INTRODUCTION

The short film *The Origin of Species: Lizards in an Evolutionary Tree* introduces the anole lizards of the Caribbean. For well over 20 years, scientists have studied these lizards to understand how the different anole species and their traits have evolved. In this activity, you will examine the results from a different experiment that included a predator of anoles.

PART 1: Observations and Hypothesis

Biologist Jonathan Losos and his colleagues conducted this experiment on a group of small islands near Abaco in the northern Bahamas (Figure 1).

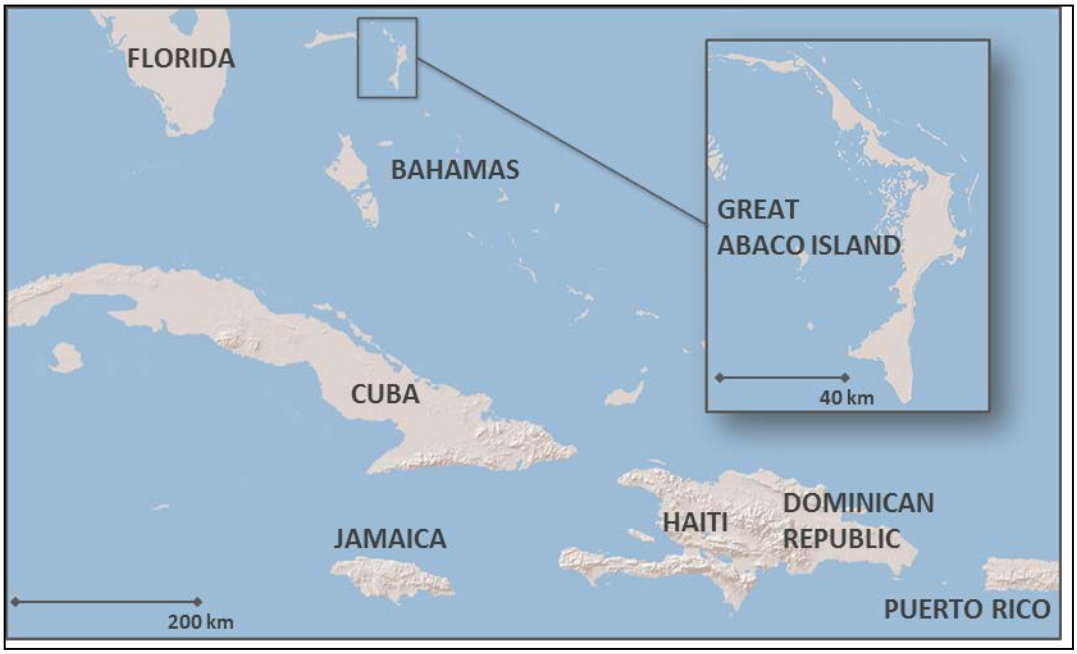

Figure 1. A map of the islands in the Caribbean Sea and North Atlantic Ocean. The inset shows Great Abaco Island in the northern Bahamas.

These islands near Abaco are home to a single species of anole, *Anolis sagrei*. These anoles spend most of their active time on the ground or on the lower parts of tree trunks, where they search for food and mates. *A. sagrei* anoles have relatively long legs compared to other species of anoles, though leg length varies among individuals in a population.

Some islands are also home to a large predatory lizard called the curly-tailed lizard (*Leiocephalus carinatus*). *L. carinatus* hunts for its prey, which includes anoles, on the ground. On islands with *L. carinatus*, scientists noticed that *A. sagrei* anoles tend to spend more time on bushes and small trees, which *L. carinatus* lizards are unable to climb (Figure 2).

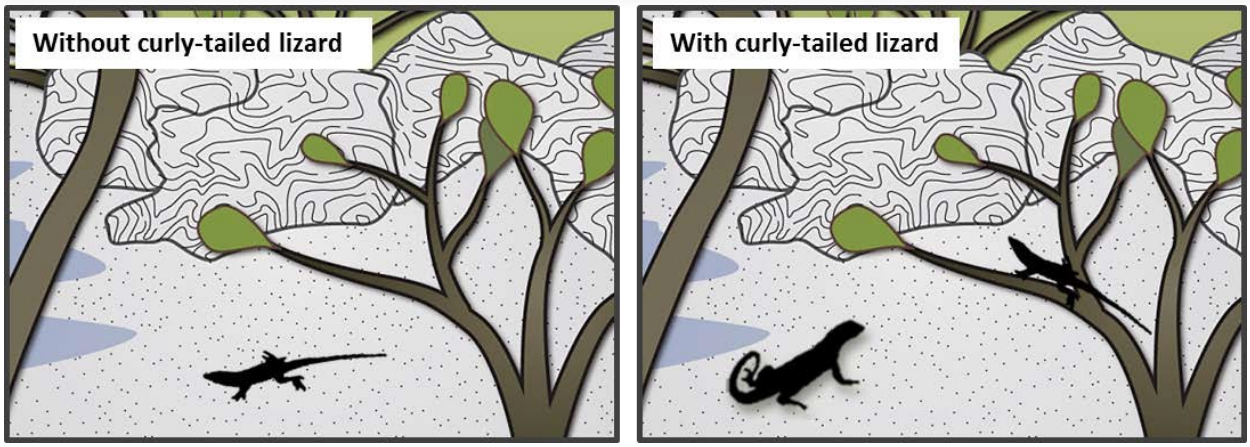

Figure 2. Illustrations of where *A. sagrei* anoles spend their time on different islands. On islands without the predator *L. carinatus* (left panel), the anoles stay mostly on the ground. On islands with *L. carinatus* (right panel), the anoles are found mostly on twigs and branches.

