2026

# AP® Biology

## Free-Response Questions

# BIOLOGY
## SECTION II
## TIME – 1 HOUR AND 30 MINUTES

**Directions:**

Section II has 6 questions and lasts 1 hour and 30 minutes.

Read each question carefully and completely. Do not spend time restating the questions or providing more than the number of examples called for. Labeled diagrams may be used to supplement your response(s), but a diagram alone will not receive credit.

You may use the available paper for scratch work and planning, but only work written in the free-response booklet will be scored. Any work done on scratch paper will not be scored. Label parts (e.g., A, B, C) and sub-parts (e.g., i, ii, iii) as needed. Use a pencil or a pen with black or dark blue ink to write your responses.

A calculator is allowed in this section. You may use a handheld calculator that is approved for this exam or the calculator available in this application. Reference information, including equations and formulas, can be used throughout the exam. A digital version is available in this application.

You may pace yourself as you answer the questions in this section, or you may use these optional timing recommendations:

Questions 1 and 2 are long free-response questions, and it is suggested that you spend about 25 minutes on each. Questions 3 through 6 are short free-response questions, and it is suggested that you spend about 10 minutes on each.

You can go back and forth between questions in this section until time expires. The clock will turn red when 5 minutes remain—**the proctor will not give you any time updates or warnings.**

Note: This exam was originally administered digitally. It is presented here in a format optimized for teacher and student use in the classroom.

During the AP Exam administration, students have access to reference information. To see the reference information for this course, please visit AP Central: https://apcentral.collegeboard.org/exam-administration-ordering-scores/administering-exams/subject-specific/reference-information

**The following information applies to all parts.**

**1.** Molecules known as dinucleoside polyphosphates, a type of nucleotide, are signaling molecules that accumulate in plant cells during dry or stressful conditions.

**Part A**

**Describe** the three structural components of a nucleotide.

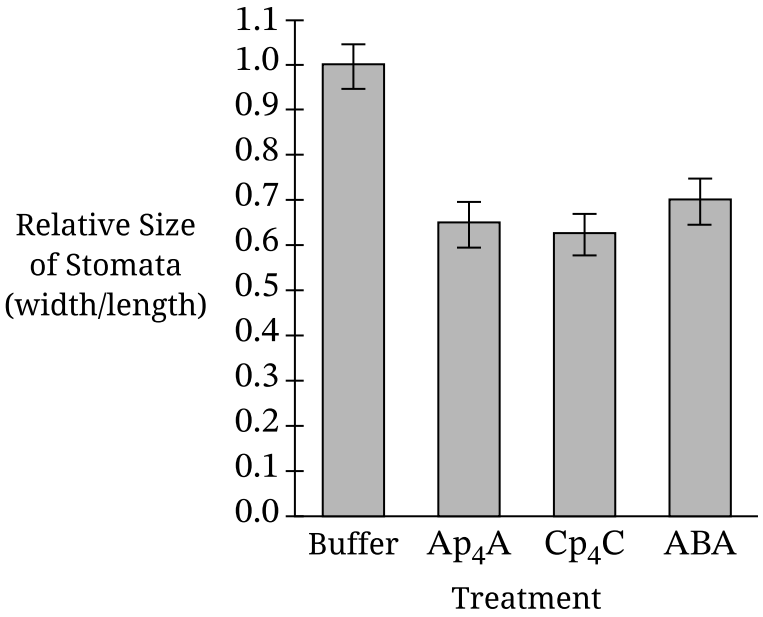
**The following information applies to parts B, C, and D.**

Stomata are pores on the surface of leaves that open when exposed to light and regulate the flow of carbon dioxide, oxygen, and water vapor in and out of a plant. In response to dry environmental conditions, many plants close their stomata, which reduces water loss.

Scientists hypothesized that the dinucleoside polyphosphates $Ap_4A$ and $Cp_4C$ bind to DORN1 receptors on the plasma membrane of plant cells and initiate signaling cascades that cause stomata to close. The scientists exposed plants to light to open the stomata and then placed samples of the leaves in buffer alone or in buffer containing one of three different compounds: $Ap_4A$, $Cp_4C$, or abscisic acid (ABA), a molecule that causes stomata to close.

The scientists measured the size of the stomata in each sample and calculated their sizes relative to the size of the stomata in the sample kept in buffer alone, as shown in Figure 1.

