AP® BIOLOGY
2010 SCORING GUIDELINES

Question 3

A new species of fly was discovered on an island in the South Pacific. Several different crosses were performed, each using 100 females and 100 males. The phenotypes of the parents and the resulting offspring were recorded.

Cross I: True-breeding bronze-eyed males were crossed with true-breeding red-eyed females. All the F_1 offspring had bronze eyes. F_1 flies were crossed, and the data for the resulting F_2 flies are given in the table below.

F_2 Phenotype	**Male**	**Female**
Bronze eyes	3,720	3,800
Red eyes	1,260	1,320

Cross II: True-breeding normal-winged males were crossed with true-breeding stunted-winged females. All the F_1 offspring had stunted wings. F_1 flies were crossed, and the data for the resulting F_2 flies are given in the table below.

F_2 Phenotype	**Male**	**Female**
Normal wings	1,160	1,320
Stunted wings	3,600	3,820

Cross III: True-breeding bronze-eyed, stunted-winged males were crossed with true-breeding red-eyed, normal-winged females. All the F_1 offspring had bronze eyes and stunted wings. The F_1 flies were crossed with true-breeding red-eyed, normal-winged flies, and the results are shown in the table below.

Phenotype	**Male**	**Female**
Bronze eyes, stunted wings	2,360	2,220
Bronze eyes, normal wings	220	300
Red eyes, stunted wings	260	220
Red eyes, normal wings	2,240	2,180

Question 3 (continued)

(a) What conclusions can be drawn from cross I and cross II? **Explain** how the data support your conclusions for each cross. **(4 points maximum)**

Conclusion for cross I (1 point maximum)	**Possible explanations for cross I (1 point maximum)**
• Bronze dominant/red recessive • Autosomal (non-sex-linked)	• All F_1 /heterozygotes express dominant trait (bronze). • F_2 shows 3:1 ratio (bronze:red/dominant:recessive). • Equal distribution of F_2 phenotypes for both genders.
Conclusion for cross II (1 point maximum)	**Possible explanations for cross II (1 point maximum)**
• Stunted dominant/normal recessive • Autosomal (non-sex-linked)	• All F_1 /heterozygotes express dominant trait (stunted). • F_2 shows 3:1 ratio (stunted:normal/dominant:recessive). • Equal distribution of F_2 phenotypes for both genders.

(b) What conclusions can be drawn from the data from cross III? **Explain** how the data support your conclusions. **(4 points maximum)**

Conclusion for cross III (1 point per bullet; 2 points maximum)	**Explanation for cross III (1 point per bullet; 2 points maximum)**
• Genes linked • Crossing over • Genes 10 map units apart	• Not a 1:1:1:1 ratio (as predicted by independent assortment). • Not a 1:1 ratio/two recombinant phenotypes (unexpected). • Frequency of recombinant phenotypes was 10 percent (setup equation OK)/parental phenotypes (bronze/stunted and red/normal) are represented in 90 percent of offspring.

Question 3 (continued)

(c) **Identify** and **discuss** TWO different factors that would affect whether the island's fly population is in Hardy-Weinberg equilibrium for the traits above. **(4 points maximum)**

Identification (1 point per bullet; 2 points maximum)	**Discussion of effect (1 point per bullet; 2 points maximum)**
• Large population	• Minimized genetic drift.
• Random mating	• No gene pool change due to mate preferences.
• No mutation	• No new alleles in population.
• No immigration/emigration/ migration (no gene flow)	• No gene pool change by addition/loss of alleles.
• No natural selection	• No alleles favored or disfavored by environment.

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(b) What conclusions can be drawn from the data from cross III? **Explain** how the data support you conclusions.

(c) **Identify** and **discuss** TWO different factors that would affect whether the island's fly populatior Hardy-Weinberg equilibrium for the traits above.

a) The conclusion that may be drawn from cross I is that bronze eyes are the dominant trait in this new fly species. Crossing homozygous bronzed eyed males homozygous red eyed females produces an F_1 generation w/

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all bronze eyes. This alone suggests that the bronze trait is dominant due to the fact that heterozygous individuals are still bronze-eyed in phenotype. The notion that bronze eyes are dominant also appears in the F_2 generation, where an approximate 3:1 ratio of bronze eyes to red eyes exists. The actual ratio is 7520 : 2580, which supports the expected result of a monohybrid cross with dominance.

F_1 Bb x Bb (where B = bronze eyes, b = red eyes)

F_2

	B	b
B	BB	Bb
b	Bb	bb

3:1 ratio of dominant phenotype : recessive phenotype exists.

Thus cross 1 shows the dominance of bronze eyes in this fly species.

