The two ketone bodies in blood are β-hydroxybutyrate (BHB) and acetoacetate (AcAc).

\[
\begin{align*}
\text{β-hydroxybutyrate} & : 
\begin{array}{c}
\text{OH} \\
\text{CH}_3-C-\text{CH}_2-C=O \\
\text{H} \\
\cdot \\
\text{O}^-
\end{array} \\
\text{acetoacetate} & : 
\begin{array}{c}
\text{O} \\
\text{CH}_3-C-\text{CH}_2-C=O \\
\cdot \\
\text{O}^-
\end{array}
\end{align*}
\]

Mark the following statements as true or false (2 points each).

1. **T** Both of these ketoads are produced by the liver via the β-oxidation of fatty acids.

2. **F** BHB is more oxidized than AcAc.

The interconversion of BHB and AcAc is catalyzed by the enzyme BHB dehydrogenase. The cofactor for this dehydrogenase is nicotinamide adenine dinucleotide (NAD).

(Circle the correct option [underlined]; 2 points each) When a person is in a starved state, the levels of “stored energy” in their hepatocytes is decreased.

3. This relatively negative energy balance would be associated with a decrease in \( \text{NADH} / \text{NAD}^+ \), the form of nicotinamide adenine dinucleotide in which energy is stored.

4. If the ratio of NADH to NAD\(^+\) favors less energy storage, then the ratio of BHB to AcAc will be \( \text{high} \) \( \text{low} \).

Which of the following characteristics are required for a signaling protein to be considered a G-protein. (Mark each True or False; 2 points each.)

1. **T** Can bind GDP.

2. **T** Can hydrolyze GTP.

3. **F** Can activate adenylyl cyclase.
Indicate whether the following physiological, cellular and metabolic parameters are increased or decreased in the fasted state. (Mark each as "increased" or "decreased"; 2 points each.)

1. **Decreased** Activity of the glycolytic pathway in liver.

2. **Increased** The activity of glycogen phosphorylase in liver.

3. **Decreased** The tyrosine phosphorylation of IRS-1 (insulin receptor substrate 1) in skeletal muscle.

4. **Increased** The content of glucose-6-phosphatase in liver.

5. **Decreased** The activity of acetyl-CoA carboxylase in liver.

6. **Decreased** The cell surface content of GLUT4 (a glucose transporter) in skeletal muscle.

Mark the following multiple choice questions as follows (2 points each):

a if only item a is correct.
b if only item b is correct.
c if only item c is correct.
d if only a and c are correct.
e if a, b and c are all correct.

1. **A** The following processes are localized to mitochondria:
   a. The urea cycle
   b. Glycogen metabolism
   c. Glycolysis

2. **C** The following require a transport or shuttle mechanism to traverse the inner and outer mitochondrial membranes:
   a. Acetyl-CoA
   b. ATP
   c. Palmitate
3. C The enzyme glycogen phosphorylase:
   a. Catalyzes both the synthesis and degradation of glycogen in vivo.
   b. Is activated in response to direct phosphorylation by cyclic AMP-dependent protein kinase.
   c. Has as a product glucose-1-phosphate.

4. E Acetyl-CoA carboxylase:
   a. Is a key regulator of fatty acid synthesis.
   b. Is a key regulator of fatty acid oxidation.
   c. Is activated in response to insulin.

5. b The second messenger, cAMP:
   a. Mediates many of its effects by activating a protein phosphatase.
   b. Activates a protein kinase that is specific for serine or threonine residues on other proteins.
   c. Is produced in response to activation of the insulin receptor by insulin.

6. d Growth factor receptor tyrosine kinases can activate growth-promoting signals:
   a. By the direct tyrosine phosphorylation of signaling enzymes.
   b. By cleaving Ras from its docking site in the nucleus.
   c. By serving as docking sites for signaling enzymes.

7. c Progression through the cell cycle requires:
   a. The degradation of cyclin D before entry into S-phase.
   b. The overexpression of the cyclin-dependent kinase inhibitor, p21Cip1.
   c. Completion of the DNA synthesis phase prior to mitosis.

FILL IN THE BLANKS (1 point each)

1. The intracellular portion of the epidermal growth factor (EGF) receptor is a protein kinase that is specific for the amino acid tyrosine.

2. When skeletal muscle is working under anaerobic conditions (for example, strenuous exercise), it produces significant amounts of lactate, which circulates to the liver where it is used for gluconeogenesis.
3. A key component of the regulation of glycogen metabolism in skeletal muscle is the control of phosphorylase kinase by calcium. This regulation allows for the coordinated control of muscle contraction and glycogenolysis.

4. The dietary constituent (vitamin) called carnitine is a required cofactor for the transport of fatty acids into mitochondria.

5. In the retina, rhodopsin, a light receptor, interacts with a G-protein called transducin.

TRUE/FALSE (1 point each)

1. False The small G-protein Ras is often mutated in human cancers. A common activating mutation is one that causes Ras to lose its ability to bind GTP.

2. False Most cyclins and cyclin-dependent kinases are active throughout all phases of the cell cycle.

3. True ATP synthesis in mitochondria involves requires the presence of a proton gradient across the inner mitochondrial membrane.

4. True The hexose monophosphate shunt contributes to fatty acid synthesis through its ability to synthesize NADPH.

5. True Cyclin-dependent kinases phosphorylate other proteins on serine or threonine residues.
FILL IN THE SPACES (2 points each)

1) The transfer of nitrogen from an amino acid to a keto acid involves the coenzyme ______pyridoxal phosphate______. The requirement for energy is ______no requirement______.

