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QUESTION 1

Many nutrients required by plants exist in soil as basic cations:

Mg²⁺, Mn², and Ca².

A soil\\'s cation-exchange capacity is a measure of its ability to adsorb these basic cations as well as exchangeable hydrogen and aluminum ions. The cation-exchange capacity of soil is derived from two sources: small clay particles called micelles consisting of alternating layers of alumina and silica crystals, and organic colloids.

A13+

Replacement of + and + by other cations of lower valence creates a net negative charge within the inner layers of the micelles. This is called the soil\\'s permanent charge. For example, replacement of an atom of aluminum by calcium within a section where the net charge was previously zero, as shown below, produces a net charge of ?, to which other cations can become adsorbed.

-		
0 ²⁻ A1 ³⁺ OH-	\rightarrow	0 ²⁻ CA ²⁺ OH ⁻

Figure 1

A pH-dependent charge develops when hydrogen dissociates from hydroxyl moieties on the outer surfaces of the clay micelles. This leaves negatively-charged oxygen atoms to which basic cations may adsorb. Likewise, a large pH-

dependent charge develops when hydrogen dissociates from carboxylic acids and phenols in organic matter.

In most clays, permanent charges brought about by substitution account for anywhere from half to nearly all of the total cation-exchange capacity. Soils very high in organic matter contain primarily pH-dependent charges. In a research study,

three samples of soil were leached with a 1 N solution of neutral KCl, and the displaced A13+ and basic cations measured. The sample was then leached again with a buffered solution of BaCl2 and triethanolamine at pH 8.2, and the

displaced H+ measured. Table 1 gives results for three soils tested by this method.

Table 1



	(meq/100 g)				Total
	pН	Al ³⁺	Basic Cations	H+	Exchange Capacity
Sample I	4.5	11.7	1.9	34.0	47.6
Sample II	5.3	1.6	16.3	19.5	37.4
Sample III	6.0	0.5	9.8	7.8	18.1

Due to the buffering effect of the soil\\'s cation exchange capacity, just measuring the soil solution\\'s pH will not indicate how much base is needed to change the soil pH. In another experiment, measured amounts of acid and base were added to 10-gram samples of well-mixed soil that had been collected from various locations in a field. The volumes of the samples were equalized by adding water. The results were recorded in Figure 2.

Figure 2.



Which soil from Table 1 most likely has the highest percentage of organic matter?

A. Sample I

- B. Sample II
- C. Sample III



D. Cannot be determined

Correct Answer: A

According to the passage, soils that are high in organic matter contain primarily pH-dependent charges. These are formed when hydrogen dissociates from the hydroxyl moieties of organic acids or alcohols. The pH-dependent charge is represented in the table by the column for H+, which was removed by leaching with a basic solution. When looking at the table, we see that sample I has far more than half its ion exchange capacity accounted for by pH-dependent charges. Samples II and III have roughly half of their total ion exchange capacity accounted for by pH-dependent charges. Therefore, sample I probably has the highest percentage of organic matter in it, choice A.

QUESTION 2

In the early nineteenth century a large number of communal experiments, both secular and religious, sprang up in the northeastern United States. Perhaps the most famous secular commune was Brook Farm, founded by transcendentalists George Ripley and William H. Channing to promote the pursuit of leisure and culture through the proper application of time and labor. Its members (among the more notable were Nathaniel Hawthorne and Margaret Fuller) pursued field labor by day, art and philosophy by night. For a time the system worked so well that two afternoons a week were set aside for leisure and Brook Farm began outcompeting local farmers at the produce market. But by nature the Farm\\'s members were thinkers, not workers; despite their success they remained mainly interested in the theoretical and philosophical implications of the experiment. Thus, when a devastating fire brought the community considerable financial burdens in its fifth year, the members felt little compunction about closing shop and returning to their comfortable Boston homes.

One of the most notable religious utopias was the Oneida community. Its founder, John Humphrey Noyes, believed that Christ\\'s second coming had already occurred and that everyone alive was favored by Divine grace, which Noves saw as an imperative to live a better life. Perhaps surprisingly, the Oneidans embraced industry and commerce, achieving success in fruit packing, trap making, and silk thread winding. They owned everything communally, and this principle extended to each other. The Oneidans saw monogamy as a selfish act and asserted that the men and women of the community were united in one "complex" marriage; sex between any two consenting members was perfectly acceptable. The Oneidans maintained order solely through "criticism"--anyone acting out of line was made to stand before the other members and hear his or her faults recounted. Oneida remained viable for some thirty years, until the leadership devolved on Noves\\' son, an agnostic. The old religious fervor died out, and the dream degenerated into a joint stock company. Doubtless the most successful communalists were the Shakers, so called for the early propensity to tremble ecstatically during religious worship. Their guiding light, Mother Ann, espoused four key principles: Virgin Purity, Christian Communism, Confession, and Separation from the World. Though the Shakers were less adamant on the last point--maintaining social relations and some commerce with heir neighbors--they insisted on the other three. and renounced both personal property and sex. Men and women lived in a single large "Unitary Dwelling" and were considered complete equals, but they occupied separate wings and could speak together only if a third person were present. Despite their religious strictness, Shakers were known as simple, sincere, intelligent people, healthy and longlived, producers of lovely books and hymns, and of furniture still prized for its quality and durability. In their eyday, six thousand Shakers lived in fifty-eight separate "families" throughout the Northeast. Later their celibacy, combined with their strict discipline, led to a decline in numbers, but even today a small number of elderly Shakers in two communities in Maine and New Hampshire continue to keep the faith.

