1) In an animal with type I diabetes describe the levels of pancreatic hormones in circulation

A. Insulin high, glucagon high
B. Insulin high, glucagon low (low glucagon:insulin ratio)
C. Insulin low, glucagon low
* D. Insulin low, glucagon high (high glucagon:insulin ratio)

Type 1 diabetes mellitus is characterized by loss of the insulin-producing beta cells of the islets of Langerhans of the pancreas leading to a deficiency of insulin. Sensitivity and responsiveness to insulin are usually normal, especially in the early stages. The condition leads to a low insulin:glucagon ratio.

2) In an animal with type I diabetes, how do pancreatic hormones in the blood stream impact adipocytes

* A. The elevated glucagon:insulin ratio would activate hormone-sensitive lipase to break down triglycerides into LCFA and glycerol
B. No impact. Insulin is low, so glucagon will also be low.
C. The elevated glucagon:insulin ratio would activate hormone-sensitive lipase inhibiting the creation of ketone bodies
D. The elevated glucagon:insulin ratio would de-activate hormone-sensitive lipase inhibiting break down of triglycerides into LCFA and glycerol

Ruminants cannot absorb dietary carbohydrate in the form of simple sugars (glucose, fructose, sucrose) like non-ruminants can. Instead, fibre, especially cellulose, is broken down into glucose in the rumen and reticulum by symbiotic bacteria and protozoa. Almost all the glucose produced by the breaking down of cellulose is used by the symbiotic bacteria. Ruminants get their energy from the volatile fatty acids produced by these bacteria: acetic acid, propionic acid and butyric acid.

3) The following are some of the molecules absorbed by ruminants following carbohydrate digestion (multiple answers)

* A. Butyrate
* B. Acetate
C. Glucose
D. LCFA
* E. Propionate

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4) When propionate is absorbed by the ruminant, it gets used for

A. creation of ketones
B. creation of LCFAs
C. glycogenolysis
D. glycolysis
* E. gluconeogenesis

Proprionate enters the TCA cycle as succinate. Gluconeogenesis essentially reverses the aerobic glycolysis cycle to create glucose. Gluconeogenesis begins with the formation of oxaloacetate through carboxylation of pyruvate (catalyzed by pyruvate carboxylase) Oxaloacetate is then decarboxylated and simultaneously phosphorylated to produce phosphoenolpyruvate (phosphoenolpyruvate carboxykinase). Both reactions take place in mitochondria. Oxaloacetate has to be transformed into malate in order to be transported out of the mitochondria. Typically, the last step of gluconeogenesis is the formation of glucose-6-phosphate from fructose-6-phosphate (phosphoglucose isomerase).

5) When butyrate is absorbed by the ruminant, it gets used for

  A. gluconeogenesis
  B. glycolysis
* C. creation of ketones
  D. glycogenolysis
  E. creation of LCFAs

Unlike propionate, butyrate enters the TCA cycle as Acetyl-CoA and thus cannot lead to a net production of oxaloacetate. Consequently, gluconeogenesis cannot occur. Instead, Beta-hydroxybutyrate, a ketone body, is formed from butyrate in the rumen epithelium.

6) When acetate is absorbed by the ruminant, it gets used for

* A. creation of LCFAs
  B. glycogenolysis
  C. glycolysis
  D. gluconeogenesis
  E. creation of ketones

Acetate, unlike butyrate, cannot be metabolized by the rumen epithelium. Instead, it travels to adipocytes or mammary glands where it is converted into LCFAs (long-chain fatty acids).

7) Cytokine release from macrophages/monocytes initiate the acute phase protein response?

* A. True
  B. False

Acute-phase proteins are a class of proteins whose plasma concentrations increase (positive acute phase proteins) or decrease (negative acute phase proteins) in response to inflammation. In response to injury, local inflammatory cells (neutrophil granulocytes and macrophages) secrete a number of cytokines into the bloodstream. [Cytokines are a group of proteinaceous signalling compounds that, like hormones and neurotransmitters, are used extensively for inter-cell communication]. The liver responds by producing a large number of acute-phase proteins. Measurement of acute phase proteins is a useful marker of inflammation.

