	.94	.94	.95
9.	.95	.96	.96	.97	.97	.98	.98	.99	.99	1.00
10.	1.00									

E.g. $\log 3.5 = 0.54$

Reminder: How to form logs of multiples

$$\log 35 = \log (3.5 \times 10^1) = (\log 3.5 + \log 10^1) = (0.54 + 1) = 1.54$$

$$\log 350 = \log (3.5 \times 10^2) = (\log 3.5 + \log 10^2) = (0.54 + 2) = 2.54$$

$$\log 0.35 = \log (3.5 \times 10^{-1}) = (\log 3.5 + \log 10^{-1}) = (0.54 - 1) = -0.46$$

1) A patient is suffering from malnutrition. You suspect that she is not taking in protein of sufficiently high biological value. You explain to the patient that to have high biological value a protein (or combination of proteins) must have all the following characteristics **except**:

- A) It should not have been exposed to excessive dry heat.
- B) It should contain all the essential amino acids.
- C) It should have a balance of amino acids resembling that of human protein.
- D) It should be accessible to digestive enzymes in the gut.
- E) It should be of animal origin.

2) A patient with uncontrolled type 1 diabetes is admitted to the hospital with symptoms of polydipsia, polyphagia, and polyuria. Which of the following pathways would be activated in the liver?

- A) gluconeogenesis
- B) TCA cycle
- C) ketone body synthesis
- D) Both A and C
- E) All of the above

3) A patient with type 1 diabetes insists she has been maintaining her insulin regimen, and indeed her blood sugar level appears normal at this time. You would like to determine if she has been consistently keeping her blood sugar down. You could find this out if you tested for which of the following:

- A) ketone bodies in the blood
- B) triacylglycerols in the blood
- C) ketone bodies in the urine
- D) glycosylated hemoglobin (HbA_{1C}) in the blood
- E) lactate in the blood

4) A medical student has been studying so intensively he has gone without food for 24 hours. The major source of fuel for his brain will now be from

- A) glycogen breakdown in muscle
- B) ketone bodies from the liver
- C) gluconeogenesis in the liver
- D) β -oxidation of fatty acids
- E) amino acid degradation

5) A newborn is brought into your clinic, and his parents indicate that their baby is lethargic, vomits periodically, and has tremors. You suspect that the baby might have hyperammonemia. You decide to screen a panel of enzymes to confirm your suspicion. Which of the following is **not** an enzyme you would screen in this circumstance?

- A) argininosuccinate synthetase
- B) carbamoyl phosphate synthetase-I
- C) ornithine transcarbamoylase
- D) carbamoyl phosphate synthetase-II
- E) arginase

The next 6 questions deal with the following clinical case:

A 3 year old boy is brought into the clinic. His parents are concerned about his distended abdomen and slow growth rate. You decide to run some lab tests following a 12 hour period in which the boy did not eat. The lab reports you received back showed the following (ND = not detected):

BASIC PANEL		
	Patient	Normal Values
BUN	15 mg/dL	6-23
Creatine	1.2 mg/dL	0.6-1.4
Glucose	22 mg/dL	65-110
Sodium	128 mEq/L	135-145
Potassium (K+)	4.2 mEq/L	3.5-4.9
CO ₂	10.3 mEq/L	20-30
Chloride	87.6 mEq/L	96-110
Anion Gap	35 mEq/L	2-16
Calcium	9.6 mg/dL	8.0-10.5
Uric Acid	?????	2.0-7.0
Lactate	36 mg/dL	4.5-14.4
Pyruvate	4.6 mg/dL	0.3-0.9
pH	7.25	7.35-7.44
PROTEIN		
Total	16.4 gm/dL	6.0-8.4
Albumin	10 gm/dL	3.5-5.0
Globulin	6.8 gm/dL	2.3-3.5

ENZYMES	Patient	Normal Values
AST	40 U/L	0-42
ALT	49 U/L	0-48
LDH	786 U/L	0-250
CK	566 U/L	25-200
Lipids	Patient	Normal Values
HDL	55 mg/dL	30-60
Cholesterol	550 mg/dL	125-200
Triglycerides	365 mg/dL	10-150
LDL	85 mg/dL	60-130
URINE	Patient	Normal Values
Color	yellow	yellow
pH	5.2	4.5-8.5
Ketone	positive	negative
Glucose	negative	negative

Liver Biopsy	Patient	Normal Values
Glycogen	9.6 g/100g tissue	up to 6g
Lipid	18 g/100 g tissue	< 5 g
Glucose 6-phosphatase	215 U/gram liver	170-260
Debranching enzyme	0.0 U/gram liver [ND]	0.3-0.7
Phosphorylase	21 U/gram liver	19-25
Fructose 1,6-bisphosphatase	10.6 U/gram liver	4-16

6) Given the available information, what is the [HCO₃⁻] in the patient's sample?