2) In the mitochondria ADP is an allosteric ______activator______ of the enzyme glutamate dehydrogenase. This makes sense since one of the products of this reaction, along with alpha-keto glutarate and free ammonia, is ______reduced NADP(H) or NADPH______.

3) The conversion of the carbon skeleton of some amino acids to glucose during fasting involves decarboxylation of the citric acid cycle intermediate ______oxaloacetate______ to ______phosphoenolpyruvate______, and then conversion to glucose. (or, PEP)

4) Patients with acute intermittent porphyria do not have photosensitivity because ______no tetrapyrrole is synthesized______.

5) Supercoiling of DNA during replication is alleviated by unwinding enzymes called ______topoisomerase______.

6) Pyrimidine dimers caused by UV light are repaired by a system called ______nucleotide excision repair______. This system is defective in individuals with the disorder called ______xeroderma pigmentosa______.

7) The peptide bond is formed on the ______60S or larger______ subunit of the mammalian ribosome and can be inhibited by the antibiotic ______chloramphenicol______.

8) Only ______initiator methionyl tRNA______ binds directly to the first AUG codon of mRNA in the ribosomal ______P site______ site during initiation of protein synthesis.
9) In the absence of globin synthesis, heme synthesis is halted by auto-regulating further production of **ALA synthase**.

10) In the absence of heme synthesis, globin synthesis is halted by phosphorylation of **eIF2**, which essentially binds and removes **eIF-2B**.

11) Symptoms of beta thalassemia are not expressed at birth because **gamma globin chain synthesis continues for a while after birth**.

12) What would be the effect of a single base mutation (C to U) in the codon CAG near the 5' end of an exon in the beta globin gene? The resulting **UAG stop codon** would terminate translation, resulting in reduced beta globin synthesis. (Beta thalassemia major results only if both beta globin genes are compromised).

**TRUE/FALSE** (1 point each)

1) **T** Proteins are hydrolyzed in the intestine by proteolytic pancreatic enzymes that are initially produced as inactive precursors called zymogens.

2) **F** Non-essential amino acids cannot be synthesized by the body.

3) **T** Non-oxidative decarboxylation of certain amino acids (e.g. histidine to histamine) and transamination of amino acids involve pyridoxal phosphate.

4) **T** The elevated level of phenylalanine in persons with untreated PKU is probably the main cause of mental retardation.

5) **T** The first amino acid in all proteins is methionine.
6) T The first major symptom of vitamin B12 deficiency is anemia, unless the individual is taking a folic acid supplement.

7) F Heme containing proteins are essentially found only in the liver and red blood cells.

8) T DNA precursors such as 2',3'-dideoxyinosine, lacking a 3' hydroxyl group, are useful antiviral agents since they can terminate DNA synthesis.

9) F RNA synthesis by RNA polymerase requires both a DNA template and a primer molecule.

10) T Some trans-acting factors that bind the promoter region of a gene act as activators while others function as repressors.

11) F The stability of mRNA is influenced by the polyA tail but not the 5' or 3' untranslated regions.
Match the following enzymes with their substrates. Each number and letter is used only once. (1 point per answer).

1) **C**. Lecithin cholesterol acyl transferase (LCAT)  
A. Cholesterol in cells

2) **A**. Acyl CoA cholesterol acyl transferase (ACAT)  
B. Triglyceride and cholesteryl ester in all lipoproteins

3) **D**. Lipoprotein lipase  
C. Phospholipid and cholesterol in HDL

4) **E**. Hepatic lipase  
D. Triglycerides in chylomicrons and VLDL

5) **B**. Core lipid exchange protein  
E. Phospholipid and triglycerides in IDL and HDL

MULTIPLE CHOICE (One correct answer per question, 1 point each)

1) **B**. Which is not a dietary source of cholesterol?
   
   A. Steak  
   B. Olive oil  
   C. Milk  
   D. Eggs

2) **D**. HDL transport cholesterol from the periphery to the liver. Which of the following is a route for reverse cholesterol transport?

   A. Direct uptake from HDL by SRB1 receptor  
   B. Esterification of cholesterol in HDL, transfer of cholesteryl ester from HDL to VLDL and uptake of LDL by liver  
   C. Esterification of cholesterol in HDL, transfer of cholesteryl ester from HDL to chylomicrons and uptake of chylomicron remnants by liver  
   D. All of the above

3) **C**. Which of the following apolipoproteins is not associated with receptor recognition?

   A. Apo B100  
   B. Apo E  
   C. Apo B48  
   D. All of the above
4) D  Small, dense LDL are associated with:
   A. Increased abdominal fat
   B. Increased triglycerides
   C. Increased susceptibility to oxidation and CHD risk
   D. All of the above

5) A  Which of the following statements is true of IDL?
   A. IDL is a substrate for hepatic lipase
   B. IDL is a substrate for lecithin cholesterol acyl transferase
   C. IDL is synthesized in the liver
   D. All of the above

TRUE/FALSE (1 point each)

1) T  Low levels of LDL and HDL are associated with elevated triglycerides.

2) F  Underproduction of apoB is associated with increased VLDL and LDL.

3) F  The function of the protein in Lp(a) is to inhibit binding of lipoproteins to the artery wall.

4) T  Excess caloric intake and obesity are associated with hypertriglyceridemia.

5) T  Exercise decreases triglycerides by increasing skeletal muscle lipoprotein lipase.