DIRECTIONS: Read each question carefully at the beginning of the exam period. Ask for help if the question is unclear. The number in parentheses by each question is the points for that question. Enough space is given for each question for a complete answer. **Partial credit is given for partial answers. Please fill in your name and student ID on each page now!!**

You may need the following section of the Chi-square table for ρ=0.05.

<table>
<thead>
<tr>
<th>d.f.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>3.84</td>
<td>5.99</td>
<td>7.82</td>
<td>9.49</td>
<td>11.07</td>
<td>12.59</td>
<td>14.07</td>
<td>15.51</td>
<td>16.92</td>
<td>18.31</td>
<td>19.68</td>
</tr>
</tbody>
</table>

You may also need this table:

- Proportion Selected (ρ): 0.5, 0.25, 0.1, 0.05, 0.01
- Selection Intensity (I): 0.8, 1.27, 1.76, 2.06, 2.67
- Standardized Selection Point (Z): 0, 0.67, 1.28, 1.65, 2.33

1. (15) Short Answer. Answer each of the following questions in the space provided. **You will be counted off for explanations that are not succinct.**

a) A GN 411 student is interested in growing larger strawberries. She weighs each strawberry in her initial population and finds that weight has a normal distribution. She decided that she wants to make the strawberries (a normal diploid variety) larger via mass selection. From preliminary experimentation, she determined that strawberry weight has a narrow-sense heritability of 0.75. She wants to increase strawberry weight with as little impact to heritability as possible. Which selection intensity would be better for her to use, 5% or 50%? Explain.

If she wants to have little impact on heritability, she must choose the weaker selection scheme. Stronger selection will eliminate alleles more quickly, reducing heritability more.

b) Consider two different populations, 1 and 2 in two different environments. The fitnesses for this trait in the two populations are:

<table>
<thead>
<tr>
<th></th>
<th>AA</th>
<th>Aa</th>
<th>aa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population 1</td>
<td>1.0</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>Population 2</td>
<td>1.0</td>
<td>0.5</td>
<td>0</td>
</tr>
</tbody>
</table>

We start the populations with the same allele frequencies and let this selection continue for 10 generations. In which population will a be less frequent? Explain.

Population 2. In that population, you have selected against the heterozygote as well, thus eliminating the a allele more quickly. (It is not "hidden" from selection).

c) Explain **WHY** the following statement is incorrect: "If two populations each have high heritability then differences between the populations must be genetic."

Heritability can only measure variation within a population (compared to phenotypic variation). Two populations in vastly different environments may be different because of that difference in environments.
2. (9) Consider deletions of portions of a chromosome. In class, we discussed at several ways that deletions are created. Give three ways a deletion can be formed, and for each describe whether it will be a terminal or interstitial deletion.

a) \( \text{Terminal} \) Interstitial (Circle One) How Created: DNA breaks. The piece not attached to the centromere is lost.

b) \( \text{Terminal} \) Interstitial (Circle One) How Created: Paracentric inversion with recombination within the loop.

c) \( \text{Terminal} \) Interstitial (Circle One) How Created: Chromatin loops and then breaks, the DNA is repaired, but such that the loop is lost.

3. (12) We are interested in whether or not a certain gene (with alleles, \( T \) and \( t \)) in a population has Hardy-Weinberg Proportions.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Observed</th>
<th>Expected</th>
<th>Chi-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>TT</td>
<td>539</td>
<td>533.27</td>
<td>0.0614</td>
</tr>
<tr>
<td>Tt</td>
<td>278</td>
<td>289.45</td>
<td>0.4528</td>
</tr>
<tr>
<td>tt</td>
<td>45</td>
<td>39.28</td>
<td>0.8342</td>
</tr>
<tr>
<td>Total</td>
<td>862</td>
<td></td>
<td>1.3484</td>
</tr>
</tbody>
</table>

a) The allele frequencies are: \( T = \frac{539 + \frac{278}{2}}{862} = 0.738 \) and \( t = \frac{278}{862} = 0.315 \).

b) Complete the table.

c) Give the statistical conclusion for this experiment. Fail to reject.

d) State your conclusion from this experiment (the genetic conclusion). Be careful with your wording.
   The data are consistent with this population having Hardy-Weinberg Proportions for this gene.