- A) 8.2 mEq/L
- B) 9.6 mEq/L
- C) 10.3 mEq/L
- D) 15 mEq/L
- E) 16.8 mEq/L

7) Before you received it, someone spilled espresso on the report covering up the Uric acid value. Being the excellent biochemist that you are you quickly determine that you can deduce an approximation of the value and deduce a reason for the uric acid levels in the patient. What would you expect to find in the patient in terms of Uric acid levels and what is your explanation for the levels?

- | | <u>Levels</u> | <u>Reason</u> |
|----|----------------------|--|
| A) | higher than normal | decreased renal clearance due to high lactate |
| B) | lower than normal | decreased production of ribose 5-phosphate |
| C) | lower than normal | it is being used as an alternative energy source |
| D) | higher than normal | triacylglycerols are being converted to uric acids |
| E) | higher than normal | decreased fatty acid synthesis |

- 8) Following the 12 hour fast, which of the following correctly describes the state of his liver enzymes?
- A) Pyruvate carboxylase will be inactive
 - B) Phosphofructokinase will be active
 - C) Pyruvate dehydrogenase will be active
 - D) Phosphoenolpyruvate carboxykinase will be active
 - E) Glucose 6-phosphatase will be inactive
- 9) Following the 12 hour fast, increased activity of HMG-CoA Synthase is most directly responsible for which of the following lab report values?
- A) Increased glycogen in the liver
 - B) Increased lactate dehydrogenase (LDH) in the serum
 - C) Decreased glucose in the serum
 - D) Increased creatine kinase (CK) in serum
 - E) Increased ketones in urine
- 10) If you could isolate the patient's glycogen stores and ascertain their structure, what would you expect to find?
- A) Increased amounts and normal branching
 - B) Increased amounts and shorter outer branches
 - C) Increased amounts and very long branches
 - D) Normal amounts and shorter outer branches
 - E) Normal amounts and very long outer branches
- 11) Which of the following statements best accounts for the increased amounts of cholesterol and triacylglycerols in this patient?
- A) Between meals, excess ketone bodies are produced by the liver.
 - B) Hormone-sensitive lipases increase fatty acid export for tissues to convert to glucose.
 - C) Excess dietary intake is used by the liver to make cholesterol and triacylglycerols, instead of glycogen.
 - D) Cholesterol and triacylglycerols become a primary fuel source for tissues.
 - E) Proteins are degraded to provide precursors for fatty acid and cholesterol synthesis.
- 12) Which of the following amino acid sequences is likely to be found in the membrane-spanning domain of an integral membrane protein?
- A) -Leu-Ile-Glu-Asn-Cys-Trp-
 - B) -Leu-Arg-Ala-Ser-Val-Phe-
 - C) -Leu-Val-Pro-Asn-His-Met-
 - D) -Leu-Arg-Ile-Asp-Val-Lys-
 - E) -Leu-Val-Met-Phe-Ala-Ile-
- 13) Glycolysis and gluconeogenesis are reciprocally regulated. Which of the following correctly describes the mechanism of this regulation?
- A) Fructose 1,6-bisphosphatase is activated by fructose 2,6-bisphosphate
 - B) Glucagon stimulates phosphofructokinase 2 and inhibits fructose 2,6-bisphosphatase
 - C) Fructose 1,6-bisphosphate negatively regulates phosphofructokinase 2
 - D) Glyceraldehyde 3-phosphate can force phosphofructokinase 1 to work in reverse.
 - E) Fructose 2,6-bisphosphate activates phosphofructokinase 1 and inhibits fructose 1,6-bisphosphatase.

14) Red blood cells require high concentrations of NADPH and energy but little ribose 5-phosphate. Which of the following enzymes is required to meet these metabolic needs?

- A) Transaldolase, UDP-glucose pyrophosphorylase, pyruvate kinase
- B) Glucose 6-phosphate dehydrogenase, transketolase, and fructose 1,6 bisphosphatase
- C) Transaldolase, phosphoglycerate kinase, and 6-phosphogluconate dehydrogenase
- D) Fructose 1,6-bisphosphatase, glucose 6-phosphate dehydrogenase and pyruvate kinase
- E) Phosphoenolpyruvate carboxykinase, glucose 6-phosphate dehydrogenase, and pyruvate kinase

The next three questions deal with the following clinical case

A patient is brought into the emergency room on the verge of death. He was exposed to a mitochondrial poison but you do not know which one. You know that he is not making enough ATP and his mitochondrial oxygen consumption is very low. Using virtual technology you are able to deduce that the addition of 2,4-DNP to his mitochondria does not rescue oxygen consumption. Finally, these purified mitochondria have an excess of NADH and limited ubiquinol.

