Unit 5 Progress Check: FRQ

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.

The sex of an organism is typically determined genetically, but environmental factors can also play a role. Scientists examined the roles of genes and environmental temperature in the sex determination of a lizard species. Individuals with a ZW pair of chromosomes are always female (ZWf), while individuals with a ZZ pair of chromosomes can be either male (ZZm) or female (ZZf). Scientists mated ZWf or ZZf females with ZZm males and incubated the eggs produced in 20 clutches at temperatures ranging from $23^{\circ}\mathrm{C}$ to $36^{\circ}\mathrm{C}$. When the young hatched, the scientists determined their sexes (Table 1). Among the eggs that did not hatch, the mortality of embryonic lizards was approximately the same for both males and females.

Table 1. Fraction of female progeny produced as a function of egg incubation temperature

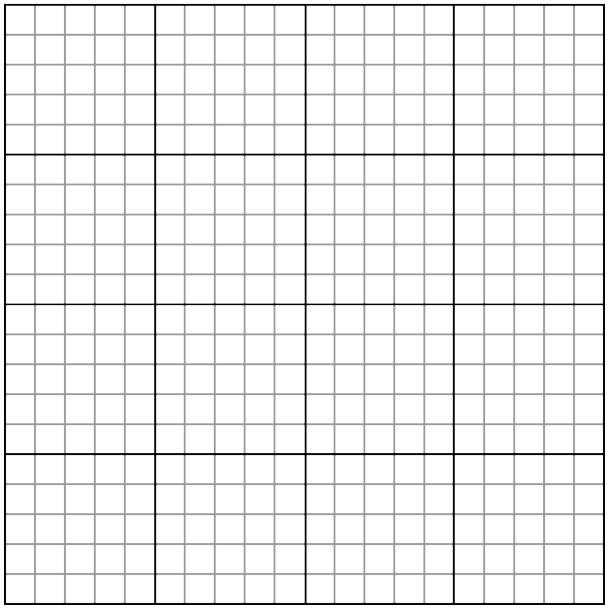
Egg Incubation Temperature ($^{\circ}\mathrm{C}$)	$\mathrm{ZZm} \times \mathrm{ZWf}$ **Crosses: Fraction of Female Progeny** $\pm 2SE_{\overline{X}}$	$\mathrm{ZZm} \times \mathrm{ZZf}$ **Crosses: Fraction of Female Progeny** $\pm 2SE_{\overline{X}}$
23	$0.5 \pm .08$	0
24	$0.5 \pm .02$	0
26	$0.5 \pm .07$	0
28	$0.5 \pm .03$	0
30	$0.5 \pm .01$	$0.03 \pm .01$
32	$0.5 \pm .03$	$0.2 \pm .02$
33	$0.58 \pm .03$	$0.52 \pm .05$
34	$0.74 \pm .04$	$0.88 \pm .04$
35	$0.93 \pm .03$	0.97 ± 0.2
36	1.0 ± 0.0	1.0 ± 0.0

(a) If a particular gene is located on the Z chromosome of this lizard species, **describe** why a lizard with a ZW genotype has a greater probability of expressing the recessive phenotype for the trait than a lizard with the ZZ genotype does.

(b) Using the template, **construct** an appropriately labeled graph, including error bars, to represent the data in Table 1. Based on the data, compare the $\mathrm{ZZm} \times \mathrm{ZWf}$ crosses and the $\mathrm{ZZm} \times \mathrm{ZZf}$ crosses to **determine** whether there is a significant difference between the two crosses in the fraction of female progeny produced at $24^{\circ}\mathrm{C}$, $32^{\circ}\mathrm{C}$, and $36^{\circ}\mathrm{C}$.

Unit 5 Progress Check: FRQ

TEMPLATE FOR PART (b)



(c) For each cross, **describe** whether genetics or temperature determines the sex of progeny produced from eggs incubated at $35^{\circ}\mathrm{C}$. For each cross, **describe** whether genetics or temperature determines the sex of progeny produced from eggs incubated at $24^{\circ}\mathrm{C}$.

(d) **Predict** the effect of increasing global temperatures on the continued presence of the W chromosome in this species of lizard. Scientists claim that, in this species, the W chromosome is unimportant in sex determination. Instead, proteins that are encoded by a gene or genes on the Z chromosome, and that are maximally expressed only at certain temperatures, are responsible for determining whether embryos will develop as females or males. Use the data to **support this claim**.

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 the lizard with the ZW genotype has only one copy of the gene, while the lizard with the ZZ genotype has two copies, one of which might be the dominant allele.

Part B (i)

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

Unit 5 Progress Check: FRQ

0	1	2	3 ✓

The sketched bars or curve meet(s) all of the criteria below.

- [ ] Correct axis labeling
- [ ] Correct scale and unit
- [ ] Correctly plotted line 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 there is no overlap of error bars between the two different crosses at 24°C or 32°C, so there is a significant difference in the fraction of female offspring produced between the different crosses at these temperatures. The data are identical for the two crosses at 36°C, so there is no significant difference at this temperature.

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 for both crosses the temperature determines that approximately all embryos will develop as females if eggs are incubated at 35°C.