8) Where are acute phase proteins produced

  A. Blood stream, by Macrophages
* B. Liver
  C. Kidney
  D. Blood stream, by Monocytes
  E. Spleen

Acute-phase proteins are a class of proteins whose plasma concentrations increase (positive acute phase proteins) or decrease (negative acute phase proteins) in response to inflammation. In response to injury, local inflammatory cells (neutrophil granulocytes and macrophages) secrete a number of cytokines into the bloodstream. [Cytokines are a group of proteinaceous signalling compounds that, like hormones and neurotransmitters, are used extensively for inter-cell communication]. The liver responds by producing a large number of acute-phase proteins. Measurement of acute phase proteins is a useful marker of inflammation.

9) Gluconeogenesis is the creation of glucose from glycogen

* A. False
  B. True

Gluconeogenesis is the production of glucose from non-carbohydrate molecules such as lactate, propionate and amino acids. The vast majority of gluconeogenesis takes place in the liver and, to a smaller extent, in the cortex of kidney. This process occurs during periods of fasting, starvation, or intense exercise and is highly endergonic (needs energy).

10) Glycogenolysis primarily occurs in tissue cells of the body

A. True
* B. False

Glycogenolysis transpires in the muscle and liver tissue, where glycogen is stored, as a hormonal response to epinephrine. Glycogenolysis is the catabolism of glycogen by removal of a glucose monomer and addition of phosphate to produce glucose-1-phosphate. This derivative of glucose is then converted to glucose-6-phosphate, a potent intermediate in glycolysis. The hormones glucagon and epinephrine stimulate glycogenolysis.

11) What function(s) can albumin/globulin ratio represent (single answer)?

A. Immune activity
B. Renal function
C. Protein metabolism
D. Inflammation
* E. All of the above

While an A/G ratio is described as a ‘snapshot’ of protein metabolism, a deviation from the norm can indicate immune activity and inflammation (increased globulins) and renal function (decreases in albumin could indicate loss through permeability at the kidneys (or renal failure).

12) What effect does dehydration have on the A/G ratio

A. Hypoalbuminemia
B. Hyperglobulinemia
C. Decreases concentration of albumin and globulin equally
* D. No effect

Dehydration equally increases concentration of A and G, so B is incorrect (and even if the question stated ‘increased, since it is a ratio, the increase would be divided out). As dehydration does change concentrations equally, there would be no change in the concentrations of globulin and albumin with respect to each other. (i.e. the a/g ratio would be within its reference range.)

13) Transamination is a process in which

* A. An amine group is transferred from an amino-acid to an alpha-keto acid
B. A protein is broken down into its amino-acids
C. Alpha-ketoglutarate donates its amine group to an amino acid, like glutamate
D. An amine group is transferred from an alpha-keto acid to an amino-acid
E. An amine group is removed from a molecule and sent to the urea cycle

Transamination (or aminotransfer) is the reaction between an amino acid and an alpha-keto acid. The amino group is transferred from the former to the latter; this results in the amino acid being converted to the corresponding alpha-keto acid, while the reactant alpha-keto acid is converted to the corresponding amino acid.

14) Deamination is a process in which

A. A protein is broken down into its amino-acids
B. An amine group is transferred from an amino-acid to an alpha-keto acid
C. Alpha-ketoglutarate donates its amine group to an amino acid, like glutamate
D. An amine group is transferred from an alpha-keto acid to an amino-acid
* E. An amine group is removed from a molecule and sent to the urea cycle

Deamination is the removal of an amine group from a molecule. In mammals, deamination takes place in the liver. It is the process by which amino acids are broken down. The amino group is removed from the amino acid and converted to ammonia. The remainder is an alpha-ketoglutarate that can be recycled or burned for energy. Ammonia is toxic to the human system, and enzymes convert it to urea or uric acid by addition of carbon dioxide molecules in the Urea Cycle. Urea and uric acid can safely diffuse into the blood and then be excreted in urine.

