Biological Sciences MCAT Practice Items (AAMC)

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Q 1 B **P1, L6-7**

The mechanism of microfilament *polymerization* is the same for all cells, eliminating answer choice **A.** Depolymerization is not mentioned in either hypotheses, eliminating answer choice **D.** Hypothesis **A** (HA) does not specify the arrangement of the microfilaments at the edge of the cell so we cannot compare this structure for HA and Hypothesis **B** (HB). This leaves us with answer choice **B.**; since the 2 hypotheses are used to describe possible mechanisms for crawling cells, it is logical that they would differ on this point. HA postulates a contraction of myosin to drive the crawling force while HB suggests that microfilament polymerization generates the forward movement.

Q 2 C **deduce**

These types of questions usually provide 4 answer choices that *support* the hypothesis (in this case that actin and myosin interact), however, you must look for the one that, on its own, could lead you to the hypothesis. For example, answer choices **B.** and **D.** suggest that myosin has a role in the generation of the crawling force but do not give information on the mechanism of crawling. Since actin and myosin interact in muscle cells, an identical cellular arrangement may suggest a similar mechanism of interaction but this is not a **definite demonstration** of the interaction. The fact that isolated microfilaments

can generate the force only when myosin is present suggests a direct interaction between the two proteins (answer choice **C.**).

Q 3 A **P2, L2-7; BIO 5.2**

HA suggests a cellular arrangement and a mechanism of force generation similar to that of muscle cells. During muscle contraction, Ca^{++} released from the sarcoplasmic reticulum binds to troponin (small protein component of actin), resulting in a movement of tropomyosin to expose myosin binding sites. The interaction of myosin cross bridging heads with actin causes ATP hydrolysis, generating the force for microfilament contraction. Therefore, Ca^{++} availability controls the actin-myosin interaction.

Q 4 C **deduce**

There is no evidence in the passage that the myosin-actin and microfilament-plasma membrane interactions are related to depolymerization, therefore, the drug should not affect them. Answer choice **D.** is incorrect because the drug will not alter the rate of polymerization.

Q 5 A **P3, L3-7**

A force generated without polymerization goes against the notion of microfilament extension as the pushing force for crawling. Answer choices **B.** and **D.** support the hypothesis while answer choice **C.** has no bearing on HB.

Q 6 C **deduce**

For a nongrowing cell, the rate of addition of material at the leading edge (exocytosis) must equal the rate of removal of material at the trailing edge (endocytosis).

Q 7 D **P2; BIO 5.2**

You should be able to answer this question with a basic knowledge of muscle contraction (refer to Q3 above). The presence of Ca^{++} binding proteins will decrease the availability of Ca^{++} released by the sarcoplasmic reticulum, which in turn reduces the myosin-actin interaction.

Q 8 B **P2; BIO 13.1**

At low temperatures, humans can generate heat by shivering or by decreasing blood flow to the skin (vasoconstriction). The insulating effect of skin is altered by changes in blood flow; the blood vessels carry heat from the core of the body to the skin where heat is dissipated to the external environment. Vasoconstriction, controlled mainly by the sympathetic nerves, will decrease the amount of blood reaching the surface of the skin to conserve body temperature.

Q 9 C P3, L7-9

The scaly integuments of a reptile prevents desiccation under warm conditions because they provide a watertight barrier. A lower body temperature in reptiles is achieved by a decrease in the metabolic rate. On the other hand, amphibians possess sweat glands that provide them with the moist skin needed for cooling purposes and respiration. While both organisms will achieve physiological homeostasis (eliminating answer choices **B.** and **D.**), amphibians will have a higher rate of evaporative water loss.

Q 10 D P3, L3-7

This question requires some basic math. According to the passage, camels and kangaroo rats have the capacity to produce urine that is 8 and 12 times more concentrated than urine, respectively. If humans produce urine which is 4 times more concentrated as plasma and camels can double that capacity then camels can produce urine which is: $4 \times 2 = 8$ times more concentrated than plasma.

To gain overall body water, an organism needs to output urine which is more concentrated than plasma. Because humans have a urine concentrating capacity of 4 times the plasma concentration and seawater osmotic concentration with respect to plasma is 4 to 1, humans can only reduce the seawater concentration in the urine to that of the plasma. This means their body water levels would remain the same. Using the same logic, camels could produce urine from the seawater that is twice as concentrated as water, which in turn would lead to an overall gain of body water:

8 (concentrating capacity relative to human plasma osmolarity)/ 4 (osmolarity of seawater compared to plasma) = 2.

Kangaroos could produce urine which is three times as concentrated as water (12/4 = 3).

Q 11 C BIO 6.3.2, 6.3.5

During acclimatization to heat, the body becomes increasingly effective at maintaining a constant temperature because of an increase in the volume of sweat and an earlier onset of sweating. The sweat glands produce a solution close to the osmolarity of plasma,

however, aldosterone stimulates reabsorption of sodium into the blood via sweat-gland ducts near the skin surface, in a manner identical to sodium retention in the kidney (renin-angiotensin system).

Q 12 D BIO 10.3

The countercurrent multiplication system of the loop of Henle is a complex process that sets up a hyperosmolar medulla in the kidney that draws water out of the collecting ducts leading to a concentration of urine output. A longer loop of Henle leads to an increase in the hyperosmolarity of the medulla, which in turn, will cause more water to flow out of the tubules by osmosis. The final concentration of urine will remain the same for any given length of collecting tubules if the osmolarity of the medulla is constant (assuming a minimum length which allows the system to reach equilibrium).

Q 13 A P3, L7-9; BIO 5.2, 11.2

Calcium is required for smooth muscle contraction and an increase in muscle tone. You should be aware that this type of muscle is found in the iris, the wall of blood vessels as well as in the wall of hollow visceral organs (refer to BIO 11.2). Inhibition of Ca^{++} influx prevents vascular smooth muscle contraction and causes dilation of the peripheral arteries.

Q 14 A P3, L1-3

The passage clearly states that a slow Ca^{++} current develops during depolarization, which corresponds to phase 1 of the graph (look at the key below the graph!).

Q 15 D P1, L7-8; F1; BIO 5.2

Ca^{++} levels in the cell are determined by both the influx of extracellular Ca^{++} and the release of Ca^{++} by the SR. If levels of Ca^{++} are sustained in the SR, less Ca^{++} ions are available in the cytoplasm for MLCK activation. The pathway in Fig. 1 shows that lower MLCK activity will lead to a decrease in the activation of myosin light chains by ATP hydrolysis.

Q 16 C P3, L3-6

A regulatory protein influences (positively or negatively) the activity of other proteins. In this case, the Ca^{++}-modulin complex increases MLCK activity. Note that in this example, MLCK is a kinase (an enzyme that catalyses the transfer of phosphoryl between ATP and other molecules; BIO 4.6).

Q 17 C **BIO 5.2**

Cardiac muscle cells are attached by gap junctions in the intercalated disks. Ca^{++} influx into the cell causes rapid depolarization which propagates from cell to cell via gap junctions. If intracellular calcium is reduced by Ca^{++} antagonists, the heart rate will decrease because of a decrease in muscle contraction.

Q 18 C **BIO 6.3.3**

Parathyroid hormone raises both Ca^{++} and PO_4^{3-} blood levels by stimulating osteoclast activity.

Q 19 B **F1; BIO 5.2, 7.4, 11.2**

Stimulation of Ca^{++} channels would lead to an increase in cellular Ca^{++} levels. Fig. 1 indicates that Ca^{++} stimulates indirectly MLCK activity, ATP hydrolysis and muscle contraction. The contraction of arterial vascular muscle will cause a rise in the diastolic blood pressure (= minimal pressure during ventricle relaxation; BIO 7.4).

Q 20 D **BIO 10.3**

Calcium is an important component of the clotting cascade leading to platelet aggregation. High levels of blood calcium stimulate calcitonin release in order to return $[Ca^{++}]$ to homeostatic levels. The tubular reabsorption of phosphate is controlled by parathyroid hormone whose levels in the blood are dictated by Ca^{++} levels (B: BIO 6.3.3, 6.3.6, 7.5). The glomerular filtration rate is proportional to the blood and osmotic pressures (BIO 10.3), not Ca^{++} levels.

Q 21 B **P2, L4-6**

An increase in Ca^{++} stimulates MLCK activity, which in turn removes the inhibitory effect of myosin light chain kinase by phosphorylation.

Q 22 A **P4, L1-4; B: BIO 7.5, 8.2**

Upon activation by antigens, B cells differentiate into plasma cells that produce and secrete antibodies into the bloodstream. Antibodies belong to the family of proteins called immunoglobulins. Since the change in function is causing the alteration in the staining pattern, we can infer that the increase in acidophilia is due to the difference in

cell function between B cells and plasma cells (i.e. the formation of antibodies). The fact that many proteins are produced does not necessarily point to an accumulation of mRNA in the cell (the antibodies could be made from the same mRNA).

Q 23 D P2, L1-2; BIO 1.2.2

DNA is a double stranded helical molecule consisting of a sugar-phosphate backbone with pyridine and purine bases extending towards the interior of the helix. Under physiological conditions, the negative charge on the oxygen of the phosphate groups interacts with the positively charged basic dye.

Q 24 C deduce; BIO 1.2, 3.0

Like DNA, RNA molecules contain negatively charged phosphate groups that can interact with the basic dye to produce a basophilic area of a cell. There are 3 types of RNA: rRNA (found in ribosomes, made in the nucleolus), tRNA (found in the cytoplasm) and mRNA (made in the nucleus, migrates to the cytoplasm for protein synthesis). Answer choice **C.** is the only structure in the cytoplasm that contains RNA that could be degraded by RNAase.

Q 25 D P2, L1-2

This question is really asking: which of these answer choices is the most negatively charged molecule and hence will contribute the most to cellular basophilia by interacting with the positively charged basic dye? As explained in Q24, ribosomes are composed of negatively charged rRNA and proteins. The other 3 structures mentioned do not consist of negatively charged molecules.