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 for the $\text{ZZm} \times \text{ZWf}$ cross, genetics determines that about one-half of the embryos will develop as females if eggs are incubated at 24°C. This contrasts with the $\text{ZZm} \times \text{ZZf}$ cross, in which the temperature

Unit 5 Progress Check: FRQ

determines the sex because none of the embryos will develop as females if eggs are incubated at this low temperature.

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 the W chromosome may disappear from populations of the lizard, especially those in cooler habitats.

Part D (ii)

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

0	1 ✓

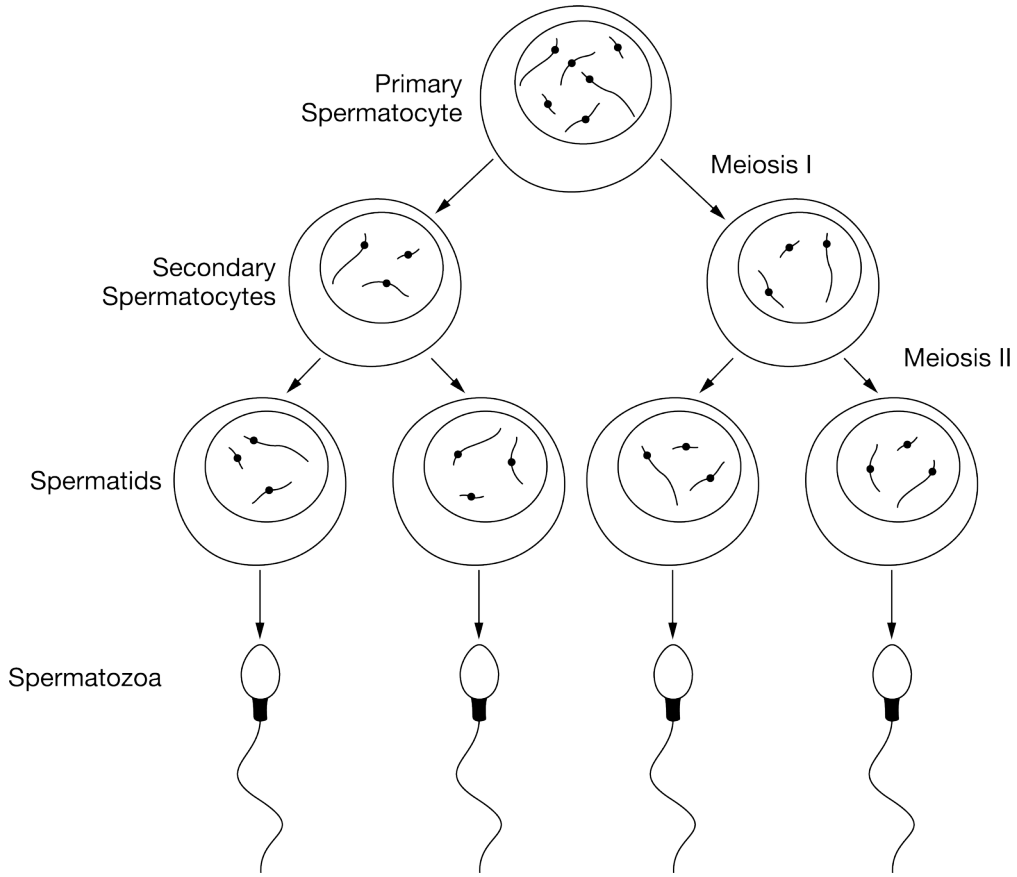
The response indicates that embryos can develop as females without the W chromosome and that embryos can only develop as males in the presence of two Z chromosomes and only at certain temperatures. Since one Z chromosome is insufficient for male development, it is likely that a sufficient amount of the Z chromosome–encoded protein is produced only from two copies of the gene(s) on this chromosome and at lower temperatures.

Unit 5 Progress Check: FRQ

2. 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.

Primary spermatocytes are diploid ($2n$) cells with all of the organelles typically found in eukaryotic animal cells. A representation of spermatogenesis from a primary spermatocyte with six chromosomes is shown in Figure 1.

Figure 1. A representation of spermatogenesis



(a) **Describe** the process in meiosis that ensures that both maternal and paternal chromosomes are passed on to each spermatozoon.

(b) **Explain** why the genetic content of individual chromosomes in a spermatozoon most likely differs from the genetic content of individual chromosomes in a primary spermatocyte.

(c) In some instances, meiosis of a primary spermatocyte with six chromosomes results in two spermatozoa that contain four chromosomes and two spermatozoa that contain two chromosomes. **Predict** the most likely cause.

(d) A student claims that if the animal producing the spermatozoa has a mutation in a mitochondrial gene, the

Unit 5 Progress Check: FRQ

probability that any offspring will inherit the mutation is zero. **Provide evidence to support** this claim.

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 the homologous pairs of chromosomes randomly segregate during meiosis I.

Part B

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

0	1 ✓

The response indicates that crossing over/recombination occurs between chromatids of homologous chromosomes during prophase of meiosis I.

Part C

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

0	1 ✓

The response indicates that the most likely cause is the nondisjunction (no separation) of one pair of homologous chromosomes during meiosis I.

Part D

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

0	1 ✓

The response indicates that spermatozoa contain no mitochondria and that all mitochondria in an organism are derived from the ovum.