
AP Biology

Sample Student Responses and Scoring Commentary

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AP[®] BIOLOGY

2018 SCORING GUIDELINES

Question 7

In the tongue sole fish (*Cynoglossus semilaevis*), sex is determined by a combination of genetics and environmental temperature. Genetically male fish have two Z chromosomes (ZZ), and genetically female fish have one Z chromosome and one W chromosome (ZW). When fish are raised at 22°C, ZZ fish develop into phenotypic males and ZW fish develop into phenotypic females. However, when fish are raised at 28°C, the Z chromosome is modified (denoted as Z*). Z*W individuals develop as phenotypic males that are fertile and can pass on the Z* chromosome to their offspring even when the offspring are raised at 22°C. A cross between a ZW female and a Z*Z male is shown in the Punnett square below.

	Z	W
Z*	Z* Z	Z* W
Z	Z Z	Z W

- (a) **Predict** the percent of phenotypic males among the F₁ offspring of the cross shown in the Punnett square if the offspring are raised at 22°C.

Prediction (1 point)

75%

- (b) At least one Z or Z* chromosome is necessary for survival of the fish. A researcher crossed two fish and observed a 2:1 ratio of males to females among the offspring. Based on the information, **identify** the genotype of the male parent in the cross. **Describe** ONE fitness cost to the female of mating with this particular male.

Identification (1 point)

Z* W

Description (1 point)

- Fewer offspring will develop/survive.
- 1/4 of the offspring are predicted to die.
- Some of her offspring will have the Z* chromosome/all of her male offspring will have a Z* chromosome.

7A

7. In the tongue sole fish (*Cynoglossus semilaevis*), sex is determined by a combination of genetics and environmental temperature. Genetically male fish have two Z chromosomes (ZZ), and genetically female fish have one Z chromosome and one W chromosome (ZW). When fish are raised at 22°C, ZZ fish develop into phenotypic males and ZW fish develop into phenotypic females. However, when fish are raised at 28°C, the Z chromosome is modified (denoted as Z*). Z*W individuals develop as phenotypic males that are fertile and can pass on the Z* chromosome to their offspring even when the offspring are raised at 22°C. A cross between a ZW female and a Z*Z male is shown in the Punnett square below.

	Z	W
Z*	Z*Z	Z*W
Z	ZZ	ZW

$Z^* \quad W$
 $Z \quad Z^*Z \quad ZW$
 $W \quad Z^*W \quad WW$

- (a) Predict the percent of phenotypic males among the F₁ offspring of the cross shown in the Punnett square if the offspring are raised at 22°C.
- (b) At least one Z or Z* chromosome is necessary for survival of the fish. A researcher crossed two fish and observed a 2:1 ratio of males to females among the offspring. Based on the information, identify the genotype of the male parent in the cross. Describe ONE fitness cost to the female of mating with this particular male.

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(a) The percent of phenotypic males among the F₁ offspring of the cross shown in the Punnett square if the offspring are raised at 22°C is about 75%.

(b) The genotype of the male parent in the cross is Z*W. A fitness cost of the female of mating with this particular male would be that only 75% of their offspring will survive, as 25% percent of the offspring will have a genotype of WW, which in turn shows the reduction of offspring survival.

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7B,

7. In the tongue sole fish (*Cynoglossus semilaevis*), sex is determined by a combination of genetics and environmental temperature. Genetically male fish have two Z chromosomes (ZZ), and genetically female fish have one Z chromosome and one W chromosome (ZW). When fish are raised at 22°C, ZZ fish develop into phenotypic males and ZW fish develop into phenotypic females. However, when fish are raised at 28°C, the Z chromosome is modified (denoted as Z*). Z*W individuals develop as phenotypic males that are fertile and can pass on the Z* chromosome to their offspring even when the offspring are raised at 22°C. A cross between a ZW female and a Z*Z male is shown in the Punnett square below.

