Multiple Choice Reasoning: Explain WHY the other answers are NOT correct.

1. Which of the following is not an example of genetic engineering?
   A. An agricultural scientist creates a hybrid strain of rice by crossing two rice varieties.
   B. A biology student inserts plant DNA into bacteria to determine its role in the cell cycle.
   C. A vaccine manufacturer inserts a plasmid containing a gene from a virus into yeast cells.

2. Which is the most challenging step in developing effective gene therapy for human diseases?
   A. Determining the DNA sequence for the gene.
   B. Delivering the gene into the cells of the body.
   C. Splicing the functional gene involved in the disorder.
   D. Determining which disorders can be cured by gene therapy.

3. A scientist uses enzymes to splice genetic DNA into a plasmid, and then inserts the plasmid into a cell. Which of the following is most likely an application of this process?
   A. Producing an exact genetic clone of a prized racehorse.
   B. Producing a vaccine against the human papillomavirus.
   C. Determining which of several rice varieties should be crossed.
   D. Determining whether a suspect’s blood was present at a crime scene.
A purebred dog has a litter of puppies. The dog’s owners are not sure which dog is the father of the puppies. They hire a scientist to identify the father through DNA fingerprinting. The scientist takes blood samples from four dogs and examines STR’s at several different loci. She amplifies the amount of DNA at each STR and separates the resulting DNA fragments using gel electrophoresis. The resulting gel, with DNA fragments visible as bands at different locations is below.

A. How many STR loci were examined by the scientist? Explain. (Keep in mind that a single STR locus has two alleles.)

B. Why are the DNA bands located at different position in each lane?

C. Which male dog is the puppy’s father? Explain your choice.
Restriction Enzymes

Name: ____________________________

Genetic Engineering

Date: ____________________ Period: ______

Objectives: Identify restriction sites; show differences between blunt and sticky (cohesive) end cuts; compare restriction enzyme differences on identical DNA.

Directions: Identify the restriction sites for each of the examples given. Show the cuts, sticky (cohesive) or blunt, number of DNA fragments produced, and the number of base pairs in each (count the top row). If there are three nucleotides on either side of the dash it is a blunt cut. If there are less than three on either side of the dash it is cohesive or sticky cut.

1. HpaI --- 5' GTT - AAC 3'

5' GGATGTAAACAATCTCTACGGGTAAACCCCTTGGTTAACATCCGGCGG 3'
3' CCTACAATTGTTAGAGATGCCCAATTGTGGGAACCCAATTGTAGGGGCC 5'

Number of pieces of DNA: _______ Circle the cut: Sticky or Blunt

2. SspI --- 5' AAT - ATT 3'

5' GGATAATATT GTTAACAATCTCTACGGGTAAACCCCTTGGGAATATTCTTTAA 3'
3' CCTATTATAAAATTTGTTAGAGATGCCCAATTGTGGGAACCCCTTATAAAATT 5'

Number of pieces of DNA: _______ Circle the cut: Sticky or Blunt

3. PstI --- 5' CTGCA - G 3'

5' ACGCTGCAGACGTATTATTAT CCGCCGCTGCAGCC GTCATCA 3'
3' TGCGACGTCTGCATAATAATTAGGCACGTGCGAGCAGTGTAGT 5'

Number of pieces of DNA: _______ Circle the cut: Sticky or Blunt

4. HindII --- 5' GTC - GAC 3'

5' ACGACGTAGTCACTATTATTAT GTCGACCACCGCCGCTGACTCATCA 3'
3' TGCTGCATCAGCTGAATTACAGCTGGGGCGGACAGCAGTGTAGT 5'

Number of pieces of DNA: _______ Circle the cut: Sticky or Blunt

5. EcoRI --- 5' G - AATTC 3'

5' ACGACGTATTAGAATTTCTTAATCGCCGCGCAATTTCATCA 3'
3' TGCTGCATAATGTACTAAAAGGCGGCGGCAATTCTTATAAGTAGT 5'

Number of pieces of DNA: _______ Circle the cut: Sticky or Blunt
6.  **HaeIII** --- 5' CC - GG 3'

5' ACGCCCGGCGGCGGATATAT CCGGATCCGCCG CCGGCTGTCCCGGATCA 3'
3' TGCGGCGGTACGAGGCGGCGGACAGGGCCTAGT 5'

Number of pieces of DNA: ________  Circle the cut: Sticky or Blunt

7.  **BamI** --- 5' CCTAG - G 3'

5' ACGCCTAGGACGTTATTATCTTAGGTAT CCGGCGGCTG CATCA 3'
3' TGCGGCCGGCATAATAGGCCTAGGCGGCGGCCAGT 5'