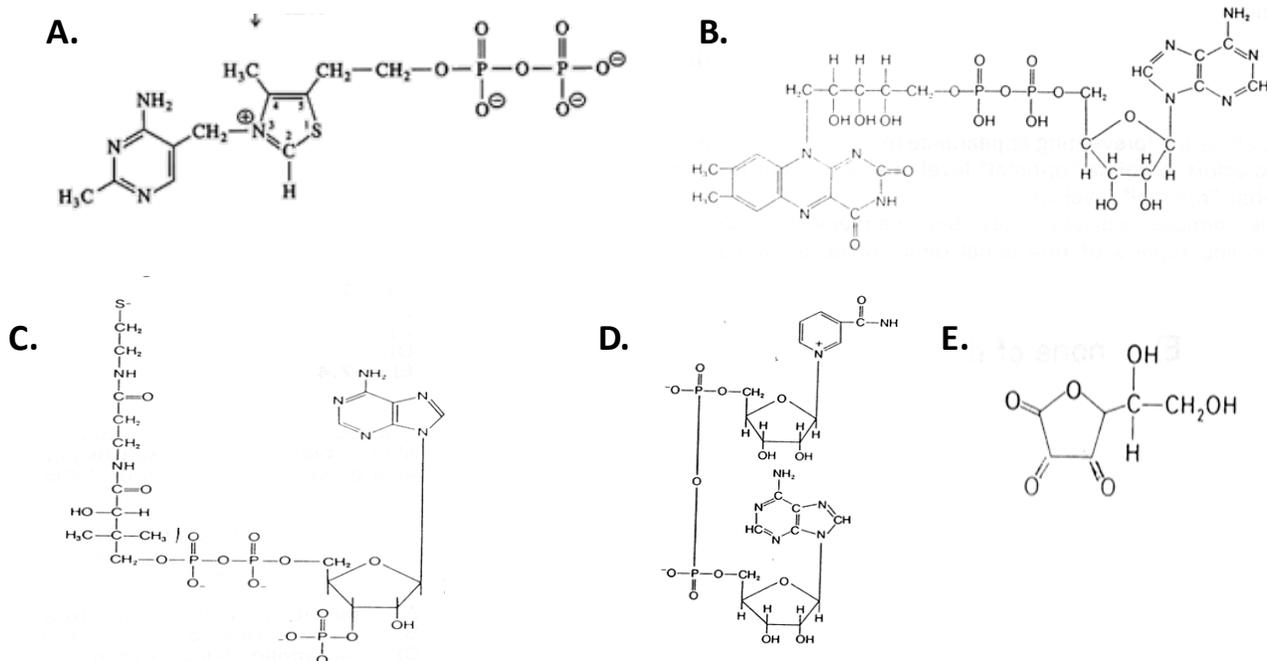
15) To which of the following poisons was the patient exposed?

- A) Oligomycin
- B) Carbon monoxide
- C) Antimycin
- D) Rotenone
- E) Cyanide

16) This type of poisoning is referred to as chemical hypoxia. The resulting mitochondrial dysfunction will most directly impact which cytosolic enzyme?

- A) Glyceraldehyde 3-phosphate dehydrogenase
- B) Phosphoenolpyruvate carboxykinase
- C) Glucose 6-phosphate dehydrogenase
- D) Fructose 1,6-bisphosphatase
- E) Glycogen Synthase

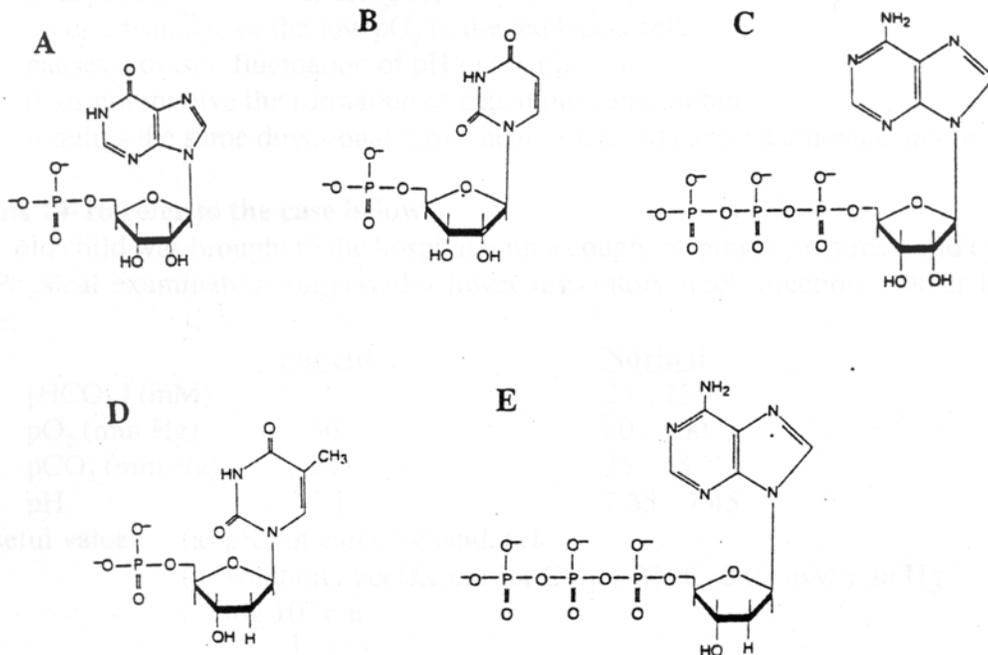
17) The poisoning and subsequent metabolic reprogramming involves which of the following coenzyme derivatives?