**Figure 1. Effect of $Ap_4A$, $Cp_4C$, and ABA on Relative Stomatal Size (Error Bars Represent $\pm SE_{\bar{x}}$)**



**Part B**

i. **Identify** the dependent variable in the scientists' first experiment.

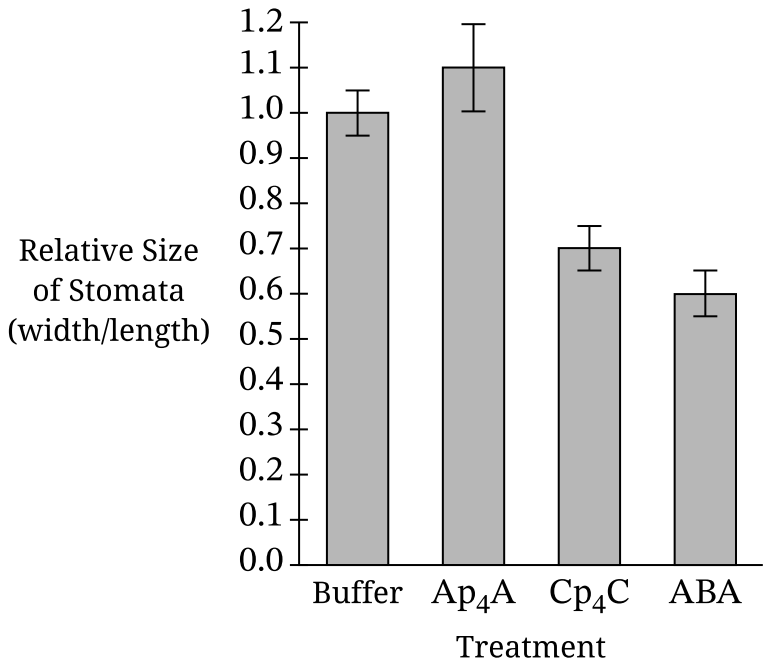
ii. Based on Figure 1, **describe** the relative size of the stomata in the $Cp_4C$ treatment group as compared with the size of the stomata in the group treated with buffer alone.

iii. **Justify** the use of buffer alone as a control in the scientists' experiments.

**Part C**

In a second experiment, the scientists used plants that were identical to those in the first experiment except that the gene encoding the DORN1 receptor was mutated. The scientists repeated the procedure of the first experiment. Their results are shown in Figure 2.

**Figure 2. Effect of $Ap_4A$, $Cp_4C$, and ABA on Relative Stomatal Size in DORN1 Mutants (Error Bars Represent $\pm SE_{\bar{x}}$)**




i. **Justify** the scientists' treating one sample of leaves with ABA in the experiments.

ii. Based on Figure 2, **describe** the difference between the effects of $Ap_4A$ and $Cp_4C$ treatments on the size of stomata in plants with mutated DORN1 receptors.

iii. Activation of DORN1 receptors induces plant cells to produce certain molecules that cause the stomata to close. Based on the data in Figures 1 and 2 for cells treated with $Ap_4A$, **predict** the relative production of the molecules by DORN1-mutated cells in comparison to the production by nonmutated cells.

**Part D**

The DORN1 receptor transmits signals that result in an increase in the transcription of genes involved in plant defenses. The scientists then developed DORN1-mutant plants in which the DORN1 receptor lacked most of its intracellular domain.

i. In cells homozygous for this mutation, **predict** the effect of $Ap_4A$ treatment on transcription of the genes involved in plant defenses relative to the effect of $Ap_4A$ on nonmutated cells.

ii. **Justify** your prediction.

**The following information applies to all parts.**

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**2.** Eukaryotic cells use small interfering RNA (siRNA) molecules that regulate the expression of certain genes by binding to complementary sequences in target mRNAs. This binding causes the protein AGO2 to cleave the target mRNAs. As a result of the cleavage, the mRNAs are not translated.

**Part A**

**Describe** one location where ribosomes are found in eukaryotic cells.

**The following information applies to parts B, C, and D.**

To investigate the role of AGO2 in the cleavage of mRNA transcribed from two genes, Gene *G* and Gene *H*, scientists determined the amount of Gene *G* and Gene *H* mRNA produced in cells with three different *AGO2* genotypes:

- Homozygous for the wild-type AGO2 protein ($AGO2^{+/+}$)
- Heterozygous for the allele encoding a nonfunctional AGO2 protein ($AGO2^{+/-}$)
- Homozygous for the allele encoding a nonfunctional AGO2 protein ($AGO2^{-/-}$)

The scientists then calculated the amount of Gene *G* and Gene *H* mRNA produced from cells of each genotype relative to that in $AGO2^{+/+}$ cells. These results are shown in the table.