Q 26 B P3, L2-7

Easy question! The answer is word for word in the text.

Q 27 C P3

In Q22, we deduced that the presence of proteins in the plasma cells caused an increase in cytoplasmic acidophilia. Similarly, in cardiac muscle cells, maturation involves the development of actin-myosin striations, proteins which will bind to negatively charged acid dyes and lead to acidophilic cellular areas.

Q 28 B P2, L1-2; B: BIO 1.2.2, ORG 12.5

Once again, this question is asking which of the following molecules is the most negatively charged (i.e. which will associate most strongly with the positively charged basic dyes). Although each of the molecules listed has the potential to be negatively charged depending on the pH of the environment, under physiological conditions, answer choice **B.** is the most charged as a result of the negative phosphate groups.

Q 29 A deduce

The nucleoplasm (medium which bathes the nucleus, analogous to the cytoplasm), chromatin and the rough endoplasmic reticulum are associated with strongly basophilic nucleic acids (*see* explanation to Q28). The Golgi apparatus located in the cytoplasm is responsible for packaging and secretion of proteins, which are less negatively charged than nucleic acids.

Q 30 D P2, L6-9; BIO 8.2, 15.2

According to the passage, antigenic shifts are measured by changes in the agglutination of the antigen-antibody complex. The fact that a pathogen becomes unable to agglutinate to the wild-type antibody reflects a **substantial** change in the surface protein of the antigen (termed antigenic shift). Antibody agglutination is used by the body as a means of defense against invading foreign organisms. The loss of antigen recognition by the antibody means that the pathogen can not be recognized and eliminated in this manner and the disease progresses. Answer choices **B.** and **D.** would not prevent agglutination because they reflect minor changes in the antigen structure, which should not affect binding. Both viruses and bacteria are potential pathogens (microorganisms that cause diseases when they infect a host).

Q 31 B BIO 15.5

This question requires knowledge of different types of mutations. A point mutation (alteration of a single base pair), a deletion mutation (deletion of a short DNA region) and a frame-shift mutation (the addition or deletion of one amino acid resulting in a shift in the reading pattern of the ribosome), will cause structural variations in the antigens. A *lethal* mutation will kill the pathogen.

Q 32 A BIO 1.2.2

DNA's semi-conservative mode of replication consists of the "unzipping" of the double stranded molecule to allow each parent strand to become a template for the polymerase.

The resulting daughter cells will contain one newly synthesized strand and one parental strand. In a mismatch, only one of the bases in a parental DNA pair is erroneous, therefore, only 1 cell of 2 will receive the mutated DNA.

Q 33 D deduce; B: BIO 2.2, 8.2

The bacterial cell wall is composed of a matrix of carbohydrates crosslinked by short polypeptides. The sugar moieties are responsible for triggering the antigen-antibody response in the host.

Q 34 C P2, L9-11; P3, L3-6

The question is asking: which of the following would lead to the greatest antigenic shift or the least amount of agglutination? The passage indicates that antigenic variation due to multiple genes will not affect the level of agglutination and that a slow mutation rate will cause a *slow* decrease in agglutination. An increase in the severity of the disease (answer choice **D.**) does not necessarily give us information about the antigenic shift of the pathogen. Answer choice **C.** is correct because a rapid rate of mutation will likely allow the antigenic shift to be of sufficient magnitude to escape agglutination with the antibody, thereby conferring a survival advantage to a pathogen.

Q 35 C deduce

Once again, the question is asking: which choice will represent the greatest antigenic shift? Recombination of different viral genomes will result in high changes in antigenic structure because of newly formed genetic combinations. This is more likely to cause an epidemic than single or multiple mutations because of an assumed greater overall change in the antigen gene sequence.

Q 36 B BIO 4.7; F IV.A.4.4

Acetate is converted to acetyl-CoA and enters the Kreb's cycle in the mitochondria.

{Recall: cellular *respiration* refers to the oxidation of organic molecules; BIO 12.1}

Q 37 D ORG 9.4, 9.4.1, 12.4

The formation of fatty acids (components of lipids) occurs through the condensation of C_2 units derived from acetate.

Q 38 C BIO 4.3, ORG 12.2.2

The tertiary structure of proteins is temperature sensitive; at higher temperatures, a breakdown in protein structure will cause enzyme inefficiency and a decrease in metabolism and growth.

Q 39 D F1

By looking at the **shape of the curves** on Day 3, we see that in general, the rate of biosynthesis of lipids at the end of the experiment is less than or equal to the rate at the beginning of the experiment, for a given ambient temperature curve. Conversely, on Day 14, the initial rate of lipid production is usually lower than the final rate for a given ambient temperature. From these observations, we can conclude that the bacteria experience a decrease in metabolic rate with increasing temperature on Day 3 while they shift to an increase in metabolic rate with increasing temperature on Day 14. In other words, the bacterial population on Day 14 prefers higher temperatures while the bacterial population on Day 3 thrive at lower temperatures.

Q 40 B PoE

This question can be answered using the process of elimination. If the aeration system malfunctions, the bacteria are surrounded by a reducing milieu so answer choices **A.** and **C.** can be eliminated (oxidizing implies oxygen is present in the environment). The major product of carbohydrate catabolism in the absence of oxygen is pyruvate, not ammonia (BIO 4.5). Protein catabolism will lead to the formation of ammonia and pyruvate or acetyl-CoA (F IV.A.4.4; BIO 10.1)

Q 41 B P2, L1-3; BIO 2.2

The terms anaerobe and aerobe describe the requirements of the metabolism of the organism (BIO 2.2). An aerobe requires O_2 while an anaerobe does not. The terms strict vs. facultative specifies the conditions in which the organism can survive. A strict anaerobe can only thrive under anaerobic conditions while a facultative anaerobe can survive in the presence or absence of oxygen. In this example, the spores of the bacterium cannot germinate in an environment of high O_2 tension so the bacterium is referred to as a strict anaerobe.

Q 42 A P1, L1-2; BIO 4.3, 9.3

The protein responsible for the symptoms of the disease, tetanospasmin, would be inactivated by gastric peptidases. The low pH in the stomach tends to destabilize the tertiary structure of proteins, leading to deactivation. Answer choice **B.** is incorrect

because O_2 tension prevents germination of *spores* but does not affect the proteins produced by the bacillus.

Q 43 D P2, L4-6; P3, L1-2; BIO 6.1

According to the passage, the toxin works at the level of the spinal cord to cause rigidity and spasms of skeletal muscles. The consciousness centers are located in the brain stem and therefore are out of the toxin's reach.

Q 44 C P3, L4; B: BIO 11.2

Since tetanus causes rigidity and spasms of skeletal muscle, a relaxant could be used to alleviate the symptoms of mild disease. An antibiotic would not affect the toxin of the bacteria already present in the body.

Q 45 C P3, L1-2; B: BIO 5.1, 11.2

The neuromuscular junction consists of the terminal portion of a motor axon (eliminating answer choices **A.** and **B.**) facing the motor end plate, where it releases the neurotransmitter acetylcholine (BIO 5.1). The symptoms of tetanus describing skeletal muscle spasms and rigidity suggest retrograde migration of the toxin through the axons of motor neurons. The movements can be explained by irregular firing of action potentials in the motor neurons.

Q 46 C P2

The trypanosome protozoan is successful in killing the host because it has a large bank of VSG genes, any of which can be activated at any time during infection to avoid recognition by antibodies specific to a particular VSG. Vaccination is used to induce the production of antibodies against a pathogen by injecting a dead or non-infectious form of the disease. A vaccine in this case is not plausible because antibodies raised for one type of VSG would be avoided by the production of a different VSG on the surface coat of the trypanosome.

Q 47 C P1, L1-6

Easy question. The answer is word for word in the text.

Q 48 D P2, L1-4

The trypanosomes in the original infection, having identical VSGs, are 99% eliminated by the host's antibodies. In order to survive, trypanosomes have evolved a mechanism whereby the remaining 1% of their population activate a different VSG gene. The expression of a type of VSG incapable of being recognized by the antibodies produced for the original infection allows the protozoan to multiply. There is no direct contact between the antibodies and the VSG genes (eliminating answer choices **B.** and **C.**) nor are the antibodies capable of altering their protein structure.

Q 49 B deduce

The observation that antibodies recognize one specific type of VSGs suggests a change in structure of this antigen such that the VSG binding site no longer "fits" the antibody binding site.

Q 50 A deduce; B: Ap C

To test the hypothesis that the expression is due to different genes, we would compare genes, not chemical differences or amino acid sequences.

Q 51 B P1, L3; BIO: 15.1, 15.3

CF is a recessive autosomal gene, which means that both copies of the gene must be present in an afflicted child. The mother and father are necessarily carriers of the disease (if they had 2 alleles, they themselves would be affected; if they had 2 normal alleles, the child would not be affected) which means they have one normal allele and one CF allele, resulting in a DNA reaction with both probes.

Q 52 A P2, L2-4

Postural (= positional) drainage is used in the treatment of CF to remove mucus from the lungs by clapping the back of patients lying on their stomachs so that mucous plugs are expulsed through the mouth.

Q 53 D BIO 6.3, 6.3.3, 9.3, 9.4.2, 13.3

As a rule, exocrine glands secretions exit epithelial surfaces by way of ducts while endocrine glands (or ductless glands) secrete hormones that diffuse into the bloodstream. Answer choices **A.** and **C.** are examples of exocrine glands while the pancreas is both an endocrine (secretes glucagon and insulin into the bloodstream) and exocrine gland (secretes digestive enzymes). Only the thyroid has no ducts.

Q 54 **C** **deduce**

In order to determine that heterozygotes have a selective advantage, we would have to show that the biological activity of the gene product is beneficial to the organism. Structural information gives no insight on the effects of the allele.

