INSTRUCTIONS:

1. Read the questions carefully and write your answers in the space provided. If you need more space, clearly indicate WHERE the rest of the answer is located (for example, on the back of the same page). If there is something that you do not wish me to count, (for example, if you make an error) please cross it out.

2. Read each question carefully before starting to answer it so you don’t overlook any additional instructions. If you get stuck on a question, go on to another question and return to the original question later. It is a good strategy to read over the entire exam and then select the questions you feel most confident about to answer first.

3. In your answers to problems that require you to calculate a numerical answer, you must show how you set up your calculation to receive full credit for your final numerical solution.

4. A blank sheet of paper has been provided for you at the end of the exam which you may use as scratch paper.

GOOD LUCK!

Question #1: ____________________ (20 pts.)

Question #2: ____________________ (15 pts.)

Question #3: ____________________ (15 pts.)

Question #4: ____________________ (13 pts.)

Question #5: ____________________ (12 pts.)

Question #6: ____________________ (13 pts.)

Question #7: ____________________ (12 pts.)

Bonus: ____________________ (5 pts.)

TOTAL: ____________________ (100 pts.)

NAME: ____________________    ID NUMBER: ____________________

Please print legibly.

SIGNATURE: ____________________
1. For each of the following, choose the one alternative that best completes the statement or answers the question (2 pts. each, 20 pts total).

________ Which of the following is true?
A.) A chromosome in its unreplicated state is made up of one double stranded DNA molecule
B.) A single double stranded DNA molecule may contain several genes
C.) After DNA replication a single chromosome will consist of two sister chromatids
D.) After DNA replication a single chromosome will consist of two double stranded DNA molecules
E.) All of the above

________ Individuals that are heterozygous for a particular trait have
A.) Two different alleles of the gene
B.) Two identical copies of the gene
C.) Two different genes responsible for the trait
D.) Offspring that all show the dominant trait
E.) Offspring in which ½ will show the dominant trait

________ For an organism with a ploidy of 2n=52, which of the following would you expect to see in a cell in prophase I of meiosis?
A.) 52 tetrads
B.) 26 bivalents
C.) 104 tetrads
D.) 52 sister chromatids
E.) 52 bivalents

________ Albinism, lack of pigmentation in humans, results from an autosomal recessive allele. Two individuals that are heterozygous for this allele marry and want to have children. Which of the following is true?
A.) There is a 50% chance their first child will be an albino
B.) If their first 3 children have pigmentation, their fourth child will be an albino.
C.) For each pregnancy, there is a 25% chance the child will be albino.
D.) If they have 2 children, there is a 25% chance that both will be albino.
E.) If their first child is not an albino, there is a 3/16 probability that their second child will be an albino

________ Color-blindness is caused by an X-linked recessive allele. Which of the following is true?
A.) A color-blind female must have a colorblind father.
B.) A color-blind male must have a colorblind father.
C.) A color-blind female must have a colorblind mother.
D.) A color-blind male must have a colorblind mother.

________ In a pedigree that traces the inheritance of an autosomal dominant trait, which of the following would you expect to see?
A.) The trait would show up in each generation.
B.) Two unaffected parents have an affected child.
C.) The same number of males with the trait as females.
D.) All of the above
E.) A and C only
Two truebreeding varieties of finches, only with black feathers and one with white feathers are crossed and the resulting F1 offspring have a mixture of black and white feathers. The allele that causes black feathers is _______ to the allele that causes white feathers.

A.) dominant  
B.) codominant  
C.) incompletely dominant  
D.) recessive  
E.) pleiotropic

In chickens the Creeper phenotype is caused by an allele (Cr) that is lethal in individuals that are homozygous for it. Two heterozygotes for the Cr allele are crossed. What percentage of the living offspring will be Creepers?

A.) 1/4  
B.) 1/2  
C.) 2/3  
D.) 1/3  
E.) 3/4

For an individual with type A blood, which of the following is true?

A.) He has A antigens present on his red blood cells  
B.) He has B antigens present on his red blood cells  
C.) He has anti-A antibodies present in his blood stream  
D.) He could receive a blood transfusion from someone with type AB blood  
E.) He could not have a child with type O blood

In a certain genetic cross, the F2 offspring show a 9:3:3:1 ratio. Which of the following is true?