**Relative Average Amounts of Gene *G* and Gene *H* mRNA in Cells with Different *AGO2* Genotypes**

| | mRNA in $AGO2^{+/+}$ Cells $\pm$ $SE_{\bar{x}}$ | mRNA in $AGO2^{+/-}$ Cells $\pm$ $SE_{\bar{x}}$ | mRNA in $AGO2^{-/-}$ Cells $\pm$ $SE_{\bar{x}}$ |
|---|---|---|---|
| Gene *G* | 1.0 ± 0.1 | 0.9 ± 0.4 | 1.5 ± 0.5 |
| Gene *H* | 1.0 ± 0.1 | 2.0 ± 0.1 | 3.0 ± 0.4 |

**Part B**

i. Using the template in the space provided for your response, **construct** a bar graph that represents the data in the table. Your graph should be appropriately plotted and labeled.

ii. Based on the table, **determine** all the cells in which the amount of Gene *G* mRNA produced is statistically the same as the amount in the cells with the $AGO2^{+/+}$ genotype.

**Part C**

i. Based on the table, **describe** the relationship between the number of wild-type copies of the *AGO2* gene and the amount of Gene *H* mRNA in the cells.

ii. Based on the data in the table for Gene *H*, **calculate** the percent by which the average amount of mRNA in $AGO2^{-/-}$ cells increases compared with that in $AGO2^{+/-}$ cells.

**Part D**

i. The scientists claim that siRNA binding and AGO2 cleavage of mRNAs play a greater role in the regulation of Gene *H* expression than in the regulation of Gene *G* expression. Based on the table, **support** the scientists' claim.

ii. Anaphase I of meiosis is blocked in mice with the $AGO2^{-/-}$ genotype. Scientists hypothesize that the block in meiosis occurs because the continued presence of a spindle-fiber stabilizing protein prevents the chromosomes from separating. Based on the table, **explain** how the $AGO2^{-/-}$ genotype could cause this effect on the dividing cells.

**The following information applies to all parts.**

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**3.** Cyanide is a chemical that affects the enzyme cytochrome *c* oxidase (CCO), a key enzyme in the mitochondrial electron transport chain. At high cyanide concentrations, CCO activity is much lower than when no cyanide is present. At low concentrations of cyanide, CCO activity is slightly higher than when no cyanide is present, as shown in Table 1.

**Table 1. Effects of Cyanide on CCO Activity**

| No Cyanide | Low Cyanide | High Cyanide |
|---|---|---|
| Normal CCO activity | Slightly increases CCO activity | Greatly decreases CCO activity |

Some strains of bacteria produce cyanide, which they then release into their environment. Other strains of bacteria do not produce cyanide. Researchers grew both types of bacteria in high-concentration nutrient medium and then isolated the medium from the bacteria. One-half of each medium sample was left at a high concentration, while the concentration of the other half was lowered.

To study the effects of cyanide on mammalian cells, researchers then added the four samples of media to the cells growing in culture dishes, as shown in Table 2. They measured ATP and lactic acid production by the mammalian cells in each of the four treatment groups.

**Table 2. Experimental Design to Test Effects of Cyanide on Mammalian Cells**

| Mammalian Cell Treatment Group | Cyanide in Nutrient Medium? | Concentration of Medium |
|---|---|---|
| 1 | Yes | High |
| 2 | Yes | Low |
| 3 | No | High |
| 4 | No | Low |

**Part A**

**Describe** the advantage to cells of producing ATP from one molecule of glucose by aerobic cellular respiration rather than by glycolysis alone.

**Part B**

**Identify** the two treatment groups that served as controls in the researchers' experiment.

**Part C**

Based on the information provided in both tables, **predict** the treatment group that is likely to have the highest ATP production of all four treatment groups.

**Part D**

The researchers claim that cells in which CCO activity is inhibited will show an increase in lactic acid production. **Support** the researchers' claim.

**The following information applies to all parts.**

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**4.** The process of meiosis enables animals that reproduce sexually to produce gametes.