18) Glyceraldehyde 3-phosphate dehydrogenase (GAPDH) plays a critical role in sugar metabolism. Which of the following **incorrectly** describes the reaction catalyzed by GAPDH?

- A) It is an oxidation reaction
- B) Its product can be shunted to form a regulator of hemoglobin
- C) Its product is used to drive the production of ATP
- D) It is freely reversible
- E) Under anaerobic conditions, lactate dehydrogenase supplies it with NADH

For Questions 19-22, choose from the nucleotides whose structures are shown below. Each nucleotide can be used more than once or none at all in these questions. You might find it helpful if you identify each compound by its name before attempting to answer the questions.



- 19) Which of the nucleotides shown above is a substrate for both the hexokinase and phosphofructokinase?
- 20) Which of the nucleotides shown above inhibits the committed step of *de novo* synthesis of purine nucleotides catalyzed by PRPP amidotransferase?
- 21) Which of the nucleotides shown above stimulates the activity of ribonucleotide reductase, which is responsible for converting ribonucleotides into their deoxy counterparts?
- 22) Which of the nucleotides shown above is the direct product of thymidylate synthase?

- 23) The direct product of the committed step of the *de novo* pyrimidine nucleotide synthesis pathway is:
- A) bicarbonate
 - B) carbamoyl phosphate
 - C) orotate
 - D) orotate monophosphate
 - E) uridine monophosphate
- 24) Which of the following molecules or cofactors carries one-carbon units at the highest oxidation level?
- A) N⁵-methyl tetrahydrofolate
 - B) N⁵, N¹⁰-methylene tetrahydrofolate
 - C) vitamin B12
 - D) S-adenosylmethionine
 - E) biotin
- 25) Methotrexate and 5-fluorouracil are both used for cancer chemotherapy. What would result if both drugs were used simultaneously?
- A) The effects of the two drugs would cancel each other out.
 - B) Both drugs would directly inhibit purine nucleotide biosynthesis.
 - C) Both drugs would directly inhibit pyrimidine nucleotide biosynthesis.
 - D) The drugs would directly block synthesis of all deoxyribonucleotides.
 - E) The combined effect would be to dramatically inhibit thymidylate synthase.
- 26) Carbon atoms from tetrahydrofolate derivatives are incorporated by *de novo* synthesis into which of the following nucleotides?
- A) The purine but not the pyrimidine nucleotides found in RNA.
 - B) The pyrimidine but not the purine nucleotides found in RNA.
 - C) All deoxyribonucleotides but no ribonucleotides.
 - D) All ribonucleotides but no deoxyribonucleotides.
 - E) Only deoxythymidylate.
- 27) Pyrimidine nucleotides are catabolized ...
- A) to uric acid, which is excreted.
 - B) to the respective bases, which are primarily salvaged.
 - C) to carbon skeletons that are used for other pathways.
 - D) only down to the nucleotides.
 - E) excessively in patients with gout.
- 28) Patients with gout arising from biochemical (rather than physiological) causes are sometimes treated with allopurinol. In cells from treated patients, allopurinol would cause an increase in which of the following metabolic events?
- A) excretion of uric acid.
 - B) *de novo* synthesis of purine nucleotides.
 - C) salvage of hypoxanthine and guanine.
 - D) synthesis of thymidine.
 - E) ribonucleotide reductase activity.

29) A 52-year old female was treated for a urinary tract infection with trimethoprim. Trimethoprim is commonly used as an antibiotic to "selectively" inhibit bacterial growth but does have weak inhibitory effects on the corresponding target enzyme of vertebrate cells. On subsequent visit to the doctor's office, she complained of fatigue and the blood profile yielded the following results, compared to her initial values as well as normal reference.