15) Aspartate aminotransferase is an enzyme that catalyzes

A. Deamination
B. Transamination or Deamination, depending on the amino acid
* C. Transamination
D. The Urea cycle

Aspartate aminotransferase catalyzes the transamination reaction of Aspartate and alpha-ketoglutarate into glutamate and oxaloacetate. Similarly, Alanine transaminase catalyzes the transamination reaction of Alanine and alpha-ketoglutarate into pyruvate and glutamate.

16) Ammonia can be recycled into protein

A. through transamination
B. through deamination
C. by oxidative phosphorylation
D. in the urea cycle
* E. by microorganisms

Ammonia is toxic to all organisms, barring microorganisms which can convert it into amino acids. Ammonia (NH4) inhibits oxidative phosphorylation and affects neurological function by inhibiting receptor function, signal transduction (transportation of stimuli) and neurotransmitters. Ammonia is excreted through the urea cycle.

17) Transamination and deamination of proteins in the liver is

A. To conjugate Bilirubin
B. The first step in the creation of plasma proteins
C. To get rid of toxins (like ammonia) through the urea cycle
* D. To catabolize excess amino acids

Amino acids that reach the liver can be used to create liver proteins (14%), plasma proteins (6%) or be sent out into system circulation (23%) for use by body tissue. The remainder (57%) are catabolized through pathways of carbohydrate metabolism, conversion to glucose or glycogen, or shunted to fatty acid synthesis.

18) When protein is catabolized in muscle, toxic ammonia is removed as follows

A. Deamination of ammonia
* B. Ammonia reacts with glutamate to produce glutamine. This is broken down in the kidney, where ammonia is excreted in urine.
C. Ammonia diffuses into the blood and is taken to the liver where it is converted into urea
D. Transamination or Deamination, depending on the amino acid

The byproduct of the transamination reaction in the muscle that ultimately produces energy from amino-acids, is glutamate. Glutamate may be converted into alanine or, with the addition of ammonia, into glutamine. Alanine goes to the liver where it is converted into glucose and urea, the latter being excreted by the kidney in urine. Glutamine is taken up by the kidney where it is catabolized into energy (or glucose, through gluconeogenesis) and ammonia. This ammonia is excreted in urine.

19) A high BUN (Blood Urea Nitrogen) points to a malfunction in :

A. Gall bladder (obstruction)
B. Spleen
* C. Kidney
D. TCA cycle
E. Liver

BUN measures the amount of nitrogen in the blood that comes from urea. Impaired kidney function results in increased BUN levels.

20) Birds excrete ammonia using uric acid while animals always excrete ammonia as urea or ammonia dissolved in urea.

  A. True
* B. False

The above is generally true. However, there are exceptions. For example, Dalmation breeds of dogs excrete urea in the form of uric acid in the urine rather than in the urea form. This is due to a defect in one of the genes controlling expression of the conversion enzymes in the Urea cycle.

21) The liver is believed to have over 500 functions. In most healthy animals the liver is operating at approximately what percentage of its maximum potential?

  A. 75
  B. 10
* C. 30
  D. 120 (like most crocodiles)
  E. 50

The liver is one of the few organs that can regenerate – so, one doesn't have to be too concerned when doing a liver biopsy. If a lobe is lost due to, say, trauma, the lobe will not regenerate; however, the remaining lobes will increase in mass to make up.

22) The parenchymal cell of the liver is the hepatocyte. Along with endothelial cells that line sinusoids, they constitute approximately what % of cells belonging to the liver?