Q 55 **A** **P3 , L7-13; BIO 1.1.2; B: BIO 5.1.1/2/3**

Recall that active transport requires the input of energy while facilitated diffusion does not (BIO 1.1.2). Transmembrane conductance suggests the transmission of electrical current across the plasma membrane (BIO 5.1.1/2/3), which implies the transport of ions (eliminating answer choices **B.** and **C.**). The fact the CF protein binds ATP on the cytoplasmic side of the cell supports a model of active transport of ions where ATP hydrolysis provides energy to form the electrochemical gradient.

Q 56 **D** **deduce**

The two observations suggest that individuals with CF have a high level of ACH in their saliva. If we add ACH to normal individuals, we get a CF phenotype. If we decrease ACH levels in CF individuals, we get a normal phenotype. Therefore, abnormal saliva from CF individuals contains a high level of ACH, which can be obtained by a decrease in hydrolysis of extracellular ACH. Answer choices **A.**, **B.** and **C.** would shift the composition of the CF saliva towards a normal type, low ACH-level saliva.

Q 57 **B** **BIO 9.4**

Hepatocytes produce and release bile (composed of water, cholesterol, pigments and salt) into the duodenum by way of the common bile duct. The pancreas releases digestive enzymes, among other things, into the common bile duct via the pancreatic duct. The bile emulsifies fat for eventual digestion while the digestive enzymes break down fat, carbohydrates, nucleic acids and proteins. The common bile duct releases its juices into the duodenum, the first section of the small intestine.

Q 58 **B** **BIO 4.4**

The end products of aerobic metabolism are CO_2 and H_2O. A reduced blood supply would lead to an accumulation of CO_2, which is cleared by the circulation to avoid cellular damage. Lactic acid is formed from the reduction of pyruvate under anaerobic conditions.

Q 59 C **deduce; BIO 7.3, 7.4**

Blood pressure is higher in the arteries because blood vessels offer resistance to flow when blood travels from the arteries to the veins. Therefore, in the circulatory system, the pressure at a later point will always be less than the pressure at an earlier point. Although answer choices **A.** and **B.** are true facts about the venous system (steady blood loss and higher volume of blood), the main factor for rate of blood loss is pressure.

Q 60 A **BIO 6.1.4, 13.1**

The majority of nerves in the arterioles are under sympathetic (vasoconstrictor nerves) control. Dilation and constriction of these vessels is accomplished by a decrease and a increase in sympathetic activity, respectively. The application of heat to the skin causes a reflex inhibition of sympathetic nerves to the skin that leads to vasodilation of the arterioles and an increase in flow.

Q 61 A **deduce; BIO 1.1.1, 6.3.1/2**

Fluid diffuses from a region of low solute concentration to a region of high solute concentration toward the equilibrium of an isosmotic environment. In hypovolemic shock, blood volume is lost (P1), which will turn on mechanisms to preserve water and electrolytes (ADH - BIO 6.3.1, aldosterone - BIO 6.3.2). Once the concentration of electrolytes becomes higher than usual in the circulation, the fluid will flow out of the cells to dissipate the gradient (BIO 1.1.1). The failing of the sodium-potassium pump would cause the membrane potential to fall to zero, allowing ions to equilibrate across the plasma membrane over a long period of time and causing eventual cell death.

Q 62 B **P3, L3-8; BIO 4.4, 5.1.1**

Under normal conditions, $[K^+]_{\text{inside cell}} > [K^+]_{\text{outside cell}}$ and $[Na^+]_{\text{inside cell}} < [Na^+]_{\text{outside cell}}$. The Na^+/K^+ pump works to maintain these concentration gradients by pumping 3 Na^+ out of the cell and 2 K^+ into the cell during one cycle driven by the energy of ATP hydrolysis.

In this example, the switch to anaerobic metabolism means that the cell is now producing much less ATP for a given period of time (aerobic metabolism = 36 ATP/glucose; anaerobic metabolism = 2 ATP/glucose). Therefore, the efficiency of the pump will decrease leading to less K^+ being pumped into the cell and an increase in K^+ flowing out of the cell, down its concentration gradient. Note that under physiological conditions, the cell is somewhat permeable to K^+ ions and relatively impermeable to Na^+ ions.

Q 63 **A** **BIO 4.5**

During anaerobic metabolism, pyruvate is reversibly reduced to lactic acid, which builds up in the tissues until oxygen is readily available and aerobic metabolism can resume.

Q 64 **C** **P2, L2-4**

During early hypovolemic shock, the initiation of the sympathetic reflexes causes activation of the vasoconstrictor nerves in the arterioles, leading to a decrease in blood flow. See the explanation for Q60.

Q 65 **A** **P2, L1-2; L6-10; B: BIO 5.4.4**

The passage states that a balance of the activities of the 2 cell types in response to stress (defined in P1) results in **continual** bone remodeling. The stresses described in P1 are consistent with everyday function.

Q 66 **A** **P3, L1-2; B: PHY 6.2.1**

The fact that fractures occur most often from tension than compression underlines the higher compressive strength of the bone.

Q 67 **C** **P3, L4-6; L11-13; B: BIO 5.4.4, 6.3.3**

PTH increases osteoclast activities of absorption and removal of bone, which results in weaker bones.

Q 68 **B** **P1, L2-5; P2, L2-6; B: PHY 6.2.1**

It is apparent from the arrows in the diagram that there is a tension or stretching force on the positive-potential surface (left side) and a compressive force on the right, negative-potential surface. It is very important to pay attention when diagrams are given in the passages because answers are often contained within them.

Q 69 **A** **P2, L4-6**

A prolonged deficiency in Ca^{++} would cause a decrease in bone density over time. Similarly, abnormally high osteoclast activity, that is, an increase in removal and absorption of bone, would likely lead to weak or brittle bones.

Q 70 B **BIO 5.4.4, 6.3.3**

Answer choices **A.**, **C.** and **D.** would all have the same effect on bone and can therefore be eliminated. Bone is composed of a frame of organic molecules upon which calcium phosphate molecules are deposited. Resorption of bones by osteoclasts releases calcium and phosphate into the circulation.

Q 71 B **P1, L2-3; P3, L1; B: PHY 6.2.1, BIO 11.3.3**

The passage states that tension causes fractures more often than compression. Since tension in this context is defined as stretching due to the pull of muscles, the greatest effect will come from muscle pulling on bone through their connecting tendon. You should know that ligaments link bone to bone while tendons link muscles to bone (BIO 11.3.3). Answer choices **C.** and **D.** can be eliminated because smooth muscle is not associated with bone (*see* BIO 11.2).

Q 72 D **P3, L5-7**

The passage states that the repair cells replace the clot with collagen and matrix material that eventually become mineralized to form the bony callus. The use of the word "eventually" implies that the cells do not themselves provide the callus material, eliminating answer choice **C.**

Q 73 A **deduce**

Answer choice **D.** is irrelevant because the question is comparing cows and humans per unit body weight. Cows are herbivores whose diet consists mainly of cellulose (the main carbohydrate component of plants, ORG 12.3.3) while humans consume varying proportions of proteins, fat and carbohydrates (F IV.A.4.4). Since the digestion of fat produces more energy than carbohydrate digestion per unit weight (i.e. there are many calories in fat!), humans can meet their energy requirements by eating less food than cows because of the higher content of fat in their diet.

Q 74 D **P1, L11-13**

The soft feces reingested by the rabbit (via crophagy) are high in vitamins and digestible protein. It is probable that this technique is used to increase the absorption of these useful products by allowing a second passage in the digestive tract.

Q 75 D **P3**

The passage states that the microbial population in the cows and rabbits create bacterial proteins that are the **equivalent** of the essential amino acids of humans, implying the lack of these bacteria in humans.

Q 76 D P1, L1-4; P2, L1-3

The question is asking: what is the main difference stated in the passage with regard to digestion by microbial fermentation? By comparing the structural organization of cows and rabbits, we see that cows have 3 extra chambers, which would lead to a longer fiber-retention time in the tract.

Q 77 C P 3

The nonprotein (eliminating answer choice **D.**) molecule urea is not broken down in humans; it is used to eliminate nitrogenous wastes and exits the body in the urine (eliminating answer choices **A.** and **B.**; BIO 10.1). Since both cows and rabbits use the microbial populations to produce the equivalent of essential amino acids, it is most likely that humans lack these microorganisms.

Q 78 D P1, L3-7; P2, L5-7

Synapsin anchors vesicles to microtubules and microfilaments near the presynaptic membrane where they undergo exocytosis in response to elevated Ca^{++} levels.

Q 79 C P1, L2-3; L8-9; B: BIO 5.1.1/2/3

Since Na^{+} influx causes depolarization and K^{+} efflux causes hyperpolarization, the neuron will retain the ability to undergo both processes. However, Ca^{++} channel blockers will prevent Ca^{++} from entering the cell.

Q 80 A deduce; B: BIO 5.1.1/2/3

The depolarization of a neuron is *necessary* for synaptic transmission, eliminating answer choice **D.** The diffusion of neurotransmitters across the synaptic cleft to the post-synaptic membrane requires additional time compared to direct electrical transmission. The process is unidirectional because (1) the vesicles fuse with the presynaptic membrane during exocytosis, rendering them unavailable to take back the neurotransmitters and (2) the neurotransmitters diffuse away from the membrane upon release.

Q 81 D **deduce**

Answer choices **A.** and **B.** provide no information with regard to function. The best evidence that the protein is *necessary* for the process is to show that without it, exocytosis cannot occur. Answer choice **C.** shows that the presence of synapsin increases the rate of exocytosis, however, it does not demonstrate that the protein is essential for the process.

Q 82 B **P2, L9-11; B: BIO 5.1**

The passage defines exocytosis as fusion of the vesicle with the presynaptic membrane (excluding answer choices **B.** and **D.**) as a result of elevated Ca^{++} levels in the cytoplasm (excluding answer choice **A.**).

Q 83 A **P2, L5-9; B: BIO 5.1**

The passage states that synapsin anchors the vesicles to microtubules and microfilaments. Since elevated levels of Ca^{++} are required for the release of the vesicles from the cytoskeleton prior to exocytosis, it is plausible that the binding of the vesicles prevents their fusion with the membrane and that a lack of the protein may lead to premature release of vesicles.