	<u>Initial</u>	<u>Post Treatment</u>	<u>Normal Range</u>
Hematocrit	42%	32%	37-47%
Hemoglobin	14 g/dL	9.9 g/dL	12 - 16 g/dL
Reticulocyte Count	1.2%	11%	0.5 - 1.5% of RBC
Total bilirubin	0.9 mg/dL	3.8 mg/dL	0.3 - 1.3 mg/dL
Direct	0.2	0.3	0.1 - 0.3
Indirect	0.7	3.5	0.2 - 1

Based on the patient's history and blood profile, you suspect that she is showing symptoms of:

- A) Folate deficiency anemia
- B) Gout
- C) Hemochromatosis
- D) Iron deficiency anemia
- E) Lead poisoning

30) Many symptoms of vitamin B12 deficiency resemble symptoms of folate deficiency because:

- A) vitamin B12 is required for folate absorption and uptake.
- B) vitamin B12 is a cofactor for dihydrofolate reductase.
- C) vitamin B12 is required for utilizing N⁵-methyl tetrahydrofolate.
- D) vitamin B12 is required for synthesis of S-adenosylmethionine.
- E) folate is required for vitamin B12 absorption and uptake.

31) The biochemical effects of vitamin B12 deficiency would most likely include:

- A) decreased absorption of folate.
- B) increased synthesis of S-adenosylmethionine
- C) increased serum concentration of homocysteine.
- D) increased intracellular concentration of hypoxanthine.
- E) decreased intracellular concentration of N⁵-methyltetrahydrofolate.

Questions 32 and 33 refer to the case described below.

A patient comes to you complaining of fatigue. The blood profile suggests that the patient may have anemia. Using your considerable skills, you pinpoint the problem to a mutation in the patient's gene encoding methionine synthase, which catalyzes the reaction
(THF = tetrahydrofolate)



The patient's enzyme has a K_m for homocysteine that is 1,000-fold higher than normal.

32) Over the short term, you want to suggest some nutritional supplements to correct the patient's problems. Which of the following might be most effective?

- A) Vitamin B6
- B) Vitamin B12
- C) Folate
- D) S-adenosylmethionine (SAM)
- E) Folate and SAM

33) Over the long-term, you dream of replacing the patient's defective methionine synthase with the "best" enzyme possible from the following list. Comparing equimolar amounts of enzyme and using 1 μM homocysteine and 1 μM N^5 -methyl THF, which of the following enzymes would you choose?

<u>Enzyme</u>	<u>K_m (homocysteine)</u>	<u>K_m (N^5-methyl THF)</u>	<u>V_{max}</u>
A)	10^{-6} M	10^{-6} M	10^4 mole/min
B)	10^{-6}	10^{-6}	10^5
C)	10^{-5}	10^{-7}	10^4
D)	10^{-7}	10^{-6}	10^4
E)	10^{-7}	10^{-7}	10^5

34) Regarding the reaction of CO_2 with hemoglobin, which of the following statements is true?

- A) It is catalyzed by carbonic anhydrase.
- B) It accounts for the "chloride shift."
- C) It is one of the mechanisms of isohydric transport.
- D) It gives rise to methemoglobin.
- E) It results in the binding of 2,3-diphosphoglycerate.

35) Select the non-protein component that forms part of an active enzyme.

- A) Apoenzyme
- B) Coenzyme
- C) Holoenzyme
- D) Isoenzyme
- E) Zymogen

36) A 3-year old child was brought to the hospital with a cough, respiratory distress, and cyanosis (bluish skin due to deoxyHb). Physical examination suggested a lower respiratory tract infection. Other laboratory data available:

	<u>Patient</u>	<u>Normal</u>
pO ₂ (mm Hg)	29	80-100
pCO ₂ (mm Hg)	75	35-45
pH	7.1	7.35-7.45

Other useful values: (a) pK_a of bicarbonate buffer, 6.1;

(b) solubility coefficient for CO₂ at 37 °C, 0.03 mM/mm Hg

What is the plasma bicarbonate concentration in the patient?

- A) 8.7 mM
- B) 22.5 mM
- C) 24 mM
- D) 48 mM
- E) 75 mM

Questions 37-39 refer to blood pH conditions listed below. For each question, choose the condition most likely to result from the description given.

- A) Metabolic Acidosis**
- B) Metabolic Alkalosis**
- C) Respiratory Acidosis**
- D) Respiratory Alkalosis**
- E) Acid-base Normalcy**

37) A common practice of competitive short-distance runners is to breathe rapidly and deeply for about half a minute before running in, say, a 100-meter dash. The purpose of this hyperventilation is to achieve:

38) An untreated type 1 diabetic will be mobilizing and metabolizing fat, as well as carrying out high rates of gluconeogenesis in the liver. The resultant excess production of ketone bodies will produce:

39) A patient is suffering from vitamin B12 deficiency. Among other severe symptoms, the accumulation of methylmalonate in the blood will cause:

40) A patient has a defective cytosolic beta-ketothiolase enzyme. In this person's liver cells, which of the following pathways would be immediately affected?