**Part A**

**Describe** one characteristic of chromosome movement during Meiosis I.

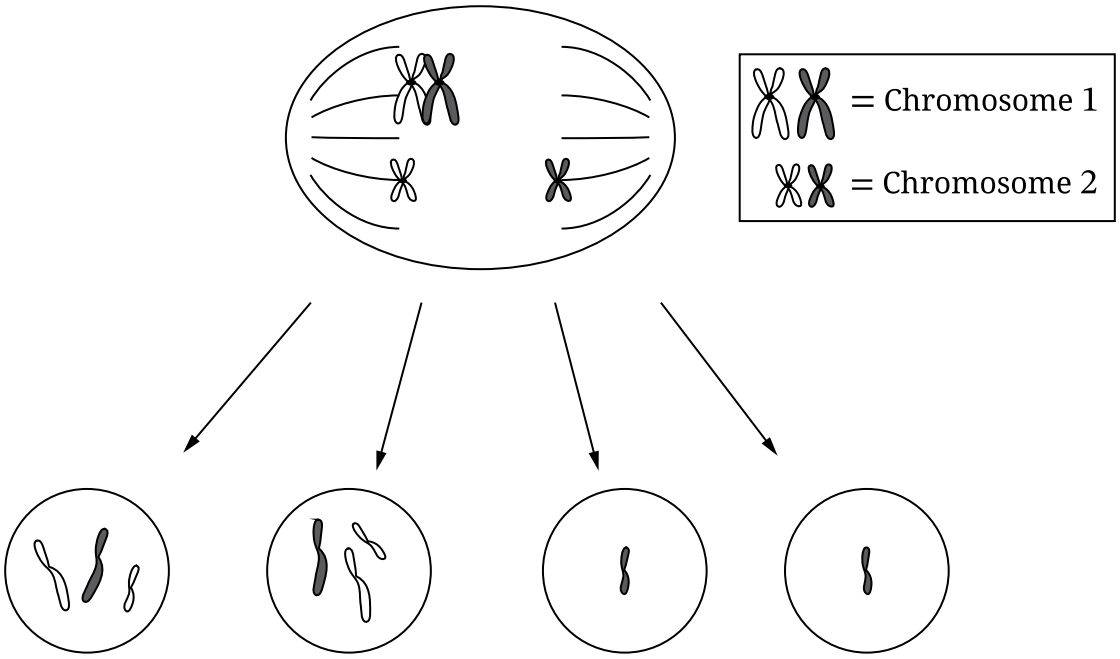
**Part B**

**Explain** why chromosomes are more visible when viewed under a microscope during mitosis or meiosis than at any other time in the cell cycle.

**Part C**

An animal cell with two pairs of homologous chromosomes (a diploid number of four) has undergone meiosis to produce four gametes, and an error occurred at one step, as shown in the figure. One set of chromosomes is represented in white, and the other set is represented in gray.

**An Animal Cell Undergoing Meiosis**




Assume that each gamete produced by the cell shown in the figure is fertilized by a gamete with a complete haploid set of chromosomes. Also assume gene regulation on Chromosome 1 is not affected by the number of copies of Chromosome 1 in the four resulting viable zygotes. **Predict** the difference in mRNA production from genes on Chromosome 1 among the four possible zygotes.

**Part D**

Triploidy describes a condition in which an organism has three complete sets of chromosomes in each cell. Provide reasoning to **justify** the claim that most organisms with triploidy cannot produce gametes with the chromosome number typical of the species.