Q 84 A **deduce**

By removing the electrical component of the process, we can accurately control the levels of Ca^{++} in the cell to study the effects on exocytosis. When electrical stimulation is present, we are unable to determine the factors affecting the rate of exocytosis because too many variables are present (Na^{+} depolarization versus Ca^{++} influx).

Q 85 D **P2, L4; P3, L2**

The answer can be deduced from the information in the text. The passage states that: (1) ganglionic blockers are nerve blockers and (2) multiunit smooth muscle stimulation is neurogenic (i.e. smooth muscles are stimulated by nerves). Therefore, it is likely that the contractions (caused by nerves) are blocked by nerve blockers.

Q 86 C **deduce; BIO 5.1.2/3**

You should be aware that the initiation of an action potential is an all-or-none phenomenon, which means that despite the fact that cells have their own characteristic

thresholds, once the cells have reached that threshold, the action potential generated always has the **same magnitude.**

Q 87 C P2, L4-8

The smooth muscles are myogenic (eliminating answer choices **A.** and **B.**) and react to mechanical stretching. In this case, the ureter - the tube connecting the renal pelvis to the bladder (BIO 10.1) - responds to mechanical stretching caused by urine.

Q 88 B P1, L2-8; BIO 11.2

The passage indicates that smooth muscle is characterized as having the capability for low-energy contractions (eliminating answer choice **A.**) and a basal resting tension. In other words, muscles are never completely relaxed and have a resting tension that results in muscle tone (BIO 11.2).

Q 89 A deduce

Since both responses are elicited by the same neurotransmitter, it is logical that the difference in the process lies in a step following exocytosis (i.e. the *types* of receptors that are binding to acetylcholine). Answer choices **C.** and **D.** are not plausible because if the response was random or uncontrollable, we should be able to observe both responses (inhibition and excitation) in the same muscle fiber over a period of time.

Q 90 B F1

By examining Fig. 1, we see that 21-hydroxylase, represented by 21*, catalyses a critical step (meaning there are no alternative pathways leading to the product) for both aldosterone and cortisol formation. If this enzyme is deficient, the intermediates will be diverted to the pathway of androgen production. You can view this easily by crossing out (or hiding with your hand) all the steps subsequent to 21* catalysis.

Q 91 C P2, L10-14; B: BIO 14.8, 15.1

The passage indicates that the phenotypic sex of the embryo usually corresponds to the genotype but that the level of androgens determines the development of the genitalia. If cortisol levels are normal, the sex of the embryo corresponds to its genotype.

Q 92 B F1

If we cross out all the steps following 17* in the diagram, the only pathway remaining is that of aldosterone. Therefore, the increase in progesterone (female sex hormone) in this pathway and the absence of testosterone (male sex hormone) in the 3rd pathway, will lead to feminization of the fetus.

Q 93 D F1

This is essentially the same question as Q92. Note that answer choice **C.** is incorrect because the lack of cortisol production resulting from 17* deficiency will not affect the sexual phenotype of the embryo.

Q 94 A P2; L2-3; BIO 15.1, 15.3

CAH is an autosomal recessive disease. If the child is to be affected with CAH, a copy of the recessive CAH allele must be inherited from each parent. In this case, all the children will be carriers but none will be affected by CAH. WARNING: The concept of autosomal recessive diseases repeats itself an unlimited number of times on the MCAT exam!

Q 95 B P2; L1-2; P3; B: BIO 6.3.1

Osmolarity is defined as the total concentration of a solute in solution. Drinking a large quantity of water will decrease the osmolarity of the blood by increasing the amount of solution for a given concentration of solute. In turn, a decrease in osmolarity sensed by the hypothalamic osmoreceptors leads to a decrease in vasopressin secretion. Since vasopressin acts on the distal tubule to increase permeability of the membrane to water, a decrease in vasopressin will cause an increase in water excretion in the urine.

Q 96 D deduce

Under normal vasopressin concentrations, the renal distal tubule's permeability will allow equilibration of the concentrations of urine and plasma. In this case, water will flow the plasma (high concentration of solute) to the urine (low concentration of solute) until they are isosmotic.

Q 97 A P3; B: BIO 6.3.6

A negative feedback loop is a common mechanism in hormonal regulation to maintain homeostasis:

$$\downarrow \text{water excretion} \rightarrow \downarrow \text{plasma osmolarity} \rightarrow \downarrow \text{vasopressin} \rightarrow$$

↓ permeability of the renal tubular cells → ↑ water excretion

In this case, the initial decrease in water excretion feedsback in the pathway to inhibit the earlier step of the release of vasopressin. This will lead to an eventual increase in water excretion.

Q 98 D P2, L1-2; L8-10

The salt solution will increase the osmolarity of the blood, which in turn will stimulate release of vasopressin by the pituitary gland. The permeability of the renal tubules will increase and water will flow from the urine to the blood (↓ urine flow, ↑ urine osmolarity, i.e. *concentration*).

Q 99 C P2, L1-5

Vasopressin is released when the plasma osmolarity is high. Following consumption of large amounts of fluid, the plasma osmolarity falls and the release of vasopressin is inhibited. Answer choices **A.** and **B.** would lead to an increase in plasma osmolarity.

Q 100 C E1; BIO 4.5, 4.7

Oxidation involves the loss of electrons while reduction involves the gain of electrons. In redox (oxidation-reduction) reactions involving 2 molecules, one reactant is oxidized while the other is reduced after a transfer of electrons (CHM 1.5.1; BIO 4.7, 4.8). In this case, NAD^+ gains 2 electrons to form a bond with H^+ while ethanol loses 2 electrons to go from a hydroxyl to an aldehyde functional group (*see* CHM 6.1 and 7.1 for structures). It should be noted that in biochemical terms, oxidation is associated with a loss of H^+ or a gain of O, while reduction involves the gain of H^+ or the loss of O.

Q 101 D BIO 6.1.4

The majority of parasympathetic fibers, responsible for the "vegetative" response, pass through the vagus nerve.

Q 102 A E1; E2; P3, L3-5

The high ratio of NADH to NAD^+ will drive the equilibrium in the equation for the formation of lactic acid to the right, in accordance with Le Chatelier's principle (CHM 9.9). The equilibrium will shift to reduce the high concentration of the reactant NADH to “normal” levels.

Q 103 **B** **E1; deduce; B: BIO 4.1/2/3**

We know from Equation 1 that ethanol is a substrate for the enzyme and the question tells us that methanol is also a substrate. If addition of ethanol to the medium where methanol is already present leads to the inhibition of the methanol pathway, we can conclude that the enzyme prefers ethanol as a substrate. If the substrates bind to different catalytic sites or have the same affinity for one binding site, we would expect some production of formaldehyde (assuming binding of the substrates is independent and the rates of reactions are similar).

Q 104 **C** **P1, L5-7**

The passage states that ethanol acts as a central nervous system depressant which means that stimulatory effects must be the result of the depression of inhibitory pathways from these centers. Logically, a pathway can be activated by increasing stimulation or decreasing inhibition.

Q 105 **B** **P1, L11; B: BIO 7.3/4**

An increase in heart rate and cardiac contractility will lead to an increase in blood flowing from the heart to the lungs (cardiopulmonary circulation; BIO 7.3) and an increase in systolic pressure of the aorta (BIO 7.4). Recall that the pulmonary artery does *not* contain oxygenated blood, eliminating answer choice **A.**

Q 106 **D** **P3, L6-8; B: BIO 2.1**

The release of the growth-promoting factor outside of the cell is indirectly promoting the growth of the virus by preparing cells for future replication of the virus.

Q 107 **B** **P2, L1-5; B: BIO 2.1**

The replication of the DNA genome of vaccinia is unusual because many of the known viruses use the replication machinery of the host cell to duplicate their own DNA. The vaccinia genome contains the genes necessary to carry out replication and consequently, the virus does not depend on the host's replicative enzymes for the production of virions.

Q 108 **A** **deduce**

Active immunization is defined as the injection of an antigen to induce an immune response (the production of antibodies), as opposed to **passive immunization**, which is the injection of the antibodies directly into the host. If the virus induces active immunity against smallpox, it must contain an antigen similar enough to smallpox that the antibodies produced by the host in response to vaccinia recognize the smallpox antigen.

Q 109 A P3, L2-3

The passage indicates that vaccinia *redirects* the cell's energy towards producing more virions which implies that the cellular mRNA translation must be stopped (not maintained) in order to use the mRNA to produce virus proteins.

Q 110 B deduce

A parasite by definition is an organism that is sustained by a live host. The word "obligate" (cf. last paragraph BIO 2.2, 3rd paragraph BIO 10.3) in this context implies that the host is necessary for the parasite to survive and replicate.

Q 111 D deduce; B: BIO 2.1

When viruses are incubated on a lawn of cells (in active laboratory structures) they produce clear viral plaques which represent areas of host cellular death. During the late phase of the infectious cycle, the infected host cell lyses and releases the virions that attack the surrounding cells to repeat the cycle. Each plaque represents one virus' progeny, therefore, we can estimate the number of viruses in the original solution by counting the number of plaques.

Q 112 C F1

Don't panic when you see biochem diagrams! It usually helps to understand the passage if you follow the diagram as you are reading the information.

From Fig. 1, we see that the 2 sources of biotin are the diet and the hydrolysis of biocytin. If we remove the biotinidase step, we are left with dietary biotin, a source that can be increased to compensate for the lack of the enzyme.

Q 113 A F1

The question is asking for the most direct way of measuring the formation of products of the biotinidase reaction. Since biocytin is the substrate of the enzyme, the best way to

measure the activity of the enzyme is to incubate it with the plasma and to measure the product, biotin.

Q 114 D F1

From the diagram:

$$\text{apocarboxylases} + \text{biotin} \rightarrow \text{holocarboxylases}$$

Since this is the only pathway leading to the formation of holocarboxylases, the lack of apocarboxyalses would result in a deficiency of holocarboxylases.

