Non-Mendelian Genetics Quiz

1. Read each question carefully. Write your response in the space provided for each part of each question. Answers must be written out in paragraph form. Outlines, bulleted lists, or diagrams alone are not acceptable and will not be scored.

Students in a class are studying patterns of inheritance using genes involved in determining the body color and wing shape of *Drosophila* flies. Each of the genes has only two alleles, one of which is completely dominant to the other.

Each student in the class performed a parental cross between a fly that is true-breeding for ebony body and vestigial wings and a fly that is true-breeding for gray body and long wings. Each student then crossed several pairs of the F_1 flies and determined the phenotypes of 500 of the resulting F_2 flies with respect to body color and wing shape. The students in the class averaged their data for the frequencies of the four possible phenotypes (Table 1).

Table 1. Averaged phenotypic data of F_2 flies

Fly Phenotype	Number of Flies $\pm 2SE_{\bar{x}}$
Ebony body and long wings	98 ± 10
Ebony body and vestigial wings	28 ± 7
Gray body and long wings	293 ± 25
Gray body and vestigial wings	81 ± 10

The students performed a second cross. The parental cross was between flies that are true-breeding for gray bodies and long wings and flies that are true-breeding for ebony bodies and curly wings. They crossed pairs of F_1 flies and determined the phenotypes of the resulting F_2 flies. The students found an approximate $3{:}1$ ratio of flies with the dominant phenotype (gray bodies and long wings) to flies with the recessive phenotype (ebony bodies and curly wings). Only a few of the flies expressed the dominant phenotype of one trait and the recessive phenotype of the other trait.

(a) In the first analysis, all of the F_1 flies from the students' crosses have the identical phenotype with respect to body color and wing shape, but the F_2 flies have four different phenotypes. **Describe** how fertilization contributes to this genetic variability.

(b) Using the template, **construct** an appropriately labeled graph, including error bars, to represent the data in Table 1. Based on the data in Table 1, **determine** whether there is a significant difference between the number of flies in each of the four phenotypes.

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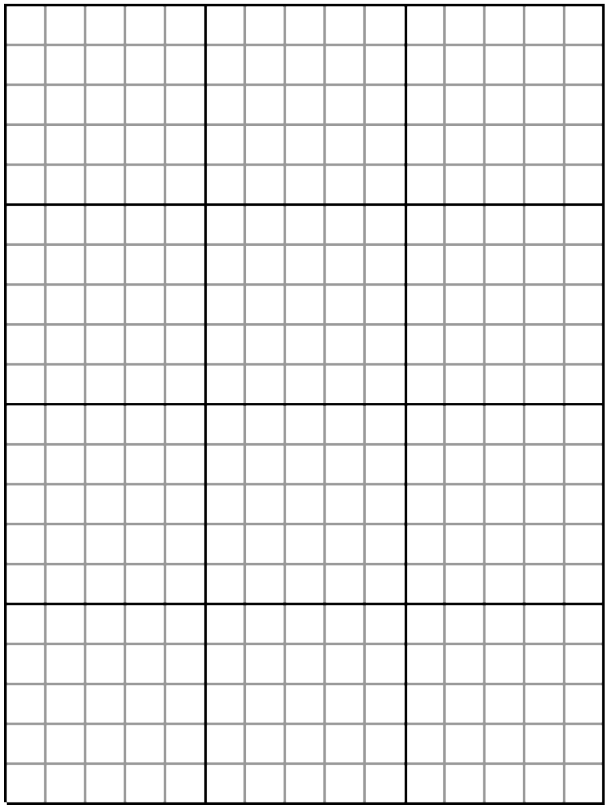
TEMPLATE FOR PART (b)



(c) Based on the data in Table 1, **describe** why the dominant alleles for body color and wing shape are the alleles that produce a gray body and long wings, respectively. Based on the data, **describe** why the two genes are most likely on different chromosomes or why they are most likely on the same chromosome. **Calculate** the probability of producing flies that have gray bodies and vestigial wings if a cross is performed between one of the F_1 flies from the first analysis and a fly that is homozygous for a gray body and vestigial wings.

(d) **Predict** the most likely cause of the F_2 ratio obtained by the students in the second analysis between parental flies that are true-breeding for gray bodies and long wings and flies that are true-breeding for ebony bodies and curly wings. Provide reasoning to **justify** your prediction.

Part A

Select a point value to view scoring criteria, solutions, and/or examples and to score the response.

0	1 ✓

The response indicates that fertilization joins gametes with different allele combinations of the genes for body color and wing shape.

Part B (i)

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Select a point value to view scoring criteria, solutions, and/or examples and to score the response.

0	1	2	3 ✓

The sketched bars meet all of the criteria below.

- ☐ Correct axis labeling
- ☐ Correct scale and unit
- ☐ Correctly plotted bar graph

Part B (ii)

Select a point value to view scoring criteria, solutions, and/or examples and to score the response.

0	1 ✓

The response indicates that based on error bars, the number of flies with the phenotype ebony body and long wings is the same as the number of flies with the phenotype gray body and vestigial wings. Based on the error bars, the numbers of flies with the two other phenotypes are significantly different from each other and from those of the first two phenotypes.

Part C (i)

Select a point value to view scoring criteria, solutions, and/or examples and to score the response.

0	1 ✓

The response indicates that flies in the largest fraction of the F_2 generation have these two traits, suggesting that the alleles for these traits are dominant.

Part C (ii)

Select a point value to view scoring criteria, solutions, and/or examples and to score the response.

0	1 ✓

The response indicates that the ratio of phenotypes is $9:3:3:1$, which is characteristic of a dihybrid cross with two

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genes that are on separate chromosomes.

Part C (iii)

Select a point value to view scoring criteria, solutions, and/or examples and to score the response.

0	1 ✓

The response indicates that the probability is 0.5. The probability of flies having gray bodies is 1.0, because the gray color is dominant and one of the flies in the cross is homozygous for a gray body. The probability of flies having vestigial wings is 0.5, because vestigial wings are recessive and one of the flies is homozygous for vestigial wings, while the F_1 fly is heterozygous for this trait. The probability of flies having the two traits is calculated by multiplying the two individual probabilities together: $1 \times 0.5 = 0.5$.

Part D (i)

Select a point value to view scoring criteria, solutions, and/or examples and to score the response.

0	1 ✓

The response indicates that in the second analysis the genes for gray or ebony body color and long or curly wings are linked on the same chromosome.

Part D (ii)

Select a point value to view scoring criteria, solutions, and/or examples and to score the response.

0	1 ✓

The response indicates that if the genes are close together/linked, the combination of parental alleles will remain unchanged except for a small percent of new combinations that result from limited crossing over in the F_1 flies as they produce gametes. The F_1 flies are heterozygous, with one chromosome that has both dominant alleles and one chromosome that has both recessive alleles. A cross between them is like a monohybrid cross. Approximately $1/4$ of the F_2 flies will be homozygous dominant for both genes, $1/2$ will be heterozygous for the two genes, and $1/4$ will be homozygous recessive for the two genes. This gives a $3:1$ phenotypic ratio of dominant to recessive for both alleles.