A.) The gene involved shows incomplete dominance  
B.) The genes involved show independent assortment  
C.) The F1 individuals were all heterozygous for two different genes  
D.) none of the above  
E.) B and C only
2. (A) Label the indicated parts of the chromosome below: (4 pts.)

(B) The shape of this chromosome can be described as _______________. (1 pt.)

(C) Circle one sister chromatid on the above chromosome (1 pt.).

(D) Three cells that are 2n=6 begin to divide. One undergoes mitosis, the other two undergo meiosis. Draw what you would see in the following stages of division (3 points each, 9 pts total):

- Anaphase of Mitosis
- Prophase of Meiosis I
- Metaphase of Meiosis II
3. A cross was carried out between two individuals having the following genotypes:
(Please show all work/calculations for full credit)

\[
\text{BbddEeGGHhNnrr} \times \text{BbDdeeggHhNNRr}
\]

\[
\text{individual #1} \quad \text{Individual #2}
\]

(a) How many different genotypes are possible among the offspring of this cross? (3 pts.)

(b) What is the probability that these two individuals will produce an offspring having the dominant phenotype with respect to all 7 traits? (3 pts.)

(c) What is the probability that these two individuals will produce an offspring having the following genotype? (3 pts.)
\[
\text{bbDdEeGghhNnrr}
\]

(d) In families that have four children, what proportion of the families will have at least one boy? (Hint: this is easier than it first looks, i.e., what happens if they don’t have at least one boy?) (3 pts.)

(e) In humans, the lack of pigmentation is called albinism (a) and it is recessive to pigmented skin (A). If two heterozygotes marry and have two children, what is the probability both children will have the same type of skin coloration? (3 pts.)
4. Determine the probable mode of inheritance for the trait shown in the affected individuals in the pedigree below by answering the following questions:

(a) Y-linked inheritance can be excluded at a glance. Explain. (2 pts.)

(b) At least 2 other modes of inheritance can be positively excluded almost as easily on the basis of one or two individuals. Name one of these and explain (naming the one or two individuals on which this is based) why it can be excluded. (2 pts.)

(c) Of the remaining modes of inheritance, which is most likely? Explain. (3 pts.)

(d) Based on your answer to (c) indicate the genotypes of the following individuals: (1 pt. each, 6 pts. total))

I-1: ___________  I-2: ___________  II-3: ___________

II-4: ___________  II-6: ___________  III-2: ___________
5. The Simpson family of Indianapolis has 3 children: Art, Nissa, and Aggie. Each child has a different blood type with respect to ABO blood type and Rh factor:

Art: Type A, Rh-positive
Nissa: Type B, Rh-negative
Aggie: Type O, Rh-negative

Art was hit by a car while skateboarding on interstate 465, and was rushed to Methodist Hospital. His doctors determined that he needed a blood transfusion. His parents, Gomer and LaFarge, raced to the blood bank to donate blood. Some interesting results arose when Gomer and LaFarge underwent blood typing.

<table>
<thead>
<tr>
<th></th>
<th>Antigens on his/her red blood cells</th>
<th>Antibodies present in his/her serum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A antigen</td>
<td>B antigen</td>
</tr>
<tr>
<td>Gomer</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>LaFarge</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

(a) Based upon the information presented in the table above, and upon the blood types of the children, please answer the following questions:

Before you begin to answer this question, define your genotypic symbols HERE:

(i) What is Gomer’s most likely complete genotype with respect to ABO and Rh blood type? (1 pt.)

(ii) What is Gomer’s complete blood type with respect to ABO and Rh factor? (1 pt.)

(iii) What is LaFarge’s most likely complete genotype with respect to ABO and Rh blood types? (1 pt.)

(iv) What is LaFarge's complete blood type with respect to ABO and Rh factor? (1 pt.)

(v) In the spaces provided in the table above, please indicate whether you would expect to find each of the antibodies in question in that person’s blood serum. (0.5 pts. each; 3 pts. total) (Please write yes or no in the appropriate space.) – See above
5. (cont.)