Q 115 B BIO 1.2.1

Lysosomes contain proteases and other degradative enzymes. The Golgi body packages proteins and releases secretory vesicles.

Q 116 B F1

Apocarboxylase is the only molecule in the list whose synthesis is independent of the biotin cycle and avidin inhibition. Therefore, it is least likely to be deficient as a result of high levels of avidin.

Q 117 C P2, L5; BIO 15.1, 15.3

Since the disorder is an autosomal recessive trait, the child must inherit a defective allele from each parent to be affected. The probability of the child inheriting the allele from the afflicted parent is 1 (because this parent is homozygous for the defective allele) while the probability of receiving the defective allele from the heterozygous parent is 1/2. Therefore, the overall probability is: $(1 \times 0.5) \times 100\% = 50\%$.

Q 118 D BIO 9.3; B: BIO 4.3, ORG 12.2.2

The pH of the stomach is very low (approx. = 2) because of the HCl secreted in the gastric juices. Therefore, biotinidase would be inactivated after ingestion due to the disruption of its tertiary structure by the acidic environment.

Q 119 A F1

A biotinidase-deficient child will have a high level of biocytin and protein-bound biotin and a low level of free biotin. Biotin will enter the biotin cycle to form the various intermediates while biocytin will accumulate, having no alternate path other than biotinidase hydrolysis.

Q 120 A F1; P2, L1-2

Protein synthesis first occurs in the 3rd step of Fig. 1 with the expression of the early genes. Therefore, only adsorption, which occurs prior to protein synthesis, will be unaffected by the antibiotic.

Q 121 C F1

The only step that involves the site of integration of lambda DNA is answer choice **C.**, so it will be the only process affected by this deletion.

Q 122 B deduce; B: BIO 1.2.2

Because circularization of the phage genome involves binding of 2 **complimentary** DNA ends of the virus, cleavage of the nucleotides will prevent the ends from annealing because they will no longer "match."

Q 123 C P3

Deletion of the excision proteins would block excision completely. If the repressor binds to DNA more tightly, the frequency of its removal will decrease (but not be inhibited completely) and consequently the excision frequency will decrease.

Q 124 A P4, L1-3; B: BIO 2.1

The mutant phage, necessarily in the lysogenic pathway (since the question states it is unable to grow lytically), would not have a mutation in the site coding for the integration proteins since these are required for the lysogenic pathway.

Q 125 D F1; deduce; BIO 1.1, 1.2

By looking at Fig. 1, we see that the virus is adsorbing to the exterior (outer membrane) of the cell. You should know that as a rule, receptors in the plasma membrane are proteins, not lipids.

Q 126 D P3, L6-7; B: BIO 2.1

Following virion production during the lytic cycle, the cell wall is broken down and the progeny are free to infect surrounding cells. During the lysogenic cycle, this enzyme must be suppressed because the virus requires an intact host cell to reproduce once it enters the lytic cycle.

Q 127 C F1; T1

The antigen concentration is determined by obtaining the % antibody-bound radiolabelled antigen for Patient 1 from Table 1 and finding the x-value that corresponds to that number on the y-axis.

Q 128 A P3, L5-9

If the antibody binds to both antigens, the amount of displacement of the radioactive antigen bound to the antibody will increase, leading to a lower % bound on the y-axis and consequently, a higher concentration on the x-axis.

Q 129 B deduce

To produce the most specific antibody, we look for a part of the protein that is unique so that we reduce the chances of encountering interfering antigens during a RIA.

Q 130 D T1; P1, L7-9

The patient with the lowest amount of radioactive antigen bound to the antibody has the highest level of non-radioactive antigen displacing it, in this case, testosterone. Testosterone will displace the radioactive antigen, which results in a decrease in radioactive binding.

Q 131 D deduce

In RIA, the labeled antigen is formed by making one (or more) of the atoms in the unlabeled antigen radioactive. Therefore, the antibody should have the same affinity for both molecules since they are essentially similar in atomic structure.

Q 132 C **T1; P1, L5-9; B: BIO 6.3.4**

If the patient has not eaten for a long time, his glucose levels will drop causing a decrease in insulin with a concomitant increase in glucagon. If the RIA represents insulin serum levels, the patient with the highest labeled antibody-bound antigen (Patient 4) will have the lowest insulin levels. His serum will contain the least amount of insulin available to displace the labeled insulin in the assay.

Q 133 B **F1; deduce**

The antibodies produced for RIA cannot distinguish between active and inactive biological molecules, that is, they will bind equally to both molecules if the same antigenic region is present.

Q 134 A **deduce**

If the molecules are too small to elicit antibody production, attachment to a larger carrier molecule (which itself does not produce antibodies) will allow stimulation of antibody production and RIA quantification. Answer choice **C.** is incorrect because if the molecules are attached to each other, the antibodies produced may recognize a part of the polymer that is not present on the monomers, leading to erroneous results.

Q 135 A **P3, L5-8**

Insulin-like growth factor is an example of an interfering antigen because its structure resembles the insulin molecules to such an extent that the growth factor can bind to the antibodies whose production was elicited by insulin.

Q 136 A **F1**

Curves B and C show that glucose is the substrate preferred by the bacterium since CO_2 production (and therefore lactate metabolism) begins during the second phase of growth, after all the glucose has been used up. In addition, the fact that there is absolutely no CO_2 production in the first phase indicates that the presence of glucose represses lactose metabolism.

Q 137 C **BIO 2.2; B: Ap A.4.2**

Most bacteria reproduce asexually by binary fission, which they undergo every 10-20 minutes, leading to exponential growth.

Q 138 B P3, L5-7; B: BIO 3.0

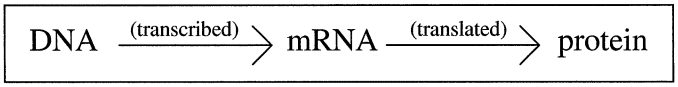
The passage indicates that when lactose is present, large quantities of the enzyme B-galactosidase are produced by the bacterial cells. Therefore, it is likely that the addition of lactose leads to the transcription and translation of the B-gal gene.

Q 139 C F1

Based on Curve A, we cannot determine that the bacteria will undergo another growth cycle. In fact, it is unlikely that this will occur since there is a limited amount of nutrients in the medium and the toxic metabolic wastes released by the cells will accumulate and lead to cell death.

Q 140 C deduce; BIO 3.0

On the Surface: The question asks about the regulation of protein synthesis. First, let's summarize protein synthesis:



If you consider the above as a reaction, regulation *must* occur either at the transcription stage (DNA → mRNA; answer choice **C.**) or the translation stage (mRNA → protein; answer choice **D.**). Of course, it's safe to bet on "DNA → mRNA" since: (i) DNA is the cell's architect (BIO 1.2.2); (ii) DNA regulates the cell cycle (BIO 1.3); (iii) DNA can be directly stimulated to regulate intracellular processes (BIO 6.3).

Going Deeper: In addition to the proteins necessary for lactose metabolism, the lactose operon (operon = a cluster of genes transcribed together under the control of one promoter on the mRNA) encodes for a repressor protein. When lactose is absent from the cell, the repressor is bound to the DNA regulatory sequence and prevents transcription of the lac mRNA. If lactose is present in the medium, it acts as an inducer by binding to the repressor and causing its release from the DNA. The genes for lactose utilization can now be transcribed and translated.

Q 141 A P3, L3-5; BIO 4.5/6/7/8/9

The radiolabelled lactose will be split into glucose and galactose before entering the glycolytic pathway (note that galactose will be converted into the glucose-6-phosphate intermediate of glycolysis; B: BIO 4.5). To find the compounds that will be radiolabelled, we look for *intermediates* of glycolysis, the Kreb's Cycle or the electron transport chain (not co-factors or co-enzymes like NAD and the cytochromes). Only answer choice **C.** contains three intermediates of these pathways.

Q 142 C **BIO 2.2**

See explanation for Q137.

Q 143 B **deduce; BIO 1.1**

To study changes in the cell membrane, we examine changes in the properties of the membrane. The plasma membrane is composed mainly of lipids (including phospholipids and glycolipids) and proteins (including glycoproteins). Answer choices **A.** and **C.** would detect changes in the molecular structure of the membrane while answer choice **D.** is a study of the permeability of the membrane. RNA molecules are not usually associated with the membrane, making answer choice **B.** the least useful in determining changes in the cell membrane.

Q 144 C **P4, L4-6**

In multicellular animals (like us), there is unidirectional transfer of genetic information from a donor cell to a recipient cell such that the recipient cell retains all the necessary genetic information to replicate.

Q 145 B **P3, L1-2**

Cilia are hairlike projections used for different purposes in animals (BIO 1.2). In protozoans such as *Tetrahymena,* cilia propel cells in aqueous environments. The process of co-stimulation requires cellular movement to increase the probability of pair formation by collisions between cells.

Q 146 A **deduce**

If we assume that the cells require 30 min for co-stimulation, then the initiation process will have taken (75 - 30 = 45) 45 min instead of the initial 70 min stated in P2. Therefore, it is plausible that a part of the process of initiation has been retained because the cells require less time to complete this stage of reproduction.

Q 147 A **P3, L7-9; P4, L2-4; BIO 1.3**

During anaphase, sister chromatids are pulled apart and migrate to opposing sides of the cell, guided by the microtubules. The kinetochore microtubules shorten at their +ve ends to pull the chromatids apart while the nonkinetochore microtubules elongate to push the centrosomes further apart so that each will be part of the daughter cells formed in

telophase. Although the passage does not state this directly, it is unlikely that the nonkinetochore microtubules will shorten because this would result in the centrosomes coming closer to the center, making it difficult to form 2 daughter cells.

Q 148 C deduce; F1; P1, L4-6; B: BIO 1.2, 1.3

The fact that plant and animal mitosis can occur without centrioles suggests that centrioles are a non-essential part of cell division and that other structures can successfully take over their role in the process. In addition, it is clear from Fig. 1 and P1 that the centrosome is the microtubular organizing center.