  A. 60%
* B. 95-98%
  C. less than 50%
  D. 80%

Cells belonging to the liver include parenchymal (65-70%), endothelial (30%), epithelial cells (1%; line small bile ducts or canaliculi) and mesenchymal cells (fibroblasts, plasma cells, mast cells)

23) Periportal hepatocytes

  A. Tend to have aerobic functions as they contain a vascular pole
  B. Tend to have anaerobic functions as they contain a biliary pole
  C. Tend to have anaerobic functions because they reside close to the central venule
* D. Tend to have aerobic functions as they reside close to the hepatic arteriole and portal venule

A liver acinus is the inter-lobular tissue surrounding the portal triad (which contains the bile duct, hepatic arteriole and hepatic portal venule). Blood from both the hepatic artery and portal vein flow through sinusoids towards the central venule (the far end of the acinus). Bile flows in the reverse direction in canaliculi, towards the bile duct in the triad (acinus center). All hepatocytes have both a vascular pole (faces the sinusoid) and a biliary pole (faces the canaliculi). Hepatocytes close to the triad (zone 1) deplete oxygen from the blood flowing past them while carrying out mainly aerobic functions (carbohydrate metabolism, glycogen storage) while hepatocytes close to the central venule (zone 3) have to work with relatively deoxygenated blood – they carry out detoxification functions. Hepatocytes in zone 2 do a bit of both.

24) Cholestrol is present in every animal cell. It also is required for the production of bile salts, steroid hormone synthesis, cell membranes, myelin and lipoproteins. Its production is regulated by which enzyme

  A. Cholestro-transferase
  B. Cholestrol aminotransferase
* C. HMG-COA reductase
  D. HMG-COA dehydrogenase

Cholestrol production occurs in the endoplasmic reticulum. About 50% of the cholestrol needs of an animal are met in diet, the remainder being synthesized by the body. Cholestrol production is regulated by controlling both the activity and levels of HMG CoA Reductase

25) Regulation of cholestrol synthesis is carried out by

  A. By controlling the activity of HMG Coa Reductase
  B. By controlling the levels of HMG Coa Reductase
  C. Synthesis isn't regulated. Instead, excess is excreted by the kidney
* D. By controlling both the activity and levels of HMG CoA Reductase

High cholestrol levels, epinephrine and glucagon inhibit enzyme activity, while insulin stimulates enzyme activity. High cholestrol levels also inhibit synthesis of HMG CoA Reductase while simultaneously promoting its degradation. Low cholestrol levels and insulin have the opposite effect.

26) Most of the cholestrol used to create bile

* A. Is reabsorbed in the ileum
  B. Is lost in the feces
  C. Is used to facilitate the excretion of bilirubin
  D. Facilitates the digestion of protein

About 90% of cholestrol in bile is reabsorbed in the ileum. Bile contains water, bile salts, bilirubin, cholestrol, fatty acids and electrolytes. Its 4 main functions are (1) elimination of cholestrol (although 90% is reabsorbed in the ileum) (2) prevent cholestrol precipitation in the gall bladder (3) facilitate digestion of fat (4) facilitate absorption of fat soluble vitamins.

27) A portosystemic shunt

  A. Is usually the result of severe trauma to the abdomen
* B. Occurs when part of the portal system bypasses the liver
  C. Is a bile duct blockage
  D. Results in reduced bile secretion into the intestine

Usually congenital, a portosystemic shunt is when part of the portal system connects directly with the vena cava. Some nutrients, thus, bypass the liver. In addition, the enterohepatic circulation (wherein bile salts secreted into the instestine are reabsorbed, then picked up by the liver) is disrupted resulting in an increase of bile salts in circulation. The solution is often surgical.

28) Cholestasis is

* A. Blockage of the flow of bile from the liver to the intestine
  B. Reduced synthesis of cholestrol
  C. Excessive production of cholestrol
  D. Reduced production of bile due to liver failure

Cholestasis can be (1) Mechanical : where there is a mechanical blockage in the duct system such as can occur from a gallstone or (2) Malignancy/Metabolic : which are disturbances in bile formation that can occur because of genetic defects or acquired as a side effect of many medications.