Cross II leads to the conclusion that stunted wings are dominant. Crossing parents where the male is homozygous normal-winged and the female is homozygous stunted wing leads to an F_1 generation of solely stunted-winged offspring. This alone suggests stunted's dominance. Furthermore, crossing the F_1 flies, the offspring exhibit a 3:1 phenotypic ratio (7420 : 2480) in favor of stunted wings, which again follows the expected monohybrid with dominance cross results

F_1 Ww x Ww (where W = stunted, w = normal)

F_2

	W	w
W	WW	Ww
w	Ww	ww

3:1 ratio in which stunted wings are dominant to normal wings.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 3

Both crosses also show that the traits of eye color and wing shape are not sex linked as equal ratios of each type of trait appear in male and female flies.

b) The test cross of cross III reveals that crossing over occurs between these two loci, which are probably on the same chromosome.

(B = Bronze, b = red; W = stunted, w = normal)

P_1 BBWW × bbww

F_1 BbWw

BbWw × bbww

	BW	bW	Bw	bw
bw	BbWw	bbWw	Bbww	bbww

F_2 1 : 1 : 1 : 1

The expected phenotypic ratios ~~show that there should~~ be equal numbers of each type of F_2 fly.

However, the F_2 offspring have way more bronze/stunted and red/normal flies when compared with bronze/normal and red/stunted flies. Thus, crossing over had to occur to cause these skewed frequencies in favor of the two phenotypes. This crossing over frequency was probably relatively high if it caused data that favored bronze/stunted and red/normal this heavily. Thus, we can conclude that the loci for eye color and wing shape are on the same chromosome and that crossing over did occur as no evidence of independent assortment can be found in this cross.

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C) Two factors that affect Hardy-Weinberg equilibrium are the population size and the amount of gene flow. The size of the population is key in that a large population size is a main component of Hardy-Weinberg equilibrium. The large population can override or mask mutations that may occur, which helps in maintaining equilibrium. Another key factor is gene flow because a population in Hardy-Weinberg equilibrium has little to no gene flow or, in other words, very few or ideally no new alleles are introduced into the population. This constant allele frequency helps to maintain equilibrium.

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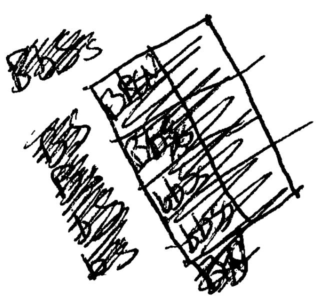

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(a) What conclusions can be drawn from cross I and cross II? **Explain** how the data support your conclusions for each cross.

(b) What conclusions can be drawn from the data from cross III? **Explain** how the data support your conclusions.

(c) **Identify** and **discuss** TWO different factors that would affect whether the island's fly population is in Hardy-Weinberg equilibrium for the traits above.

A) Data drawn from cross I shows that the bronze eyed allele is dominant. This is shown because when the parents mated, all offspring where heterozygous. When these mate, the

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3B2

ratio of phenotypes would be 3:1, 3 being the dominant phenotype, and the ratio of the results was roughly 3 bronze : 1 red. Cross II showed that stunted wings were dominant in the same way. All of the F_1 generation, which where heterozygous, had stunted wings. Even from there you can see that stunted are dominant because all flys contain both alleles for the gene, yet stunted wings are expressed.

B) The conclusion that the F_1 generation was heterozygous for both genes can be seen through the results that were gathered. This is because if they were homozygous dominant, then all of the offspring would be too because the bronze eyes and stunted wings are dominant. The data shows that all four possible phenotypes were expressed, and since the flys that were breeded with the F_1 were homozygous recessive, the F_1 generation has to be heterozygous for both.

C) Mutations could affect the traits that were discussed because the mutation could cause the fly to have white eyes. When this happens, the gene for the white eye will be introduced into the gene pool. Another thing that has to happen in order to keep the equilibrium is that random mating must occur. If random mating does not occur, then whichever allele becomes

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more desirable will attract the most mates. ~~They~~ the allele that doesn't attract mates will begin to become less ~~frequent~~ frequent in the population as a result and equilibrium will be thrown off.

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3a.) in cross I brone eyed males where crossed with red eyed females and in F_1 all of them had bronze eyes so that must be the dommant allele. In cross II norma winged males were crossed with stunted winged femal

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and in F_1 all the offspring had stunted wings so that must be the dominant allele as well. and the data table shows that as well.

	B	B
R	BR	BR
r	Br	Br

3b.) In cross III it shows that the dominant homozygous fly would have bronze eyes & stunted wings

3c.) If there are no mutations and the flies can reproduce and if there is random mating or Natural selection.