- A) ketone body synthesis
- B) cholesterol synthesis
- C) beta-oxidation of fatty acids
- D) ketone body synthesis and beta-oxidation of fatty acids
- E) ketone body synthesis, cholesterol synthesis, and beta-oxidation of fatty acids

41) Which of the following statements regarding the reciprocal regulation of fatty acid synthesis and beta-oxidation is **incorrect**?

- A) Acetyl CoA carboxylase is activated by insulin.
- B) Carnitine acyl transferase II (CAT II) is inhibited by malonyl CoA.
- C) Leptin inhibits fatty acid synthesis.
- D) Glucagon stimulates beta-oxidation of fatty acids.
- E) Palmitoyl CoA is an inhibitor of fatty acid synthesis.

42) The first three enzymatic reactions of β -oxidation of fatty acids carry out the **same** sequence of reactions as which of the following enzymes, respectively?

- A) aconitase, isocitrate dehydrogenase, and α -ketoglutarate dehydrogenase
- B) β -ketoacyl-ACP reductase, β -hydroxyacyl-ACP dehydratase, and enoyl-ACP reductase
- C) citrate synthase, aconitase, and isocitrate dehydrogenase
- D) glyceraldehyde 3-P dehydrogenase, phosphoglycerate kinase, and phosphoglycerate mutase
- E) succinate dehydrogenase, fumarase, and malate dehydrogenase

43) Which of the following statements is **incorrect**?

- A) The lipid soluble vitamins are A, D, E, and K
- B) Lipases are enzymes that synthesize lipids.
- C) Chylomicrons and VLDLs primarily transport triacylglycerols.
- D) Both sphingomyelin and glycolipids can be synthesized from ceramide.
- E) *De novo* synthesis of phospholipids requires CTP.

44) A newborn is diagnosed with a defect in his medium-chain acyl CoA dehydrogenase (MCAD) enzymes. Which of the following statements regarding the biochemical/clinical effects of this disease is **true**?

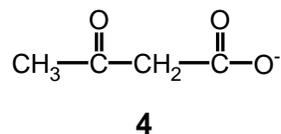
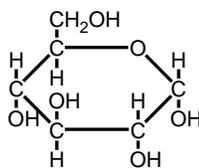
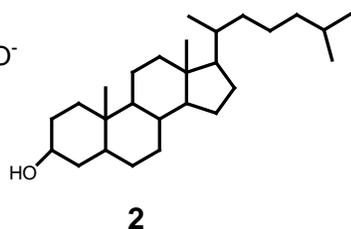
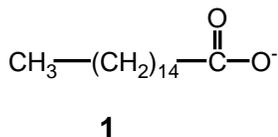
- A) The baby will be fine on an exclusive diet of breast milk.
- B) The baby will synthesize and utilize ketone bodies as a major fuel source for tissues.
- C) The baby must be fed a glucose source about every two hours.
- D) The baby is unable to utilize his glycogen stores to buffer blood glucose.
- E) The baby must not get any fat in his diet.

45) Fatty acids are released from adipose triglyceride stores through the action of

- A) hormone-sensitive lipase
- B) lipoprotein lipase
- C) lecithin:cholesterol acyltransferase (LCAT)
- D) phospholipase A₂
- E) acyl CoA synthetase

46) Which of the following statements about ketone bodies is **correct**?

- A) deprotonation of acetoacetate and β -hydroxybutyrate can lead to a lowering of blood pH
- B) ketone bodies produced by the liver can be converted to acetyl CoA in tissues needing energy
- C) the spontaneous decarboxylation of acetoacetate contributes to a lowering of blood pH
- D) A and B only
- E) all of the above



47) Which of the above molecules can ultimately be synthesized from acetyl CoA?

- A) Molecules 1 and 2 only
- B) Molecules 2 and 4 only
- C) Molecules 1, 2, and 3 only
- D) Molecules 1, 2, and 4 only
- E) Molecules 1, 2, 3, and 4

48) Which of the following statements **correctly** describes fatty acid synthesis and β -oxidation of fatty acids?

- A) Carnitine acyl transferase I (CAT I) is active for β -oxidation, but is inactive for fatty acid synthesis.
- B) Fatty acid synthesis occurs in the mitochondrial matrix and β -oxidation occurs in the cytosol.
- C) The carboxylation of acetyl CoA to malonyl CoA is the committed step in β -oxidation.
- D) The fatty acid chain is elongated by 3 carbons during each round of synthesis.
- E) FAD and NAD^+ are co-factors in fatty acid synthesis, while NADPH is a co-factor in β -oxidation.

49) A patient is suffering from cirrhosis of the liver resulting in very low production of bile salts. Which of the following compounds would **not** be affected in its digestion and absorption from the gut?