Q 149 C P3, L5-9

The opposing forces stabilize the microtubules (until they pull apart in anaphase, eliminating answer choice **A.**) and ensure that one sister chromatid goes to each end of the cell. A one-sided pulling force would lead to genetic abnormalities in the daughter cells caused by unequal distribution of the chromosomes.

Q 150 B F1; P1, L10-12; P3, L1-2; B: BIO 1.3

The passage indicates that the growing kinetochore microtubules become stabilized by attaching to the kinetochores of chromatids. Because the question is asking for the microtubule action responsible for the array of microtubules and chromosomes, answer choice **C.** is incorrect.

Q 151 A P1, L4-6

The polarization of the molecules allows organization of the protein molecules into polymers such that they can undergo rapid elongation or shortening. Unpolarized protein subunits do not "fit together" as well and cannot undergo dynamic polymerization required for mitosis.

Q 152 D deduce

If the process remains the same in the species spanning the evolutionary tree, it is plausible that the genes have remained largely unchanged during evolution. Answer choice **C.** can be ruled out by looking at Q148 which states that plants (eukaryotes) lack centrioles or by assessing that the question does not contain enough information to imply that the genes must be the same in **all** eukaryotes.

Q 153 D F2; ORG 1.4, 4.2.1, 5.2, 10.2, 11.2

A resonance structure is obtained by shifting electron positions on the original structure, while leaving the overall charge and molecular formula unchanged. Answer choice **A.** is incorrect because of an additional positive charge (which implies that an electron pair has been removed from the system) while answer choice **C.** is the result of the removal of a hydrogen atom. Answer choice **B.** is incorrect because 2 electrons have been removed from the system (one pi bond). Answer choice **D.** is the result of the lone pair on the neutral N in the imidazole ring forming a double bond while the other N retrieves its lone pair from the double bond already in place (cf. amides, BIO 11.2).

Q 154 B deduce; cf. Q140

In general, organisms regulate the expression of genes by controlling the rate of transcription of the gene via regulatory sites on the DNA (*see* the explanation for Q140).

Q 155 D deduce; P1, L9-10; BIO 6.3.2, 6.3.5

Angiotensin II is a vasoconstrictor that stimulates the release of aldosterone thereby causing an increase in blood pressure. Only answer choice **D.** would decrease blood pressure by increasing urine output.

Q 156 A P1, L6-7

A noncleavable analog of angiotensin I will compete for the angiotensin I binding site of the enzyme. An increase in ACE-analog complex will lead to a decrease in the availability of the enzyme to carry out the cleavage reaction thus reducing the concentration of the product angiotensin II.

Q 157 D deduce; BIO 1.2.1, 3.0

The presence of an increase in ribosomes available to carry out translation of the ACE enzyme supports the hypothesis that hypertension is caused by an overproduction of a protein (i.e. the ACE enzyme).

Q 158 D deduce; BIO 3.0; ORG 12.2.2

Hypothesis B suggests that a structural defect resulting in an increase in reaction rate is responsible for the higher turnover of substrate. The level of mRNA has no bearing on the structure of the protein transcribed from it. The primary structure of a protein is

determined by its amino acid sequence (determined by the DNA gene sequence) while the secondary structure is the result of local folding within the protein.

Q 159 D ORG 3.1

The IUPAC name indicates that the amino group is bonded to a tert-butyl and a methyl group. Therefore, C_4H_9 must represent tert-butyl, whose structure is shown by answer choice **D.**

Q 160 C deduce; CHM 4.2(3.); ORG 1.5

When a chemical bond is made up of atoms of different electronegativity, a polar bond is formed as a result of slight pulling of electron density by the most electronegative atom. As a result of this charge separation, dipole-dipole interactions can occur between hydrogen atoms bonded to strongly electronegative atoms (N, O, F) and lone pairs on electronegative atoms in other molecules. In this question, answer choice **C.** is incorrect since C is not sufficiently electronegative to induce enough polarity to lead to hydrogen bonds. Thus the structure will not contribute to the water solubility of albuterol.

Q 161 B ORG 7.2.1; 8.2

$NaBH_4$ in step 2 reduces the ketone group to an alcohol. Note that reduction is the gain of electrons that are donated in this example as part of the hydride ion (H^-) from $NaBH_4$. You must be able to quickly recognize $LiAlH_4$ (powerful) and $NaBH_4$ (milder) as important reducing agents.

Q 162 D ORG 10.2

The question is asking: which of these hydrogens is the most acidic? The most acidic hydrogen, and therefore the one most easily extracted by the strong base NaOH, will be the hydrogen bound to the most electronegative atom. Since electronegativity increases as we go up a column in the periodic table (CHM 2.3F), oxygen is the winner. Furthermore, you should recognize that albuterol is a derivative of a phenol, which is well known for its acidic hydrogen (ORG 10.2).

Q 163 A ORG 4.2.3

In Step 3, the benzyl group bound to the amino group is cleaved with the help of H_2 gas and a metal catalyst. The reaction is called "hydrogenation" and can use many different metals (i.e. Ni - nickel, Pd - palladium, Pt - platinum). This reaction is referred to as

heterogeneous catalysis since there are 2 phases present in this step [gas (H_2) and solid (Pd)].

Q 164 D P2, L3-4; ORG 7.2.1, 8.2

The passage indicates that $NaBH_4$ typically reacts with aldehydes and ketones (P2). In the reaction provided, the reactant contains a ketone that will be reduced to form an alcohol.

Q 165 B Figure; ORG 11.1

The tertiary amino group (N is bound to 3 non-hydrogen groups) of the reactant for step 3 is reduced to a secondary amino group (the N is bound to 2 non-hydrogen groups).

Q 166 B Figure; ORG 2.2

The only carbon in albuterol that is bound to 4 different substituents is the one that was initially reduced from a ketone to an alcohol in Step 2.

Q 167 C ORG 9.4

The hydrolysis of an ester yields an alcohol and a carboxylic acid. Since the alcohol portions remain bound to the benzene ring after Step 1, two molecules of acetic acid have been released.

Q 168 D deduce; E1

Even with limited knowledge about the hydrolysis of the glycoside, you can usually deduce these questions by comparing reactions. In Equation 1, **methyl-α-D-**glucopyranoside is hydrolyzed to **methanol** and both **α**- and **β-D**-glucopyranose. In the same manner, **phenyl-α-D**-glucopyranoside will be hydrolyzed to **phenol** and both isomers of **D**-glucopyranose.

Q 169 A E1; T1

Since both glycosides contained the same aglycone and both reactions occurred at the same temperature, answer choices **D.** and **B.** can be eliminated. In the diagram, we see that the most stable chair conformer contains the methoxy group in the equatorial position. As a rule, the bulkier group on the ring is most stable on the side of the ring (equatorial) rather than above or below the ring (axial) because this minimizes electron

repulsion with the other groups in the ring (ORG 3.3; F IV.B.12.1). The only plausible answer is that there is repulsion between the lone pairs of the oxygens. If the molecule is more unstable, hydrolysis will be faster because the reactant will have a higher energy and will require less input of energy to overcome the activation energy of the reaction (B: CHM 9.5; 9.7).

Q 170 B E1; T1; CHM 9.6/8/9

The reaction is as follows:

$$\text{glycoside} + H_2O + \text{Heat} \rightarrow \text{methanol} + \text{sugars}$$

Using Le Chatelier's principle (CHM 9.9), we can increase the reverse reaction by removing the reactants (glycoside or H_2O), **or** increasing the concentration of the products (aglycone or sugars) **or** by lowering the temperature. The addition of HCl (the catalyst) will increase the rate of the reaction by lowering the energy of activation, however, the equilibrium of the reaction will be unchanged (CHM 9.8). Increasing the reaction time may allow the reaction to reach the thermodynamic equilibrium (if it had not already done so in the original experiments; B: CHM 9.6) but the equilibrium itself will be not be affected.

Q 171 D deduce; CHM 9.7; ORG 7.2.2

Because the passage states that HCl is present in *catalytic* amounts, we know that it accelerates the rate of the reaction without itself being consumed. The mechanism of the reaction is the same as for non-cyclic acetals (ORG 7.2.2). Glycosides are cyclic acetals (P1). In other words, it is the proton (H^+) not the halide (Cl^-) which serves as the catalyst. Since Cl^- is not involved in the reaction, it cannot be regenerated, eliminating answer choice **C.**

Q 172 A ORG 12.3.1

When a linear sugar molecule becomes cyclic, the two possible diastereomers formed are termed anomers. The hemiacetal or the hemiketal carbon is the anomeric carbon (ORG 12.3.1; F IV.B.12.1).

Q 173 D deduce; T1

There are too many variables in this experiment to determine anything about the effect of temperature on the rate of hydrolysis. Ideally, we would compare the relative rate of hydrolysis of the same reactant at two different temperatures. In this case, the general higher rates of hydrolysis at the lower temperature could be due to temperature and/or differences in the structures of the reactants.

Q 174 B T1

The iodine value represents the amount of iodine absorbed by 100 g of fat. We know from the diagram that one I_2 molecule is absorbed by each double bond.

In essence:

$$\uparrow \text{iodine value} = \uparrow \#\text{ double bonds.}$$

If we are attempting to lower saturated fat from our diet, we should use the compound with the highest number of double bonds (i.e. the highest degree of unsaturation and the highest iodine value).

Q 175 D Diagram; ORG 2.1

According to the mechanism shown in the passage, the iodine atoms add from opposing sides of the molecule. In a linear molecule, addition to the double bond cannot yield a *trans* product because the single bonds rotate in space. However, the bonds in cyclic molecules are rigid and the addition of iodine above and below the molecule to **adjacent** carbons will give us a *trans*, saturated alkane product.

{For more information regarding the mechanism of reaction, *see* the explanation for GS-3, Passage IV, Questions 164-168.}

Q 176 D Diagram; ORG 2.1

For carbon atoms, an sp^2 hybridization state corresponds to a carbon with 3 bonds (one double +2 single bonds), an sp hybridization corresponds to a carbon with 2 bonds (one triple and one single bond) while an sp^3 hybridization represents a carbon with 4 bonds (4 single bonds). The diagram shows that C_1 in the fat sample has 3 bonds, while C_1 in the intermediate and in the iodinated fat sample has 4 bonds.