**The following information applies to all parts.**

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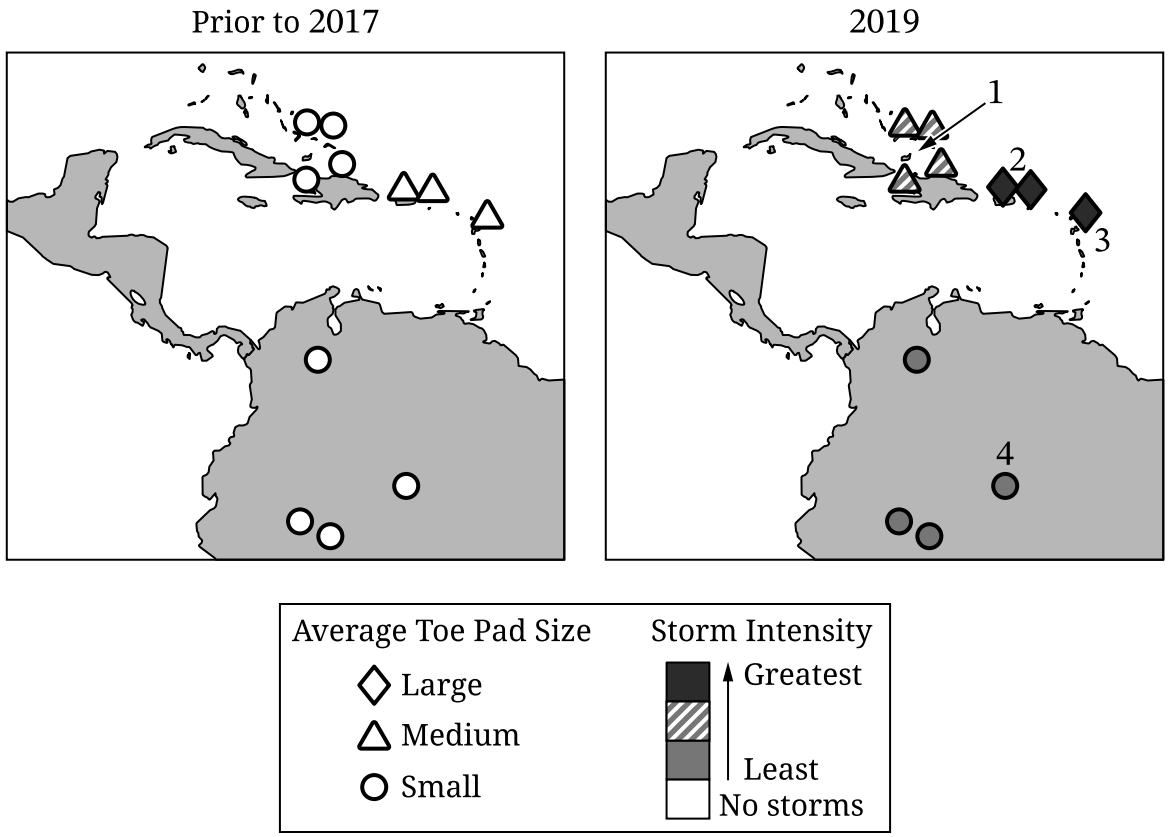
**5.** Anole lizards throughout the Caribbean islands and Central and South America have pads of varying sizes on the bottom surfaces of their toes. The sizes of the toe pads are genetically determined and not the result of phenotypic plasticity. During storms with high winds, anoles cling to trees with the help of their toe pads. In recent years, an increase in both the number and intensity of storms has occurred across the range of anole habitats.

In 2017, two very intense storms occurred in the Caribbean islands within a month. In 2019, scientists investigated the relationship between the intense storms and the average toe pad size of the offspring of lizards that survived the storms. The scientists determined the average toe pad size of the surviving offspring and grouped their measurements into three categories: small, medium, and large toe pads. The scientists then compared the 2019 toe pad measurements with measurements recorded prior to 2017. Their data are represented in the figure.

**A Map Representing Toe Pad Size Distributions Prior to 2017 and in 2019**




**Part A**

**Describe** the role that changes in abiotic factors have in natural selection.

**Part B**

Based on the figure, **explain** the relationship between storm intensity and average toe pad size.

**Part C**

**Identify** the region on the 2019 map, by indicating the number, that experienced the least storm intensity.

**Part D**

Based on the information provided, **explain** how continued differences in storm intensity can apply different selective pressures on anole populations living on the Caribbean islands, eventually leading to speciation.