The passage implies that the end of the Brook Farm experiment was probably brought on by:

- A. faltering commitment in the face of hardship.
- B. a failure to attract members of sufficient intellect or ability.
- C. the completion of the community\\\'s aims.
- D. the incompetence of philosophers at field labor.



Correct Answer: A

This is an inference question regarding Brooke Farm\\'s demise. The last half of the first paragraph suggests that Brook Farm failed because the Farm\\'s members, although interested in the theoretical aspects of their community, were not committed to maintaining the Farm in the face of hardship, choice (A). The first paragraph does suggest that Brook Farm was successful in meeting its aims, but it does not imply that such success led to the end of the experiment, as choice

(C) suggests. You probably know that Margaret Fuller and Nathaniel Hawthorne were major American intellectuals of the 19th century; even if you don\\'t, you are told that these two are among the Farm\\'s more notable members. Thus, you can infer that Brook Farm was indeed able to attract members of sufficient intellect or ability, so (B) is wrong. Although the author notes that Brook Farm\\'s members were thinkers, not workers, the fact that the members had more leisure than expected and outcompeted local farmers suggests that the Farm\\'s philosophermembers were competent field hands; therefore, (D) is incorrect.

QUESTION 3

Which of the following compounds share the same absolute configuration?





A. I and III

B. II and IV

C. I and II

D. II, III, and IV



Correct Answer: B

This question asks you to compare the absolute configurations of four compounds which are in the form of Fischer projections. There are certain rules which you need to be familiar with in order to decipher the absolute configuration. First, the substituent with the lowest priority must be positioned vertically, that is, either up or down. Remember that in 3-D terms, vertical lines represent bonds going into the page. Second, to move your diagram around on the page you have to remember that interchanging any two pairs of substituents will give you the same compound -- that is, it will preserve the absolute configuration. Interchanging just ONE pair of substituents will always REVERSE the absolute configuration. Also, you can hold one group steady while rotating the other three clockwise or counterclockwise. The third rule is that once you have the lowest-priority group positioned vertically, you should determine the order of priority among the other three substituents. If that order increases clockwise, that means the chiral carbon has an R configuration, while if it increases counterclockwise, the chiral carbon has an S configuration. If you look at compound I, you can see that the order of increasing priority is hydrogen, methyl, carboxyl, and hydroxyl. In order to get the hydrogen into a vertical position, you can hold the methyl group steady and rotate the others by 90? The order of increasing priority is clockwise and so the configuration is R, for compound II, the hydrogen is already placed vertically, so you don//'t have to worry about moving the molecule around the page. The order of increasing priority is hydrogen, methyl, carboxyl and amine, so when you draw arrows between the last three, the direction is counterclockwise and so the configuration is S. Therefore, you can discard choice C since these two molecules have opposite configurations. Compound III may catch you off guard, because if you look at this molecule closely you can see that it is achiral. Although they are written differently, there are two ethyl substituents in this molecule, therefore this molecule is neither R nor S, and so choices A and D can be eliminated. This leaves choice B, but let/\'s just look at compound IV anyway. Again, the hydrogen is positioned vertically and the order of priority is the same as in compound I. However, if you connect the arrows this time, you can see that the direction is counterclockwise and so the configuration is S. This makes compounds II and IV the same, and so choice B is correct.

QUESTION 4

Aerobic respiration is the major process used by oxygen- requiring organisms to generate energy. During respiration, glucose is metabolized to generate chemical energy in the form of ATP:

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 36ATP$

The biochemical machinery necessary for cellular respiration is found in the mitochondria, small organelles scattered throughout the cytoplasm of most eukaryotic cells. The number of mitochondria per cell varies by tissue type and cell function.

Mitochondria are unusual in that they have their own genetic systems that are entirely separate from the cell\\'s genetic material. However, mitochondrial replication is still dependent upon the cell\\'s nuclear DNA to encode essential proteins required for replication. Despite this fact, mitochondria seem to replicate randomly, out of phase with both the cell cycle and other mitochondria.

The nature of the mitochondrial genome and proteinsynthesizing machinery has led many researchers to postulate that mitochondria may have arisen as the result of the ingestion of a bacterium by a primitive cell millions of years ago. It is postulated that the two may have entered into a symbiotic relationship and eventually became dependent on each another; the cell sustained the bacterium, while the bacterium provided energy for the cell. Gradually, the two evolved into the present-day eukaryotic cell, with the mitochondrial DNA is inherited in a non-Mendelian fashion (mitochondria are inherited from the maternal parent, who supplies most of the cytoplasm to the fertilized egg), it has been used to look at evolutionary relationships among different organisms.