Number of pieces of DNA: ________  Circle the cut: Sticky or Blunt

8.  **HpaI** --- 5' GTT - AAC 3' and **SspI** --- 5' AAT - ATT 3'

5' AGTTAACCGACAATATTGTATTTATCC GCGGCC GTGTTAACATCA 3'
3' TCAATTTGCTGTTATAACATAATATAGGCCGGCGGACGAATTGTATG 5'

Number of pieces of DNA: ________  Circle the cut: Sticky or Blunt

9.  **HindIII** --- 5' GTC - GAC 3' and **HaeIII** --- 5' CC - GG 3'

5' ACGGTGCACAGCTATTATTAGTGACTCGACCACCGC CGGCGGCTGTCCCGGATCA 3'
3' TGCCAGCTGTGATAATCAGCTGAGGCGGCGGATCCCAGT 5'

Number of pieces of DNA: ________  Circle the cut: Sticky or Blunt

10. **HindIII** --- 5' GTC - GAC 3', **HaeIII** --- 5' CC - GG 3' and **BamI** --- 5' CCTAG - G 3'

5' ACGCCCGGACGTACGTTAGGTGTA GCTGACTCGACCACCGC CGGCGGCTGTCCCGGATCA 3'
3' TGCGGSpainGATAGCATCCAAATCAGCTGAGGCGGCGGATCCCAGTAGT 5'

Number of pieces of DNA: ________  Circle the cut: Sticky or Blunt
Restriction enzymes are highly specific proteins that can cut DNA into smaller pieces. There are hundreds of different restriction enzymes, such as EcoRI, which comes from the *E. coli* bacteria. We want to break the DNA into more manageable pieces so that we can study it. To do this, we use a process known as **gel electrophoresis** to separate DNA that has been cut by restriction enzymes and analyze the different size fragments.

Below is a DNA fragment that is 41,386 base pairs long. Below the DNA strand are 3 restriction enzymes. The restriction enzymes **EcoRI, BamI, and HaeIII**, will cut the DNA at different spots on the DNA sequence (as indicated below). Calculate the length of each DNA fragment. Once you have all the fragment lengths, transfer them to the appropriate column on the back of this sheet corresponding to the base pair length (the numbers on the left side of the sample gel).

*Original DNA fragment:*

<table>
<thead>
<tr>
<th>Original DNA fragment:</th>
</tr>
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<tbody>
<tr>
<td>1 ___________________________________________________________</td>
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**EcoRI**

<table>
<thead>
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<tr>
<td>I _____________________ I I I _____________________________ I</td>
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<td>19,213  25,776  30,993</td>
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**BamI**

<table>
<thead>
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<tbody>
<tr>
<td>I ___________________ I I I I ___________________________ I</td>
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<tr>
<td>15,194  22,415  27,511</td>
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</table>

**HaeIII**

<table>
<thead>
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<th>HaeIII</th>
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</thead>
<tbody>
<tr>
<td>I __________________ I I I I I I I I I I I I I I I I I I</td>
</tr>
<tr>
<td>13,310  24,538  33,055  38,972</td>
</tr>
<tr>
<td>Number of base pairs (bp)</td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>40,000</td>
</tr>
<tr>
<td>35,000</td>
</tr>
<tr>
<td>30,000</td>
</tr>
<tr>
<td>25,000</td>
</tr>
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<td>20,000</td>
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<td>15,000</td>
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<tr>
<td>10,000</td>
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<tr>
<td>5,000</td>
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<tr>
<td>1,000</td>
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</table>

**Questions:**

1. Which fragment moved the farthest? Why?  
   [Answer]

2. Which fragment had the slowest rate of migration? Why?  
   [Answer]

3. Why are restriction enzymes used to cut DNA?  
   [Answer]
1. In humans, the gene for polydactyly (having extra fingers or toes) is dominant over the gene for normal number of digits. If parents who are both homozygous dominant for polydactyly have four children, how many of these children would most likely have extra fingers or toes?
   A. 0  B. 2  C. 3  D. 4

2. Which mutation in a fruit fly could be passed on to its offspring?
   A. a mutation in a cell of an eye that changes the color of the eye
   B. a mutation in a leg cell that causes the leg to be shorter
   C. a mutation in a sperm cell that changes the shape of the wing
   D. a mutation in a cell of the digestive tract that produces a different enzyme

3. The diagram below shows a normal gene sequence and three mutated sequences of a segment of DNA.

   Which row in the chart below correctly identifies the cause of each type of mutation?