29) Bilirubin is formed by the breakdown of senescent RBCs in the

  A. Spleen, Liver and Kidney
* B. Reticuloendothelial system
  C. Spleen only
  D. Liver only

The main sites of destruction of RBCs are the liver and the spleen. However, mobile and fixed macrophages in the entire reticuloendothelial system participate. These include tissue macrophages in the liver (Kupffer cells), spleen and bone marrow. The lungs, lymph nodes, skin and subcutaneous tissue and brain (microglia) also participate. RBC breakdown results in the production of unconjugated bilirubin which binds to albumin and is transported to the liver where glucuronic acid is added to create conjugated bilirubin (that is soluble). The solubility of conjugated bilirubin allows it to be detected by diazo dye.

30) Diazo dye detects

A. Unconjugated bilirubin because it is insoluble
B. Unconjugated bilirubin because it is soluble
C. Conjugated bilirubin because it is insoluble
* D. Conjugated bilirubin because it is soluble

Conjugated bilirubin, produced in the liver from unconjugated bilirubin, reacts through a direct reaction with diazo dye because it is soluble. Unconjugated bilirubin, produced when RBCs are broken down in the RE (reticuloendothelial) system, reacts only through an indirect reaction with diazo dye because it is insoluble, thus needing an accelerator.

31) Bilirubin, in a healthy animal

A. If unconjugated, being a smaller molecule, will pass through the glomerulus
B. If conjugated, will not pass through the glomerulus
C. Is normally present in small quantities in urine
* D. Is not normally present in urine
E. Is never present in blood serum

In a healthy animal, bilirubin will not be present in the urine. If present, it will be only conjugated bilirubin as unconjugated bilirubin in the blood always travels complexed with albumin, thus too big pass through healthy glomeruli. Urine bilirubin is typically elevated prior to elevation in serum bilirubin and the appearance of jaundice.

32) The brownish color of feces is due to

A. Urobilinogen
* B. Stercobilin
C. Unconjugated bilirubin
D. Conjugated bilirubin

Stercobilin, responsible for the typical brown color of human feces, is created by bacterial action on bilirubin and subsequent oxidation. Unconjugated bilirubin does not enter the intestine. Conjugated bilirubin is reduced, by bacterial action in the intestine, into urobilinogen and stercobilinogen. Urobilinogen is reabsorbed, while stercobilinogen is oxidized to sterocobilin and excreted in feces.

33) Under conditions of hepatic lipidosis, a blood test could show the following

A. AST, ALT, Albumin normal; Bile acids higher than normal; Bilirubin lower than normal
B. AST, ALT normal; Bile acids, Bilirubin higher than normal; Albumin lower than normal
C. AST, ALT, Albumin and bile acids higher than normal; Bilirubin lower than normal
* D. AST, ALT, Bilirubin and bile acids higher than normal; Albumin lower than normal

When fat accumulates in hepatic cells, hepatocytes can rupture elevating AST and ALT. Fat accumulation could also result in bile duct blockage resulting in bile acids being higher than normal in the serum. Reduced liver function will result in higher bilirubin and low to normal albumin. Chronic disease of the liver would show similar results, barring those of bile acids which would closer to normal.

34) Peptides are broken down into free amino acids and di/tripeptides at the level of the

A. lumen of the stomach
B. membrane of the stomach
C. lumen of the small intestine
* D. membrane of the small intestine

Membrane bound peptidases are responsible for breaking peptides into di/tripeptides and amino acids. These enzymes are located within the enterocyte and on the membrane surface extending into the glycocalyx (the brush border).