**The following information applies to all parts.**

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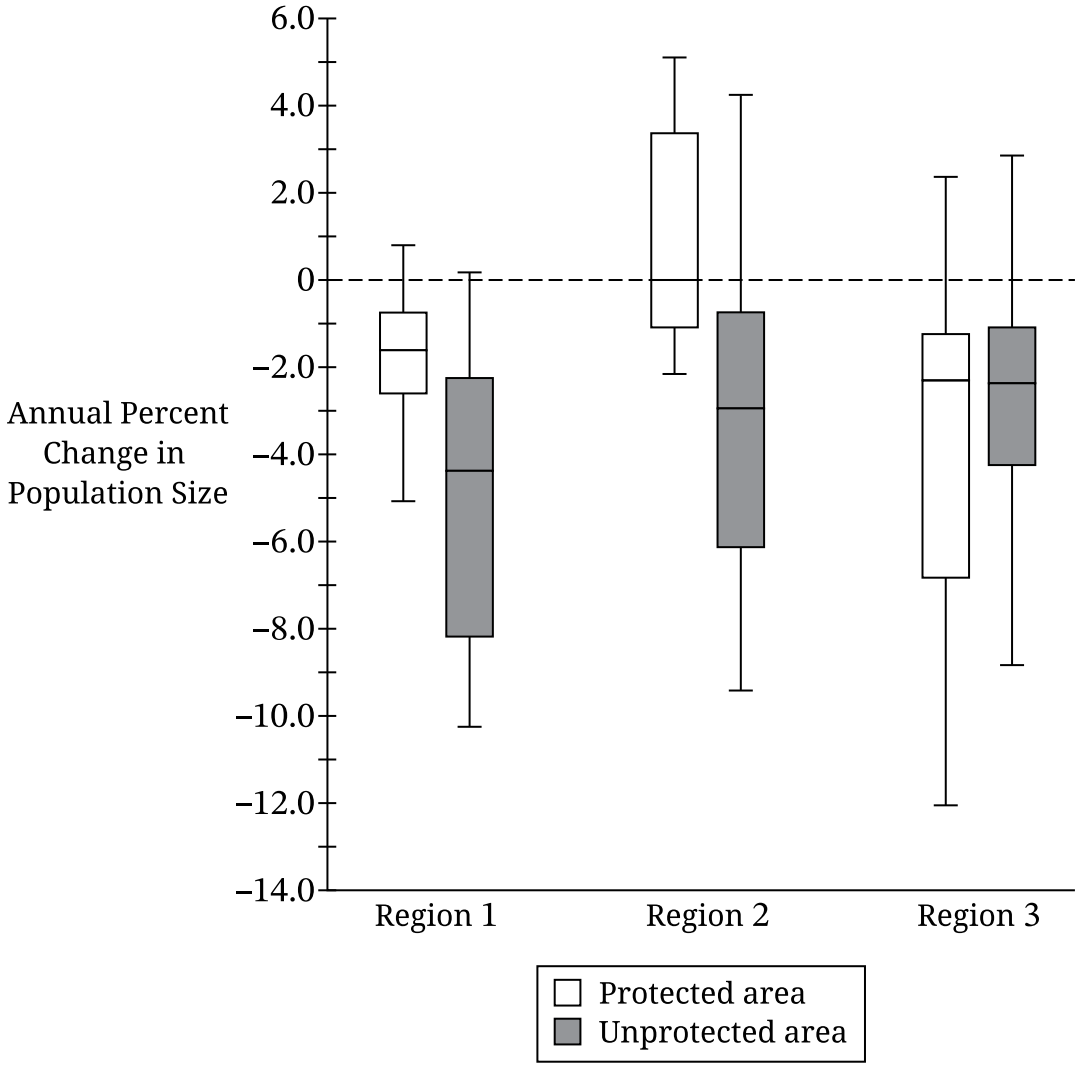
**6.** Many raptors in Africa are top predators and keystone species in their ecosystems. Raptor population sizes have been declining in recent years.

Scientists studied the relationship between the conversion of the raptors' natural habitat into farmland and the population sizes of raptors in those regions. They compiled raptor population size data from three different regions of Africa: Region 1, Region 2, and Region 3. In each of the regions, the scientists compared the annual percent change in the raptor population size in areas that were protected from farming (protected) with the annual percent change in areas where farming occurred (unprotected). Their results are shown in the box and whisker plot.

type of bird

**Median Annual Percent Change in the Population Size of Raptors in Protected and Unprotected Areas**



**Part A**

Based on the box and whisker plot, **identify** the median annual percent change in population size in the unprotected area of Region 2.

**Part B**

Based on the box and whisker plot, **identify** the region and area that experienced the greatest median annual percent change in population size.

**Part C**

Researchers hypothesize that if farming is eliminated in Region 2, there will no longer be a decline in the raptor population size. Based on the data in the box and whisker plot, **evaluate** the researchers' hypothesis.

**Part D**

Based on the information provided, **explain** why ecosystem resilience in unprotected areas may decline over time.

**STOP**

**END OF EXAM**