<table>
<thead>
<tr>
<th>Row</th>
<th>Mutation A</th>
<th>Mutation B</th>
<th>Mutation C</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>deletion</td>
<td>substitution</td>
<td>insertion</td>
</tr>
<tr>
<td>(2)</td>
<td>insertion</td>
<td>substitution</td>
<td>deletion</td>
</tr>
<tr>
<td>(3)</td>
<td>insertion</td>
<td>deletion</td>
<td>substitution</td>
</tr>
<tr>
<td>(4)</td>
<td>deletion</td>
<td>insertion</td>
<td>substitution</td>
</tr>
</tbody>
</table>

   A. Row 1  B. Row 2  C. Row 3  D. Row 4

4. A cross between two plants that have pink flowers produced plants that have red, pink, or white flowers. Which is the most likely explanation for these results?
   A. Intermediate inheritance involved alleles that were not clearly dominant or recessive.
   B. Mutations occurred during gametogenesis.
   C. Crossing-over of white and red alleles occurred during meiosis.
   D. Nondisjunction of homologous pairs of chromosomes resulted in the production of abnormal offspring.

5. A scientist observes that a certain trait is determined by a single allele. An organism inherited one version of the trait from one parent and another version from the other parent. Both versions of the trait are expressed in the phenotype of the offspring. Which pattern of inheritance best classifies the observed trait?
   A. dominance  C. co-dominance
   B. sex-linkage  D. incomplete dominance
6. A mutation occurs at the midpoint of a gene, altering all amino acids encoded after the point of the mutation. Which mutation could have produced this change?
   A. deletion of two nucleotides  
   B. deletion of three nucleotides  
   C. insertion of six nucleotides  
   D. insertion of twelve nucleotides

7. Blood type is inherited through multiple alleles, including \( I^A, I^B, \) and \( i \). A child has type A blood. If the father has type AB blood, what are all the possible phenotypes of the mother?
   A. phenotypes O and A  
   B. phenotypes A or AB  
   C. phenotypes A, B, AB  
   D. phenotypes O, A, B, AB

8. In a flowering plant species, red flower color is dominant over white flower color. What is the genotype of any red-flowering plant resulting from this species?
   A. red and white alleles present on one chromosome  
   B. red and white alleles present on two chromosomes  
   C. a red allele present on both homologous chromosomes  
   D. a red allele present on at least one of two homologous chromosomes

9. A genetic mutation resulted in a change in the sequence of amino acids of a protein, but the function of the protein was not changed. Which statement best describes the genetic mutation?
   A. It was a silent mutation that caused a change in the DNA of the organism  
   B. It was a silent mutation that caused a change in the phenotype of the organism  
   C. It was a nonsense mutation that causes a change in the DNA of the organism  
   D. It was a nonsense mutation that caused a change in the phenotype of an organism

Use the diagram below to answer question 10.

![Chromosome Change Diagram]

10. Which type of change in chromosome composition is illustrated in the diagram?
   A. deletion  
   B. insertion  
   C. inversion  
   D. translocation
Use the pedigree chart below to answer questions 11-13.

11. The genotype of individual 1 could be
   A. EE, only  B. Ee, only  C. ee  D. EE or Ee

12. The genotype of individual 2 could be
   A. EE, only  B. Ee, only  C. ee  D. EE or Ee

13. The genotype of individual 3 could be
   A. EE, only  B. Ee, only  C. ee  D. EE or Ee

14. What is the role of restriction enzymes in studying the human genome?
   A. copying pieces of DNA.
   B. labeling different nucleotides with different colors of dyes.
   C. separating different pieces of DNA based on their size.
   D. cutting large DNA molecules into smaller pieces.

15. If nondisjunction occurs during meiosis,
   A. only two gametes may form instead of four.
   B. some gametes may have an extra copy of some genes.
   C. the gamete cannot join another to form an organism.
   D. the gametes redistribute chromosomes after meiosis.

16. Which piece of DNA would move fastest in gel electrophoresis? A segment that is
   A. 100 base pairs long.
   B. 1,000 base pairs long.
   C. 5,000 base pairs long.
   D. 100,000 base pairs long

17. The gene for colorblindness is carried on the X chromosome and is recessive. A man, whose father was colorblind, has a colorblind daughter.
   a) Is this man colorblind? How do you know?
   b) Where did he get his gene for colorblindness?
   c) Must the fathers of all colorblind girls be colorblind? Why?
Multiple Choice Reasoning: Explain WHY the other answers are NOT correct for questions #2, #6-10.

2. Correct Answer: ________ Why are the other choices not correct?

6. Correct Answer: ________ Why are the other choices not correct?

7. Correct Answer: ________ Why are the other choices not correct?

8. Correct Answer: ________ Why are the other choices not correct?

9. Correct Answer: ________ Why are the other choices not correct?

10. Correct Answer: ________ Why are the other choices not correct?