- A) vitamin A
- B) cholesterol
- C) sucrose
- D) triglyceride
- E) vitamin K

Using the list of compounds below, select the best completion of the statements in Questions 50, 51, 52.

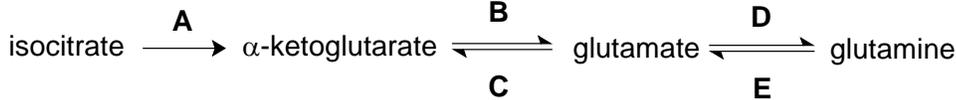
- A) LCAT (lecithin-cholesterol acyltransferase)
- B) apoprotein B-100
- C) apoprotein C-II
- D) cholesterol esters
- E) triacylglycerols (TAGs)

50) VLDLs are lipoproteins designed to primarily transport and deliver _____ to the tissues.

51) An apoprotein that is important for endocytosis of LDLs by tissues is _____.

52) When an HDL performs its role of picking up excess cholesterol, it uses _____ to produce an efficient transport form.

Use the scheme below to answer Question 53 (each arrow represents an enzyme catalyzed reaction, and not all of the reactants and products are shown)



53) Which letter associated with an arrow represents a reaction that would occur in peripheral tissues and brain to synthesize a non-toxic compound that carries two nitrogens?

54) Endogenous protein degradation in the body

- A) is catalyzed entirely by the ubiquitin-dependent pathway.
- B) results in production of free amino acids which are stored in a large amino acid pool that is available for synthesis.
- C) accomplishes the changes in metabolism necessary to deal with changes in nutrient intake.
- D) occurs at about the same rate for every enzyme or protein in the body.
- E) is always an energy-independent process.

55) The two nitrogens that are incorporated into a single molecule of urea by carbamoyl-P synthetase I and the urea cycle come directly from:

- A) ammonia and glutamate
- B) glutamine and glutamate
- C) ammonia and arginine
- D) fumarate and aspartate
- E) aspartate and ammonia

56) Aminotransferases are enzymes that have all of the following characteristics **except**

- A) can make an α -ketoacid from an α -amino acid.
- B) use pyridoxal phosphate as a carrier of amino groups
- C) are highly reversible
- D) use ATP
- E) serum levels are used as a clinical measure of tissue damage

57) Digestion and absorption of proteins

- A) requires amylases.
- B) is more effective if the protein has a high content of essential amino acids
- C) occurs by hydrolysis of peptide bonds by proteases that are stored as zymogens
- D) occurs only by removal of amino acids from the ends of chains (N-terminal or C-terminal)
- E) does not occur in the stomach.

58) A marathon runner is several hours into a race. His metabolism is dominated by the influence of epinephrine and glucagon. Which of the following enzymes is likely to be phosphorylated and **active** in the liver and muscle tissue?

- A) glycogen synthase
- B) pyruvate dehydrogenase
- C) HMG CoA reductase
- D) glycogen phosphorylase
- E) fatty acyl transferase

59) A major allosteric effector of the urea cycle is

- A) glutamine
- B) arginine
- C) cAMP
- D) carbamoyl phosphate
- E) *N*-acetylglutamate

60) Which of the organs listed below is **incorrectly** matched with a substance it normally *stores (S)* or *uses as fuel (F)*?

- A) muscle: glycogen (S)
- B) liver: triacylglycerols (S)
- C) adipose tissue: fatty acids (F)
- D) red blood cell: ketone bodies (F)
- E) heart: fatty acids (F)

61) After five weeks of starvation, which of the following statements would **correctly** describe the changes in levels of circulating fuels compared to the well-fed state?

- A) lactate, pyruvate, and alanine are lower
- B) glucose is higher
- C) overall caloric value of circulating fuel is lower
- D) fatty acids are lower
- E) ketone bodies are lower