35) Proteins can only be taken up by enterocytes in the form of amino acids

* A. False
  B. True

Enterocytes can absorb di/tripeptides and break these down with peptidases inside the cell. However, the bloodstream always receives amino acids, not di/tripeptides.

36) Which of the following statements is true”

  A. The stomach is the main site of protein digestion, gastric enzymes work in neutral pH
* B. The small intestine is the main site of protein digestion, pancreatic proteolytic enzymes work at neutral pH
  C. The stomach is the main site of protein digestion, gastric enzymes work at high pH
  D. The small intestine is the main site of protein digestion, pancreatic proteolytic enzymes work at low pH

The small intestine is the site of both luminal and membranous phases of digestion for proteins; the stomach has luminal phase of digestion only. In the small intestine, peptides are broken into di/tripeptides as well as amino acids; the stomach breaks down protein to peptides. The proteolytic enzymes in the small intestine are most active at pH 7-8, therefore neutralization of the acidic stomach contents is essential before digetion in the small intestine begins. Gastric enzymes work best at acidic/low pH.

37) Which of the following enzymes are found only in the small intestine?

  A. chymosin (rennin)
  B. pepsin
  C. intestinogen
* D. trypsin

Trypsin is a pancreatic proteolystic enzyme secreted into the lumen of the pancreas. Trypsin plays the role of “activator” in pancreatic zymogens (enzyme precursors) into functioning enzymes (eg. Chymotrypsinogen into Chymostrypsin). Note that trypsin's zymogen form, trypsinogen, itself needs to be activated by Enterokinase, secreted by intestinal crypts of Lieberkuhn. Pepsin and Chymosin are protein digesting enzymes in the stomach.

38) Which of the following is true concerning di/tripeptides and amino acids in the adult gut lumen-enterocyte interface

* A. they are cotransported with sodium
  B. they are actively transported by chloride transporters
  C. they are cotransported with bicarbonate
  D. they are absorbed by pinocytosis

They are absorbed by at least 4 different Na+ co-transporters on the apical side, while active transport of Na+ out of the cell via the Na/K pump occurs on the basal membrane side; therefore the essential Na gradient is maintained.

39) Which of the following is true regarding carbohydrate and protein digestion in the intestine?

* A. Carbohydrates must be absorbed only as simple sugars whereas proteins can be taken up as di/tripeptides and amino acids
  B. Proteins must be absorbed only as amino acids whereas carbohydrates can be taken up as disaccharides or glucose
  C. Both carbohydrates and proteins must be broken down to their basic building blocks (glucose and amino acid respectively) before they can be absorbed
  D. Carbohydrates can be taken up as di/trisaccharides and broken down into glucose within the enterocyte

Di/Tripeptides can be broken down to amino acids at the surface of the enterocyte OR can first be taken up within the enterocyte and then broken down to amino acids. Carbohydrates can only be absorbed as glucose.

40) Mammals can never absorb large peptides through the gut

* A. False
  B. True

Neonate mammals are able to absorb immunoglobulins (large proteins) found in colostrum because proteins are not digested by the neonate stomach and because of the ability of specialized enterocytes of the gut to pinocytose the large molecules.

The gut will be 'close' in about 24 hours after which specialized enterocytes are replaced by normal enterocytes.

41) The acute phase responder protein in horse and cows during an inflammation is:

  A. Enterokinase
  B. Albumin
* C. Fibrinogen
  D. Globulin

Fibrinogen is the acute phase responder of early inflammation in horses and cows. Acute phase responders differ between species. In the case of horses and cows, a change in the fibrinogen will be detected before a change in their while blood cell count. Enterokinase is a digestive enzyme secreted by the crypts of Lieberkuhn.

42) Relative hyperproteinemia refers to

  A. increase in albumin only
  B. increase in fibrinogen only
  C. increase in globulin only
  D. increase in the A/G ratio
* E. none of the above

The A/G ratio stays the same, but both albumin and globulin have increased. Hyperproteinemia is often a sign of dehydration