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Question 3

Overview

This question offered an opportunity to demonstrate fundamental knowledge about the Mendelian inheritance of single gene traits with complete dominance as well as the opportunity to recognize and explain the effects of gene linkage on phenotype. The question further provided an opportunity to project an understanding of genetics from the level of individual flies to the level of population genetics by discussing the effects of genetic change on Hardy-Weinberg equilibrium. Data tables containing the phenotypic results of three different fly crosses were provided. Cross I showed the F_2 data of a cross between two heterozygotes for eye color (bronze versus red). Cross II showed the F_2 data of a cross between two heterozygotes for wing type (stunted versus normal wings). Both sets of data indicated a typical autosomal dominant form of inheritance. In part (a) students were asked to draw conclusions from the cross I and cross II data and then explain how the data supported their conclusions. Data from a third cross showed the results of crossing a heterozygote for both traits with a fly that was recessive for both. The data clearly indicated linkage between the genes for eye color and wing type. In part (b) students were again asked to draw conclusions from the data and to explain how the data supported their conclusions. In part (c) students were asked to identify and discuss two factors that would affect the Hardy-Weinberg equilibrium of the fly population.

Sample: 3A
Score: 10

In part (a) 1 point was earned for the conclusion that in cross I "bronze eyes are the dominant trait." One point was earned for the explanation of the cross I conclusion by stating that the cross between homozygous parents "produces an F_1 generation w/ all bronze eyes." The response earned the 2-point maximum from cross I but also could have been awarded a point for noting that the F_2 generation had "an approximate 3:1 ratio of bronze eyes to red eyes." For cross II, 1 point was earned for the conclusion that "stunted wings are dominant." One point was earned for the explanation that the parental cross "leads to an F_1 generation of solely stunted-winged offspring." Again, the 2-point maximum was reached for this section; however, another point could have been earned for explaining how the F_2 data support the conclusion of the dominance of stunted wings. Furthermore, if the maximum points for part (a) had not already been earned, all 4 points in part (a) could have been earned by the response that "[b]oth crosses also show that … eye color and wing shape are not sex linked as equal ratios of each … trait appear in male and female flies."

In part (b) 1 point was earned for the statement that "crossing over occurs between these two loci," and 1 point was earned with the response that these loci "are probably on the same chromosome." After stating and demonstrating with a Punnett square that the expected phenotype ratio for cross III should be 1:1:1:1, the student notes that, "[h]owever, the F_2 offspring have way more bronze/stunted and red/normal flies when compared with bronze/normal and red/stunted flies." This response earned 2 points: 1 point for noting that there was not a 1:1:1:1 ratio as would be predicted by independent assortment, and 1 point for explaining that the frequency of parental phenotypes is much greater than that of the recombinant phenotypes.

In part (c) 2 points were earned for identifying "population size and the amount of gene flow" as two factors that affect Hardy-Weinberg equilibrium. An additional point could have been awarded for discussion of the effect of gene flow on the population, had the response not already earned the maximum 10 points.

Question 3 (continued)

Sample: 3B
Score: 8

In part (a) 1 point was earned for the cross I conclusion that "the bronze eyed allele is dominant." One point was earned for the explanation that when the heterozygous offspring of the original parents mated, the F_2 "ratio of phenotypes would be 3:1, 3 being the dominant phenotype, and the ratio of the results was roughly 3 bronze:1 red." One point was earned for the cross II conclusion that "stunted wings were dominant," and 1 point was earned for the explanation that "[a]ll of the F_1 generation … had stunted wings."

No points were earned in part (b).

In part (c) 1 point was earned for identifying that mutations could affect Hardy-Weinberg equilibrium, and 1 point was earned for explaining that a mutation such as "white eyes" could introduce new genes into the gene pool. One point was earned for identifying random mating as a second factor that could affect Hardy-Weinberg equilibrium, and 1 point was earned for the discussion that "[i]f random mating does not occur, … [t]he allele that doesn't attract mates will begin to become less frequent in the population … and equilibrium will be thrown off."

Sample: 3C
Score: 6

In part (a) 1 point was earned for explaining the conclusion to cross I by stating that "in F_1 all of them had bronze eyes," and 1 point was earned for the cross I conclusion with the statement, "so that must be the dominant allele." One point was earned for explaining the cross II conclusion — "in F_1 all the offspring had stunted wings" — and 1 point was earned for the cross II conclusion, "so that must be the dominant allele."

No points were earned in part (b).

In part (c) 2 points were earned for identifying "no mutations" and "random mating" as two factors that affect Hardy-Weinberg equilibrium.