Four different human cell cultures -- erythrocytes, epidermal cells, skeletal muscle cells, and intestinal cells -- were grown in a medium containing radioactive adenine. After 10 days, the mitochondria were isolated via centrifugation, and their level of radioactivity was measured using a liquid scintillation counter. Which of the following cells would be expected to have the greatest number of counts per minute of radioactive decay?



- A. Erythrocytes
- B. Epidermal cells
- C. Skeletal muscle cells
- D. Intestinal cells

Correct Answer: C

According to the question stem, four different human cell cultures were grown in a medium containing radioactive adenine. So, the first thing that you should be thinking about is DNA replication; while these cells are replicating they/\'re going to incorporate this radioactive adenine into all of their DNA. This includes chromosomal DNA, as well as mitochondrial DNA. Mitochondria replicate independently of their cells. Since all autosomal human cells have the same amount of DNA in their nuclei, the only difference in radioactivity will be the amount that was incorporated into the mitochondrial DNA. And this is why the cells\\' mitochondria were isolated via centrifugation, and then the radiation from each sample was measure using a scintillation counter. The cells with the greatest number of mitochondria will have the highest radioactive count when their mitochondria. This number is dependent on the energy needs of the tissue. Given the choices -- erythrocytes, epidermal cells, skeletal muscle cells, and intestinal cells -- you should know that the correct answer is choice C, skeletal muscle cells. Muscle cells need a lot of energy in order to contract. ATP is required every time a molecule of myosin binds to actin in the sarcomeres. In general, muscle cells have a higher content of mitochondria. Choice B, epidermal cells, do not have any special energy requirements. The same thing applies to intestinal cells, choice D.

QUESTION 5

Agonistic behavior, or aggression, is exhibited by most of the more than three million species of animals on this planet. Animal behaviorists still disagree on a comprehensive definition of the term, but aggressive behavior can be loosely described as any action that harms an adversary or compels it to retreat. Aggression may serve many purposes, such as food gathering, establishing territory, and enforcing social hierarchy. In a general Darwinian sense, however, the purpose of aggressive behavior is to increase the individual animal/\'s -- and thus, the species/\' -- chance of survival. Aggressive behavior may be directed at animals of other species, or it may be conspecific -- that is, directed at members of an animal///s own species. One of the most common examples of conspecific aggression occurs in the establishment and maintenance of social hierarchies. In a hierarchy, social dominance is usually established according to physical superiority; the classic example is that of a pecking order among domestic fowl. The dominance hierarchy may be viewed as a means of social control that reduces the incidence of attack within a group. Once established, the hierarchy is rarely threatened by disputes because the inferior animal immediately submits when confronted by a superior. Two basic types of aggressive behavior are common to most species: attack and defensive threat. Each type involves a particular pattern of physiological and behavioral responses, which tends not to vary regardless of the stimulus that provokes it. For example, the pattern of attack behavior in cats involves a series of movements, such as stalking, biting, seizing with the forepaws and scratching with the hind legs, that changes very little regardless of the stimulus -- that is, regardless of who or what the cat is attacking. The cat\\'s defensive threat response offers another set of closely linked physiological and behavioral patterns. The cardiovascular system begins to pump blood at a faster rate, in preparation for sudden physical activity. The eyes narrow and the ears flatten against the side of the cat\\'s head for protection, and other vulnerable areas of the body such as the stomach and throat are similarly contracted. Growling or hissing noises and erect fur also signal defensive threat. As with the attack response, this pattern of responses is generated with little variation regardless of the nature of the stimulus. Are these aggressive patterns of attack and defensive threat innate, genetically programmed, or are they learned? The answer seems to be a combination of both. A mouse is helpless at birth, but by its 12th day of life can assume a defensive threat position by backing up on its hind legs. By the time it is one month old, the mouse begins to exhibit the attack response. Nonetheless, copious evidence suggests that animals learn and practice aggressive behavior; one need look no further than the sight of a kitten playing



with a ball of string. All the elements of attack -- stalking, pouncing, biting and shaking -- are part of the game which prepares the kitten for more serious situations later in life.

Which of the following topics related to agonistic behavior is NOT explicitly addressed in the passage?

- A. The physiological changes that accompany attack behavior in cats
- B. The evolutionary purpose of aggression
- C. Conspecific aggression that occurs in dominance hierarchies
- D. The relationship between play and aggression

Correct Answer: A

By now you should have a pretty good idea of what\\'s in the passage. Scan the Choices and eliminate the ones that look familiar. Choice B, the evolutionary purpose of aggression, is explicitly addressed in the final sentence of Paragraph 1. Conspecific aggression occurring in dominance hierarchies, Choice C, is discussed in Paragraph 2. The relationship between play and aggression, Choice D, is mentioned in the final two sentences of the passage. Choice A seems to be the winner by the process of elimination. Indeed, the physiological changes that accompany aggressive behavior were discussed in detail only with respect to defensive threat response and not with respect to attack behavior in cats. A is the correct answer.

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