Q 177 A deduce

The purple color in the solution is caused by the presence of the halides (P3). With this in mind, if a fat sample added to the purple solution becomes colorless, this suggests a disappearance of the halides in solution, which in turn would lead us to reasonably conclude that an equal or an excess amount of fat is reacting with the IBr solution.

Q 178 C T1

Table 1 represents the amount of iodine absorbed by the fat sample. By going backwards from Step 3 to Step 1, we get a better idea of the purpose of the experiment:

$$\uparrow[I_2] \text{ in Step 3} = \uparrow[IBr] \text{ in Step 2} = \downarrow [I_2] \text{ reacted in Step 1}$$

$$= \downarrow \text{unsaturation} = \downarrow \text{iodine value.}$$

Therefore, a low $[I_2]$ absorption in Step 1, an increase in [KI] (which in turn will increase [I_2 in Step 3]) and large amounts of IBR (which means $\uparrow[I_2]$) unreacted in Step 1 will lead to a low iodine value. The small amounts of thiosulfate needed to reach the end point means a low $[I_2]$ in Step 3 and consequently, a high degree of unsaturation.

Q 179 C Diagram; ORG 1.3.1

The trend in bond lengths (make sure you memorize this!) is:

Longest Single bond > Double bond > Triple bond **Shortest**

Q 180 B deduce

As explained in Q178, an increase in I_2 reacting in Step 1 (in this example, with the impurities) will lead to an increase in the perceived unsaturation of the molecule. Excess KI will lead to an increase in I_2 in Step 3, which will decrease the perceived unsaturation of the molecule.

Q 181 D P2, L4; L6; B: ORG 13.2

Carboxymethyl cellulose is a negatively charged column which binds positively charged proteins, causing them to be retained until the charges are neutralized by pH or by washing with salt solution. If the mystery protein is not retained, it is likely that it has an overall negative charge repulsed by the ligand, causing it to elute from the column without a salt gradient.

Q 182 D P2, L2-9; B: ORG 13.2

Ion-exchange chromatography separates molecules according to charge, irrespective of their molecular weights, thereby eliminating answer choices **A.** and **B.** The stationary phase will consist of one charge (either +ve or -ve) and will retain molecules of the opposite charge. Therefore, if two negatively charged molecules are introduced in the column, they will both be retained if the column charge is +ve, or they will both elute

without a salt gradient if the column charge is -ve. Note that if the salt gradient is gradually increased, the proteins will elute from the column at different times, however, this is not as efficient as answer choice **D.**

Q 183 B deduce

The smaller a protein, the more pores it can fit into, the longer it will be "stuck" in the column. The largest proteins will be unable to fit in most of the pores and will exit quickly because their path down the column is relatively uninterrupted. A longer column will allow an increase in separation of the proteins because there will be more pores to trap more proteins.

Answer choice **A.** would have no effect because this process is independent of charge. A larger sample would decrease the efficiency of the experiment because the pores may become saturated while a faster flow rate may not allow sufficient time for proteins to enter the pores.

Q 184 B deduce

The salt molecules will disrupt the interaction between the molecules and the stationary phase because the +ve and -ve ions of the salt will interact with the opposing charges in the column, thereby reducing the strength of the binding of the molecules to the stationary phase.

Q 185 D P2, L5

At first glance, we see that a molecule similar to the positive ligand mentioned in the passage, diethylaminoethyl cellulose, is present in the list. However, since the question asks which compound would have the **greatest affinity**, we have to check the other answers. The passage states that carboxymethyl is a negatively charged ligand, therefore we can assume that at a low pH, at best, this ligand will be neutral (the negative charge will be neutralized by a proton; cf. ORG 12.1.2). Answer choice **C.** has a similar structure to carboxymethyl and will behave in a similar manner. Answer choice **A.**'s hydroxyl group will be protonated (and therefore neutral) at a low pH.

Q 186 A deduce; B: ORG 13.2

A sieve column separates molecules on the basis of molecular weight. If Protein A was composed of peptide chains joined by disulphide bonds, the presence of a compound which breaks those bonds would produce molecules of smaller molecular weight which should elute at a slower rate than the intact protein.

Q 187 D deduce; B: ORG 13.2

In gel chromatography, we assume that proteins are migrating according to their molecular weights. This question is best answered through elimination. Answer choices **A.** and **C.** can be eliminated because they relate to ion-exchange chromatography. The results show that molecular weight is inversely proportional to elution rate, which means that the statement is an experimental observation, not an assumption. We have to assume that the effect of molecular shape on migration is negligible. In fact, the experiment is more accurate if the proteins are first denatured before entering the column such that we eliminate the variable of shape. In theory, shape could be a substantial problem; for example, a circular protein of 30 kDa may not enter a pore that fits a linear 50 kDa protein because of its bulk.

Q 188 C deduce; B: ORG 13.2

Proteins of unequal molecular weight should elute at different rates down the column unless both of them are too large to enter any pores at all. Answer choice **D.** is irrelevant because the number of amino and carboxyl groups would affect charge, not molecular weight. Answer choice **A.** is incorrect because the total molecular weight of the protein is important, not the distribution of weight within the molecule.

Q 189 D Experiment 2; ORG 6.2.3

Since the reaction involves the substitution of a hydroxyl group by a bromine group, answer choices **A.** and **B.** can be eliminated. The rate-determining step (RDS) of an S_N1 reaction is the formation of the carbocation following the release of the leaving group (H_2O). An S_N2 reaction involves the attack of the nucleophile (Br^-) on one side of the molecule with concomitant release of the leaving group (H_2O) on the opposite side, leading to an inversion of configuration if the carbon under attack is chiral. Note that 1 and 2 designate unimolecular (1 molecule in the RDS) and bimolecular reactions (2 molecules in the RDS), respectively. In this case, since a relatively unstable primary carbocation (recall for stability of carbocations: tertiary > secondary > primary > methyl) would be formed by the release of water in an S_N1 reaction, the one-step S_N2 reaction is favored.

Q 190 B P5, L1-3; deduce; ORG 6.2.4 (P6)

The passage states that Experiment 2 proceeded via protonation of the hydroxyl followed by the release of H_2O. As a rule, neutral molecules (like H_2O) are more stable that charged molecules (like OH^-) in solution, making answer choice **B.** correct. In S_N2 reactions, the rate is dependent on the nucleophilicity of the attacking group (Br^-) and the stability of the leaving group (OH^- vs. H_2O). For the substitution to occur, the leaving

group must be more stable that the group coming in to replace it. Since Experiment 1 does not occur in an acidic milieu, an S_N2 reaction is not favored because Br^- is a better leaving group (more stable) than OH^-. Br is a larger molecule that can accommodate the negative charge better than oxygen.

Q 191 C P5, L1-3; ORG 6.2.4 (P6)

The moral of the passage is that the reaction is favored in an acidic environment because of protonation of the OH^- molecule, rendering a more stable leaving group, water. Only the answer choice **C.** contains an acid (sulfuric acid).

Q 192 C ORG 6.2.3

See explanation to Q189. You should be able to rank the stability of the carbocations:

answer choice **C.** > answer choice **B.** > answer choice **A.** > answer choice **D.**

Q 193 B deduce; ORG 6.2.3

The RDS of an S_N1 reaction is the formation of the carbocation. Therefore, all other steps in the process will have faster rates.

Q 194 D ORG 6.2.3

Answer choices **A.** and **C.** can be eliminated because:

(a) the molecules do not contain a secondary carbon and

(b) even after carbocation formation, there is no potential for rearrangement to a secondary carbocation for a molecule with only 2 carbons (answer choice **A.**) or for a molecule that is already a stable tertiary carbocation (answer choice **C.**).

The word pure in the question means that the student is trying to minimize side reactions. Answer choice **B.** could proceed with rearrangement from a secondary to a more stable tertiary carbocation (analogous to the reaction in Experiment 3). Only answer choice **D.** would lead to a secondary alkyl halide because the secondary carbocation formed would not rearrange to a less stable primary carbocation.

Q 195 A ORG 6.2.1

Under conditions of high temperature and acid, alcohols will undergo dehydration to yield alkenes; therefore, we can quickly eliminate answer choices **C.** and **D.** To discern between the two leftover choices, we must consider the mechanism of the reaction. The first step (like in Experiment 2), involves the protonation of the hydroxyl group to form H_2O, a better leaving group. To distinguish between answer choices **A.** and **B.**, we have to ask ourselves this question: will the H extracted to form the alkene come from the methyl carbon (the C to the left of the carbocation) or from the secondary carbon (the C to the right of the carbocation)? As a rule, elimination will yield the **most substituted** double bond. To determine this, count the number of non-hydrogens bound to the 2 carbons in the double bonds (ORG 4.2.1, 6.2.4). Answer choice **A.** has 3 groups (3 methyls) while answer choice **B.** has only 2 groups (one methyl, one ethyl), making answer choice **A.** correct.

Q 196 C deduce; B: ORG 6.1

The first thing to do for these types of questions is to DRAW the structures. Answer choices **A.** and **B.** are incorrect because the compounds are structural isomers (ORG 2.1), which mean they have the same molecular weight and density (mass/volume). We can't assume that boiling of the samples will lead to a carbocation intermediate unless the question specifies that the conditions are favorable for this reaction to occur. Hydrogen bonds lead to an increase in the interaction of molecules and since boiling requires the input of energy to break these intermolecular bonds:

$$\uparrow \text{hydrogen bonds} = \uparrow \text{energy input to break them} = \uparrow \text{boiling point.}$$

The hydroxyl group in 2-methyl-2-propanol is bound to a tertiary carbon, as opposed to a primary carbon in 1-butanol. Consequently, it will be less exposed to other molecules for hydrogen bond formation as a result of the bulky methyl groups surrounding it, and will boil at a lower temperature.