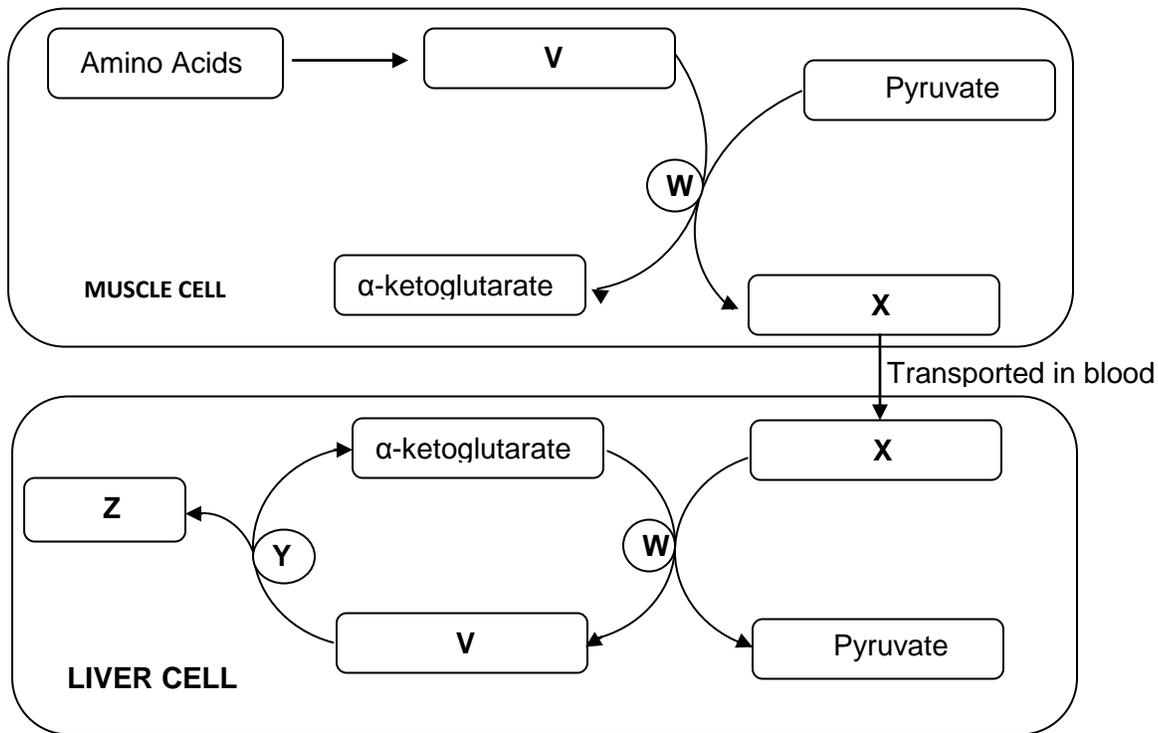
62) Insulin and glucagon are similar in the following ways **except**:

- A) Both have self-limiting activity due to breakdown
- B) Both are synthesized as inactive precursors that are activated by proteolysis
- C) Both are effective at low concentrations
- D) Both target muscle tissue
- E) Both are effective regulators of sugar metabolism

63) All the following key intermediates in energy metabolism are correctly paired with enzymes that would directly consume or produce them **except**:

- A) glucose-6-phosphate: glycogen synthase
- B) pyruvate: lactate dehydrogenase
- C) acetyl CoA: pyruvate dehydrogenase complex
- D) pyruvate: pyruvate carboxylase
- E) glucose-6-phosphate: hexokinase

64) For this question, fill in the lettered blanks (V-Z) to complete the flow diagram shown below:



V

W

X

Y

Z

- | | | | | |
|--------------|--------------------|----------|-------------------------|---------------------|
| A) glutamate | amino acid oxidase | alanine | glutamate dehydrogenase | ammonia |
| B) glutamine | amino acid oxidase | fumarate | glutamate dehydrogenase | ammonia |
| C) glutamine | aminotransferase | alanine | amino acid oxidase | carbamoyl phosphate |
| D) glutamate | aminotransferase | alanine | amino acid oxidase | carbamoyl phosphate |
| E) glutamate | aminotransferase | alanine | glutamate dehydrogenase | ammonia |

END OF EXAMINATION

Tear off this sheet and save to check your answers.

Please remember to:

- Write the letter corresponding to your **FORM** in the appropriate place on the **answer sheet**.
- SIGN AND RETURN YOUR EXAMINATION** to an instructor **before leaving the exam room**.

FORM: A

- | | | | |
|-----------|-----------|-----------|-----------|
| 1. _____ | 21. _____ | 41. _____ | 61. _____ |
| 2. _____ | 22. _____ | 42. _____ | 62. _____ |
| 3. _____ | 23. _____ | 43. _____ | 63. _____ |
| 4. _____ | 24. _____ | 44. _____ | 64. _____ |
| 5. _____ | 25. _____ | 45. _____ | |
| 6. _____ | 26. _____ | 46. _____ | |
| 7. _____ | 27. _____ | 47. _____ | |
| 8. _____ | 28. _____ | 48. _____ | |
| 9. _____ | 29. _____ | 49. _____ | |
| 10. _____ | 30. _____ | 50. _____ | |
| 11. _____ | 31. _____ | 51. _____ | |
| 12. _____ | 32. _____ | 52. _____ | |
| 13. _____ | 33. _____ | 53. _____ | |
| 14. _____ | 34. _____ | 54. _____ | |
| 15. _____ | 35. _____ | 55. _____ | |
| 16. _____ | 36. _____ | 56. _____ | |
| 17. _____ | 37. _____ | 57. _____ | |
| 18. _____ | 38. _____ | 58. _____ | |
| 19. _____ | 39. _____ | 59. _____ | |
| 20. _____ | 40. _____ | 60. _____ | |