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## **QUESTION 1**

Hemophilia is a genetically inherited disease that causes the synthesis of an abnormal clotting factor. As a result, hemophiliacs bleed excessively from the slightest injury. The figure below is a partial pedigree for the hemophilia trait in Queen Victoria\\'s descendants. The pedigree indicates no history of hemophilia for either parent prior to the F1 generation.



## Figure 1

Theoretically, what percentage of Victoria Eugenia\\'s sons should have been hemophiliacs?

A. 25%

B. 33%

C. 50%

D. 75%

Correct Answer: C



If you look at the pedigree, you\\'II see that Victoria Eugenia had four sons, three of which were hemophiliacs. So, 75% of her sons turned out to be hemophiliacs. You know that these sons inherited the disease from their mother, as opposed to their father, Alfonso III of Spain, because their mother was a carrier of the disease, as can be seen on the pedigree, and their father was normal. Okay, so 75% was the actual percent, but the question asks you to determine the theoretical probability that Victoria Eugenia\\'s sons would be hemophiliacs. So, what you have to do is just work out the cross between a carrier female and a normal male and look at the results. And, if you do that, you\\'II find that theoretically, 50% of Victoria Eugenia\\'s daughters should have been carriers, 50% should have been normal; and 50% of her sons should have been hemophiliacs, 50% should have been normal. So the probability that Victoria Eugenia\\'s sons would have been normal. So the probability that Victoria Eugenia\\'s sons would have been normal. So the probability that Victoria Eugenia\\'s sons would have been normal. So the probability that Victoria Eugenia\\'s sons would have been normal. So the probability that Victoria Eugenia\\'s sons would have been normal.

### **QUESTION 2**

Several models have been developed for relating changes in dissociation constants to changes in the tertiary and quaternary structures of oligomeric proteins. One model suggests that the protein\\'s subunits can exist in either of two distinct conformations, R and T. At equilibrium, there are few R conformation molecules: 10 000 T to 1 R and it is an important feature of the enzyme that this ratio does not change. The substrate is assumed to bind more tightly to the R form than to the T form, which means that binding of the substrate favors the transition from the T conformation to R.

The conformational transitions of the individual subunits are assumed to be tightly linked, so that if one subunit flips from T to R the others must do the same. The binding of the first molecule of substrate thus promotes the binding of the second and if substrate is added continuously, all of the enzyme will be in the R form and act on the substrate. Because the concerted transition of all of the subunits from T to R or back, preserves the overall symmetry of the protein, this model is called the symmetry model. The model further predicts that allosteric activating enzymes make the R conformation even more reactive with the substrate while allosteric inhibitors react with the T conformation so that most of the enzyme is held back in the T shape.

Experiment Evaluating Non-Symmetry Model Enzymes

Experiments were performed with enzyme conformers that did not obey the symmetry model. The data is summarized in Figure 1.



Figure 1: Equilibrium distribution of two conformers at different temperatures given the free energy of their interconversion. (modified from Mr.Holmium). What assumption is made about the T and R conformations and the



#### substrate?

A. In the absence of any substrate, the T conformation predominates.

B. In the absence of any substrate, the R conformation predominates.

C. In the absence of any substrate, the T and R conformations are in equilibrium.

D. In the absence of any substrate, the enzyme exists in another conformation, S.

Correct Answer: A

Explanation: Paragraph 1. Information concerning the relative amounts of T and R conformations present before substrate is added is given in the passage.

## **QUESTION 3**

Four major blood types exist in the human ABO blood system: types A, B, AB, and O; and there are three alleles that code for them. The A and B alleles are codominant, and the O allele is recessive. Blood types are derived from the presence of specific polysaccharide antigens that lie on the outer surface of the red blood cell membrane. The A allele codes for the production of the A antigen; the B allele codes for the production of the B antigen; the O allele does not code for any antigen. While there are many other antigens found on red blood cell membranes, the second most important antigen is the Rh antigen. Rh is an autosomally dominant trait coded for by 2 alleles. If this antigen is present, an individual is Rh+; if it is absent, an individual is Rh-. For example, a person with type AB blood with the Rh antigen is said to be AB+.