(vi) What is the most probable complete genotype for each of the three children with respect to ABO and Rh? (1 pt. per person; 3 pts. total)

<table>
<thead>
<tr>
<th>Child</th>
<th>Blood type</th>
<th>Most probable genotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Art</td>
<td>Type A, Rh-positive</td>
<td></td>
</tr>
<tr>
<td>Nissa</td>
<td>Type B, Rh-negative</td>
<td></td>
</tr>
<tr>
<td>Aggie</td>
<td>Type O, Rh-negative</td>
<td></td>
</tr>
</tbody>
</table>

(b) Do the results of all of these tests suggest anything about the paternity of the three children? Please elaborate, and explain how you came to this conclusion. (2 pts.)
6. Andalusian blue chickens have feathers that are bluish-grey in color. Although prized by chicken breeders, a true-breeding variety of Andalusian blues has never been developed. Fred Sanders knowing of your extensive knowledge of genetics has asked for your help. He shows you the results of crosses he has conducted over the years, seen in the following table:

<table>
<thead>
<tr>
<th>P:</th>
<th>Black chicken</th>
<th>X</th>
<th>White chicken</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>------------------------</td>
<td>---</td>
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</tr>
<tr>
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<td>..........................</td>
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<td></td>
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<tr>
<td></td>
<td>..........................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F₁:</td>
<td>All Andalusian Blues</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>..........................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F₂:</td>
<td>205 Black</td>
<td>410 Andalusian Blues</td>
<td>198 White</td>
</tr>
<tr>
<td></td>
<td>..........................</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A.) You immediately spot the problem and give Fred the bad news. What is the mode of inheritance of plumage color in these chickens? Assigning symbols to all alleles, explain why chicken breeders will never develop a true-breeding variety of Andalusian Blues (4 pts.)

B.) In the table above, fill in the genotypes of the parents for each of the crosses (1 pt. each, 5 pts. total)

C.) What genotypes and phenotypes would you expect to see, and what ratios would you see them in, among the offspring of a cross between an Andalusian Blue and a black chicken? (4 pts.)
7. Lesh-Nyhan syndrome is a fatal human genetic disorder caused by a recessive allele of a gene found on the X-chromosome. Individuals with this disorder have an enzyme deficiency that prevents purine use. As such purines accumulate and are converted to uric acid. At birth, infants with the syndrome are normal, but as uric acid increases in their systems, delays in motor development occurs, leading to weak muscles, involuntary muscle spasms and mental retardation. By 2 to 3 years of age, individuals often show self-mutilation behavior, such as biting of fingers and lips, and the inside of the mouth. Most individuals die before they reach their 20’s due to infection, kidney failure, or uremia (uric acid in the blood).

(A) Ann and Mike who are both healthy mountain climbers get married in the Alps. After their first child was diagnosed with Lesh-Nyhan syndrome, the couple went to their families to investigate. Although Mike’s family had no history of the disorder, much to Ann’s surprise, her mother told her that she had had a brother with the disorder (Ann’s uncle) that died before Ann was born. Give the genotypes of the following individuals: (1 pt. each, 6 pts. total)

<table>
<thead>
<tr>
<th>Ann:</th>
<th>Mike:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ann’ s</td>
<td>Ann’s</td>
</tr>
<tr>
<td>mother</td>
<td>Dad</td>
</tr>
<tr>
<td>Ann’s uncle</td>
<td>Mike’s dad</td>
</tr>
</tbody>
</table>

(B) If Ann and Mike decide to have a second child: (1 pt. ea., 3 pts. total)

i) What is the probability it will be a son with Lesh-Nyhan syndrome?

ii) What is the probability it will be a daughter with Lesh-Nyhan syndrome?

iii) If the child is a daughter, what is the probability she will be a carrier?

(C) No female with Lesh-Nyhan syndrome has ever been recorded. Explain why this is so. In order to aid your explanation, include diagram of the cross that would have to occur in order for a female to show the disorder (3 pts.).
**Bonus**

A corn geneticist has three pure lines of genotypes aaBBCC, AAbbCC, and AABBcc. All the phenotypes determined by a, b and c will increase the market value of the corn, so naturally he wants to combine them all in one pure line of corn with the genotype aabbcc. Note: corn will self- or cross pollinate easily.

(A) Outline an *effective* crossing program (i.e., with the fewest possible generations) that he can use to obtain the aabbcc pure line. At each stage, state exactly which phenotypes will be selected and give their expected frequencies (4 pts.).

(B) Is there more than one way to obtain the desired genotype? Explain (1 pt.).
SCRATCH PAPER