4. (12) The Genetics Department is interested in increasing the wing beat frequency (beats per sec) of *Drosophila melanogaster* (fruit fly). From preliminary studies, we know the mean wing beat frequency for our (unusual) strain as 15 bps, with a standard deviation of 1.2 bps. Heritability in the narrow sense is 65%. For our experiment, we will keep the best 10% of the flies (give units).

a) \( 17.112 \text{ bps} \) Give the mean of the flies that are kept.

\[ \mu + \sigma I = \frac{15}{1.2} = 12.5 \]

\[ t = 1.2 \text{ bps} \]

\[ p = 0.1 \]

b) \( 7.112 \text{ bps} \) Give the Selection Differential.

\[ \sigma I = 2.112 \text{ bps} \]

\[ I = 1.76 \]

\[ t = 1.28 \]

c) \( 16.3728 \) Give the mean of the offspring for the next generation.

\[ \mu + h^2 \sigma I = 16.3728 \]
5. (12) An individual is heterozygous for an inversion as diagrammed below:

Normal Chromosome

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
</table>

Inverted Chromosome

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>E</th>
<th>D</th>
<th>C</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
</table>

a) This inversion is \textbf{Paracentric}

b) Give the \textbf{four} chromatids that result when there is crossing over between C and D.

\[
\begin{align*}
ABC \cdot OE \cdot FG & \quad A \cdot C \cdot D \cdot E \cdot B \cdot A \\
A \cdot B \cdot E \cdot D \cdot C \cdot F \cdot G & \quad G \cdot F \cdot E \cdot D \cdot C \cdot F \cdot G
\end{align*}
\]

6. (12) Consider a plant population with the following genotypic frequencies:

\[0.2401\text{ AA } + 0.4998\text{ Aa } + 0.2601\text{ aa}\]

a) Give the allelic frequencies.

\[
\begin{align*}
A & = 0.49 \\
a & = 0.51
\end{align*}
\]

b) This population undergoing migration from a large population with genotypic frequencies 0.01 AA + 0.18 Aa + 0.81 aa. The migration rate is 0.30. Calculate the allele frequency for A after one generation.

\[
\begin{align*}
A & = 0.373 \\
\rho & = 0.99 \\
\bar{p} & = 0.10 \\
m & = 0.3 \\
\rho' & = (1 - 0.3)(0.99) + (0.3)(0.1) \\
\rho' & = 0.373
\end{align*}
\]

c) Consider the original population in a). Assume that AA has a fitness of 1.0, Aa has a fitness of 0.8, and aa has a fitness of 0.2. Compute the allele frequency of A for the next generation.

\[
\begin{align*}
A & = 0.625903 \\
\frac{\text{Frog}}{\text{Survivor}} & \text{ AA } \text{ Aa } \text{ aa} \\
\bar{w} & = 1.2401 \cdot 0.4998 \cdot 0.2601 \\
\bar{w} & = 0.69194 \\
\rho' & = 0.396985 \cdot 0.77837 \\
\rho' & = 0.625903
\end{align*}
\]

You may need to use some of these equations:

\[
\begin{align*}
p^2W_{AA} + 2pqW_{Aa} + q^2W_{aa} & \quad (1 - m)p + mP \\
p^2 + Fpq & \quad (1 - \mu)p + \nu(1 - p) \\
p^2 + Fpq & \quad 2(1 - F)pq \\
q^2 + Fpq & \quad q^2 + Fpq
\end{align*}
\]
7. (6) These are several statements about The Central Dogma of Genetics.

1. The process is reversible.
2. Occurs many times per cell cycle.
3. Occurs naturally.
4. Used in the expression of genes.

For each process, circle the number for ALL statements that are true. Each statement can be used more than one time.

a) Replication
   1) 2) 3) 4)

b) Transcription
   1) 2) 3) 4)

c) Translation
   1) 2) 3) 4)

8. (8) These are several statements about population genetics.

1. Caused by small population size.
2. Changes allele frequencies.
3. Required for evolution to occur.

For each population genetic term, circle the number for ALL statements that are true for that type. Each statement can be used more than one time.

a) Mutation
   1) 2) 3)

b) Migration
   1) 2) 3)

c) Selection
   1) 2) 3)

d) Random Drift
   2) 3)

e) Inbreeding
   1) 2) 3)

9. (8) These are several statements about numerical chromosome mutations.

1. Down Syndrome is an example.
2. Found among many horticultural plants.
3. Autoreduction can cause this.

For each type of chromosomal mutation, circle the number for ALL statements that are true for that type. Each statement can be used more than one time.

a) Allopolyploidy
   1) 2) 3)

b) Autopolyploidy
   1) 2) 3)

c) Aneuploidy
   1) 2) 3)

d) Euploidy
   1) 2) 3)

10. (6) For each genetic defect, indicate whether it is a biosynthetic or degradative block.

a) **Biosynthetic** Degradative (Circle One) Albinism

b) **Biosynthetic** Degradative (Circle One) Phenylketonuria

c) **Biosynthetic** Degradative (Circle One) Alkaptonuria