These antigens become most important when an individual comes into contact with foreign blood. Because of the presence of naturally occurring substances that closely mimic the A and B antigens, individuals who do not have these antigens on their red blood cells will form antibodies against them. This is inconsequential until situations such as blood transfusion, organ transplant, or pregnancy occur.

Erythroblastosis fetalis is a condition in which the red blood cells of an Rh+ fetus are attached by antibodies produced by its Rh- mother. Unlike ABO incompatibility, in which there are naturally occurring antibodies to foreign antigens, the Rh system requires prior sensitization to the Rh antigen before antibodies are produced. This sensitization usually occurs during the delivery of an Rh+ baby. So while the first baby will not be harmed, any further Rh+ fetuses are at risk.

The Coombs tests provide a method for determining whether a mother has mounted an immune response again her baby\\'s blood. The tests are based on whether or not agglutination occurs when Coombs reagent is added to a sample. Coombs reagent contains antibodies against the anti-Rh antibodies produced by the mother. The indirect Coombs test takes the mother\\'s serum, which contains her antibodies but no red blood cells, and mixes it with Rh+ red blood cells. Coombs reagent is then added. If agglutination occurs, the test is positive, and the mother must be producing anti-Rh antibodies. The direct Coombs test mixes the baby\\'s red blood cells with Coombs reagent. If agglutination occurs, the test is positive, and the baby\\'s red blood cells must have been attacked by its mother\\'s anti-Rh antibodies.

If a man with type AB blood needed a transfusion of red blood cells, which of the following individuals could safely donate blood?

- A. A man with type A blood
- B. A man with the genotype BO
- C. A woman with the genotype AB
- D. All four blood types are equally safe



#### Correct Answer: D

The thinking process behind this question is similar to the one used to answer the previous question. A person with type AB blood expresses both the A and B antigens on his red blood cells, which implies that his blood does NOT contain any anti-A or anti-B antibodies. Since the recipient\\'s blood does not contain anti-A antibodies or anti-B antibodies; this means that any blood type can b safely transfused, regardless of the A and B antigens found in the donor\\'s blood. Be aware that there are other blood antigens typically present that could cause problems during transfusions, but this is beyond the scope of this question. Also recognize that the gender of the person donating the blood is in no way relevant.

### **QUESTION 4**

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 Noyes 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 Noyes\\' 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.

According to the passage, all of the following were characteristic of the Oneida community EXCEPT:

- A. complex marriage.
- B. maintenance of order through social pressure.
- C. belief in present grace.
- D. shared living quarters.

Correct Answer: D



This is a detail question about the Oneida community in the "All of the Following Except" format. The Oneida community is discussed in paragraph 2. In the middle of that paragraph, the author states that the Oneidans believed that all the men and women of the community were united in one "complex\\\\\' marriage, choice (A). Order was maintained through "criticism", a sort of social pressure, choice (B). You can infer that present grace, choice (C), refers to the Oneida founder\\'s belief that the second coming of Christ had already occurred. But communal living, choice (D), is mentioned in relation to the Shakers, not the Oneidans.

## **QUESTION 5**



Which of the following expressions best approximates the work required to move the box with a mass m to the top of the ramp? (Assume that the ramp is frictionless.)

- A. mglcosT
- B. mghsinT
- C. mgdcosT
- D. mgdsinT
- Correct Answer: D

Explanation: This question asks the examinee to determine the work required to move a box from the bottom of a ramp to the top of a ramp. While a ramp provides a mechanic advantage, which reduces the force required to push the box to the top of the ramp, the work required to move the box using the ramp is the same amount of work required to lift the box to a height h without the use of a ramp. Therefore, the correct answer is mgdsinT, which is equal to mgh.

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