Q 197 A deduce

In you would rather memorize, in general: HI > HBr > HCl. Since the reaction is S_N2 (recall that there is no carbocation intermediate), the rate will be dependent on both the leaving group and the nucleophile. In this case, the leaving group is the same in both cases so the difference in rate must be accounted for by the difference in nucleophiles. If Cl^- can't displace Br^-, it must be a weaker nucleophile.

Q 198 B Diagram; F1; deduce

Fig. 1 shows that the addition of ADA to Compound C results in the formation of a ketone group in Compound D from the amino group on the six-membered ring in

Compound C. The amino group on the six-membered ring of adenosine should react in a similar fashion to yield answer choice **B.**

Q 199 C P2, L5-6

Since $POCl_3$ reacts with oxygen-containing compounds, the hydroxyl groups on the sugar must be protected by acyl groups to prevent their chlorination, a step that is subsequently reversed in the reactions leading to the production of Compound C. $POCl_3$ reacts with the ketone group on the six-membered ring but not with the esters on the sugar (although this is also oxygen-containing) because the ester carbonyl group is less susceptible to nucleophilic attack than the ketone groups as a result of the extra oxygen in an ester which can donate its lone pair during resonance (*see* ORG 8.1).

Q 200 A BIO 1.2.2; ORG 12.5

The backbone of DNA and RNA molecules is composed of sugar (DNA = deoxyribose, RNA = ribose) linked by phosphodiester bonds. During replication and transcription, nucleotides must form phosphorylated intermediates before they can be incorporated into the growing nucleic acid chain.

Q 201 D deduce

This question is a gift! Just compare the structures.

Q 202 B ORG 7.1

Keto-enol tautomerism is common in biological molecules. The enol form (**en** = double bond, **ol** = alcohol) will contain an oxygen (either in the form of O^- or OH) attached to a carbon by a single bond. In turn, this carbon will be sp^2 hybridized; that is, it will be attached to one atom by a double bond, as shown by answer choice **B.** Answer choice **C.** is incorrect because the carbon at the junction of the rings violates the octet rule (it has 10 valence electrons).

Q 203 B BIO 1.2.2; deduce

Since the sugar moiety in guanosine and Compound D are identical, answer choice **C.** and **D.** can be eliminated. During replication, the bases of the new "daughter" strand will bind to the template via hydrogen bonds. Recall that there are 3 hydrogen bonds between the G-C base pair and 2 hydrogen bonds between the A-T base pairs.

Q 204 D BIO 1.2.2; F IV.B.12.1; F1

The two main difference between the chemical composition of DNA and RNA are: (1) RNA contains a hydroxyl group on the 2' position of the sugar while DNA does not and (2) RNA contains the pyrimidine base uracil instead of thymine found in DNA. The removal of the 2' hydroxy on the ribose of Compound D would allow it to be incorporated into DNA. Answer choices **A.**, **B.**, and **C.** would result in compounds whose structures are even more diverse than Compound D's, making it increasingly unlikely that they could be part of the DNA structure.

Q 205 C ORG 9.4

An ester group (RCOOR') was formed in the reaction.

Q 206 C F1

Answer choices **A.** and **B.** are incorrect because a base will accept rather than donate a proton. Since $POCl_3$ is added to a step after the addition of the base (note that the base is not added in this step), answer choice **D.** can be eliminated. This reaction requires a basic medium because it involves the nucleophilic attack of the alcohol groups of the sugar on acetic anhydride. The hydrogen of the alcohol is slightly acidic (because of the electronegativity of oxygen) and will tend to be extracted under basic conditions, leaving a more nucleophilic O^-, and thus increasing the rate of the reaction. The acetic acid produced by the reaction will lower the pH of the medium unless a base is present to neutralize it, making answer choice **C.** correct.

Q 207 C P1, L3-7

The passage indicates that a carbanion results after the treatment of Compound I with BuLi, thereby eliminating answer choices **A.** and **B.** A stabilization of the product of a reaction will lead to a shift in the equilibrium favoring the products because the energy of activation to go from product to reactant will increase, making the reverse reaction more unfavorable. The sulfone group stabilizes the carbocation by resonance structures formed from the negative charge delocalizing between the C-S-O atoms.

Q 208 B T1; P2, L4-5; deduce; B: ORG 13.2

By looking at the percentages on Table 1 that correspond to Trial 4, we should have 3 peaks of similar area: Product A = 36%, Product B = 43%, Product C = 0% (no peak) and Compound I = 21%. According to the retention times in P 2, Compound I should exit

first (so the first peak on the graph is the smallest representing 21%), followed by Product A, and Product B. Only answer choice **B.** fits this profile. Answer choice **D.** is incorrect because there are 4 peaks present.

Q 209 D T1; Diagram

This is a two part question. The first thing to do is to identify which of the alkyl halides will react to give the highest Product A/Product B ratio, giving us the least amount of Product B contamination. From Table 1, we see that Trial 1 yielded the highest ratio. Now we have to answer this question: Which structure represents the Product A of a reaction between the alkyl halide from Trial 1 and Compound I? From the diagram, we know that when an alkyl halide is added to Compound I, the alkyl group will replace one of the hydrogens on the methyl group. Answer choice **D.** corresponds to this structure.

Q 210 B deduce

In order to obtain a disubstituted product, we need to extract a second hydrogen from Product A with a base, and react the resulting carbanion with a second equivalent of alkyl halide. Answer choice **A.** is incorrect because two negative charges on the carbon will yield a highly unstable molecule (due to electron repulsion) and thus this reaction is unfavorable.

Q 211 A T2

Table 2 represents the ratio of monoalkylation to dialkylation for various reactions. Therefore, the smallest ratio on Table 2 will represent the largest dialkylation to monoalkylation ratio. In the answer choices given, the smallest ratio of Table 2 corresponds to the reaction of the unsaturated alkyl halide (CH_2=$CHCH_2Br$) with BuLi (1.6:1).

Q 212 D T1

Table 1 indicates that Product B is the major product in Trial 4. To obtain the structure of Product B, replace the R groups in the diagram of Product B with the alkyl portion of the alkyl halide from Trial 4 (alkyl portion $\rightarrow C_6H_5CH_2^-$).

Q 213 A deduce

In methyl ethyl sulfone, the two hydrogens on the secondary carbon in the ethyl portion will be the most acidic (because their extraction will yield a more stable, secondary carbanion) followed by the 6 primary hydrogens on the terminal carbons. We know from

the diagram that this reaction can lead to multiple products. The reaction involving Compound I can yield 3 products because of 3 available hydrogens. Similarly, the reaction with methyl ethyl sulfone has the potential of yielding 8 products because of the 8 protons available for extraction by BuLi.

Q 214 B Diagram; P2, L2-5; ORG 12.4

Oleic acid is a *cis* (because the 2 groups with the highest priority are on the same side of the bond; ORG 2.1) unsaturated acid or oil, which can be reduced with hydrogen to yield stearic acid, a solid.

Q 215 D Diagram; P3, L2-5; ORG 9.4.1

Saponification involves the hydrolysis of the ester in glyceryl trialkanoate to yield glycerol and the salt of the fatty acid. This is essentially the hydrolysis of an ester into an alcohol and a carboxylic acid, except we remove the terminal hydrogen from the RCOOH portion of the carboxylic acid and form a salt with a sodium ion, yielding $Na^{+-}OOCR$. The products, when Compound 2 undergoes saponification, are glycerol and the sodium salt of stearic acid (*see* ORG 9.4.1).

Q 216 A P4, L4-6

The passage indicates that phosphoric acid can be esterified by the alcohol choline. Only the molecule represented in answer choice **A.** is an alcohol that can exist.

{Note the unreasonable number of bonds to phosphorus in answer choice **D.**}

Q 217 B deduce; B: ORG 9.4.1, 12.5; BIO 1.1

The salt of a fatty acid contains a polar region consisting of sodium bound to the unprotonated carboxyl group of the fatty acid, and a nonpolar region consisting of the fatty acid hydrocarbon chain. The polar region of the soap is soluble in water while the nonpolar region is insoluble in water but soluble in organic materials. Therefore, the soap molecule forms a type of molecular bridge between water and grease such that the grease will now be suspended in the solution (and can therefore be "cleaned" from surfaces by the soapy water).

Q 218 C Diagram; ORG 1.5

The phosphate-choline group on carbon 3 is considered polar because it contains 2 charges, despite the fact that the overall charge of this neutral molecule is zero.

Q 219 A deduce

Since saturated compounds have a higher molecular weight than the corresponding unsaturated compounds (because of the two extra hydrogens necessary to go from a double bond to a single bond), answer choices **C.** and **D.** are incorrect (recall that density = mass/volume). Answer choice **B.** is incorrect because a higher susceptibility to hydrogen bonds would lead to an increase in intermolecular interactions, and a shift from a liquid state toward the solid state. The *cis* double bond disrupts the orderly arrangement of a solid crystal lattice (ORG 4.1).

Q 220 D P2, L2-5

Hydrogenation of an unsaturated liquid fat would convert it to a saturated solid fat at room temperature (cf. ORG 4.2.3). The melting point of a solid is higher than that of a liquid (think about it: at room temperature, the liquid has already melted but the temperature must be increased in order for the solid to melt). Heating or cooling a substance does not change its melting/boiling point.

Q 221 B Diagram; ORG 2.2

Recall that a chiral carbon is attached to 4 different groups. Only carbon 2 fits this criterion.

Q 222 C Diagram

The question is really asking: which of these bonds is not present in the structure of a glyceryl trialkanoate. Therefore, to monitor the conversion of glycerol into a fat, we look for the disappearance of the hydroxyl peak, which is present in glycerol but is esterified to form the glycerol trialkanoate.

Q 223 D deduce

The acid will neutralize the salt according to the following equation:

$$RCOO^-Na^+ + H^+Cl^- \rightarrow RCOOH \text{ (carboxylic acid)} + NaCl \text{ (salt)}$$