	Z	W	
Z*	Z*Z male	Z*W female	
Z	ZZ male	ZW female	

- (a) Predict the percent of phenotypic males among the F_1 offspring of the cross shown in the Punnett square if the offspring are raised at 22°C.
- (b) At least one Z or Z* chromosome is necessary for survival of the fish. A researcher crossed two fish and observed a 2:1 ratio of males to females among the offspring. Based on the information, identify the genotype of the male parent in the cross. Describe ONE fitness cost to the female of mating with this particular male.

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a. 50% of the offspring will be phenotypic males.

b. The genotype of the male was Z*W. A fitness cost to the female is a decrease in the survivability of offspring. A female increases its fitness by having many offsprings that survive to pass on the genes and increase the species survivability. But by mating with a Z*W male the chance of having all healthy offspring out of 4 of offspring decreases.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 7

	Z^+	W		
Z	Z^+Z	ZW		
W	Z^+W	WW	ZW	Female
			Z^+W	male
			Z^+Z	male
				WW cannot survive

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7. In the tongue sole fish (*Cynoglossus semilaevis*), sex is determined by a combination of genetics and environmental temperature. Genetically male fish have two Z chromosomes (ZZ), and genetically female fish have one Z chromosome and one W chromosome (ZW). When fish are raised at 22°C, ZZ fish develop into phenotypic males and ZW fish develop into phenotypic females. However, when fish are raised at 28°C, the Z chromosome is modified (denoted as Z*). Z*W individuals develop as phenotypic males that are fertile and can pass on the Z* chromosome to their offspring even when the offspring are raised at 22°C. A cross between a ZW female and a Z*Z male is shown in the Punnett square below.

	Z	W
Z*	Z*Z	Z*W
Z	ZZ	ZW

- (a) Predict the percent of phenotypic males among the F₁ offspring of the cross shown in the Punnett square if the offspring are raised at 22°C.
- (b) At least one Z or Z* chromosome is necessary for survival of the fish. A researcher crossed two fish and observed a 2:1 ratio of males to females among the offspring. Based on the information, identify the genotype of the male parent in the cross. Describe ONE fitness cost to the female of mating with this particular male.

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~~a) 25% of the offspring are males~~

a) in the F₁ offspring cross, 25% of the offspring will be phenotypic males

b) The male parent in the cross would have the genotype of Z*Z. This would have a negative effect on the female mating with this male because 25% of her offspring are not expected to live.

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2018 SCORING COMMENTARY

Question 7

Overview

This question presented students with information about how environmental temperatures can impact sex determination in a species of fish. Information was provided on the ZW sex determination system in the tongue sole fish (males are ZZ, and females are ZW). If fish are raised at 28°C instead of 22°C, the Z chromosome is modified (Z^*) and Z^*W individuals develop as phenotypic, fertile males. The students were shown a Punnett square of a cross between a Z^*Z male and a ZW female and asked to predict the percent of phenotypic males that might result from that cross. Further information was provided that all fish must have a Z or Z^* chromosome to survive, and the results of another genetic cross were given. The question asked students to use those results to identify the genotype of the male in the cross and to describe one fitness cost to the female in the cross as a result of that particular mating.

The key understandings and skills students were expected to demonstrate included the following:

- Concepts of Mendelian and non-Mendelian inheritance patterns, along with the impact of abiotic factors, were used to determine outcomes of a cross and to indicate the genotypes of the individuals involved in a cross.
- The relationship among genotype, phenotype, and the environment was used to describe the reproductive fitness of an individual.

Sample: 7A

Score: 3

The response earned 1 point in part (a) for predicting that 75 percent of the F_1 offspring would be phenotypically male. The response earned 1 point in part (b) for identifying Z^*W as the genotype of the male parent in the cross. The response earned 1 point in part (b) for describing that one fitness cost to the female is “only 75% of their offspring will survive.”

Sample: 7B

Score: 2

The response earned 1 point in part (b) for identifying Z^*W as the genotype of the male parent in the cross. The response earned 1 point in part (b) for describing that one fitness cost to the female is a “decrease in the survivability of offspring.”

Sample: 7C

Score: 1

The response earned 1 point in part (b) for describing that one fitness cost to the female is “25% of her offspring are not expected to live.”