1. Based on these initial observations, formulate a hypothesis about how the predatory lizard *L. carinatus* affects where *A. sagrei* anoles live. Explain your reasoning.

PART 2: Hypothesis and Experiment

Losos and his colleagues hypothesized that the presence of the curly-tailed lizard, *L. carinatus*, causes *A. sagrei* anoles to live mostly above the ground, on small branches and bushes. Is this similar to the hypothesis you formulated in Part 1?

The scientists also hypothesized that, over many generations, the anoles living above the ground, on the small branches and bushes, would evolve features different from those of the anoles living on the ground.

How would you test these two hypotheses? Here is the experiment Losos and his colleagues conducted:

- They identified 12 small islands in the Bahamas with *A. sagrei* but not *L. carinatus*. Remember that on islands without *L. carinatus*, the anoles live mostly on the ground or on the lower parts of tree trunks. They only occasionally climb higher branches and bushes in this case.
- On each island, the scientists counted and marked all *A. sagrei* anoles and noted where they were found (i.e., on the ground or on branches/bushes). By marking these individuals, the scientists could track the initial populations of anoles over the course of the experiment.
- On six of the islands, the **experimental islands**, the scientists then introduced *L. carinatus*, which preys on anoles. They added one *L. carinatus* lizard for every seven *A. sagrei* anoles to ensure equal proportions on all the experimental islands. The six remaining islands without *L. carinatus* served as **control islands**.
- The scientists planned to return to each island every six months to monitor the anole populations over several generations. (One generation for *A. sagrei* is about 12 months.) During their visits, the scientists recorded how many anoles had survived and where the anoles were found (i.e., on the ground or on branches/bushes). The scientists also collected data on the anoles' hindlimb lengths.

PART 3: Data Collection and Analysis

After about a year, a hurricane swept all the lizards off the islands, ending the experiment. As a result, the scientists were only able to return to the islands twice (after 6 months and after 12 months) and could only get data on the initial populations of anoles. You will now analyze and interpret some of this data.

Your instructor will distribute 24 "island snapshot" cards, which may be divided among multiple groups of students. The cards represent *eight* of the islands in the experiment (four control islands labeled A–D, and four experimental islands labeled E–H) at *three* different times (at the start of the experiment, after 6 months, and after 12 months). Each snapshot shows only the anoles from the island's *initial* population. Over time, some of the anoles in the initial population died, so the anoles you see in the snapshots are the **survivors**. You will count the anole survivors and record their locations, just like the scientists did.

After you receive your snapshots, follow these steps:

- For each snapshot, count all the anole survivors and calculate the proportion found on the ground.
- Fill in Table 1 (number of survivors) and Table 2 (proportion of survivors on the ground) below for your snapshots. If you were given only a few snapshots, your instructor will collect results from the entire class so that you can complete both tables.
- Once both Table 1 and 2 are complete, calculate the **mean** (average) of each column and record the results in the last rows of both tables.
- Answer the questions below the tables.

Table 1. Total numbers of *A. sagrei* anoles from the initial populations, not including offspring.

NUMBER OF SURVIVORS	CONTROL ISLANDS			EXPERIMENTAL ISLANDS			
Island	**Start**	**6 Months**	**12 Months**	**Island**	**Start**	**6 Months**	**12 Months**
A				**E**			
B				**F**			
C				**G**			
D				**H**			
Mean				***Mean***			

Table 2. Proportions of *A. sagrei* anoles found on the ground.

PROPORTION ON GROUND	CONTROL ISLANDS			EXPERIMENTAL ISLANDS			
Island	**Start**	**6 Months**	**12 Months**	**Island**	**Start**	**6 Months**	**12 Months**
A				**E**			
B				**F**			
C				**G**			
D				**H**			
Mean				***Mean***			

2. Compare the mean *numbers* of anole survivors, as shown in the last row of **Table 1**. Do you see any difference in the results for the control and experimental islands over time? Explain your answer.

Some islands had more anoles than others at the start of the experiment, which can make them difficult to compare. One way to determine whether there is a difference in survival between the control and experimental islands is to calculate the survival rate for each group.

The **survival rate** for a population over a given time is the *proportion* of the population that survived over that time. A survival rate of 1 means that all individuals in the initial population survived, and a rate of 0 means they all died. To calculate the survival rate, divide the mean number of *survivors after a given time period* (e.g., after 6 or 12 months) by the mean number of *individuals in the initial population* (i.e., at the start of the experiment).

3. Use the data in Table 1 to calculate the survival rates on the control and experimental islands after 6 and 12 months. Record your results in the table below.

Survival Rate	**Equation**	**Control Islands**	**Experimental Islands**
After 6 months	$\frac{\text{mean \# after 6 months}}{\text{mean \# at the start}}$		
After 12 months	$\frac{\text{mean \# after 12 months}}{\text{mean \# at the start}}$		

4. Based on your calculations, were the anoles more likely to survive on the control or experimental islands? How would you explain this difference?

5. What additional factors could cause the anoles to die, even on control islands?

6. Compare the mean *proportions* of survivors on the ground, as shown in the last row of **Table 2**. Do you see any difference in the results for the control and experimental islands over time? Explain your answer.

So far, you have looked at your data tables to identify some trends in the proportion of anoles on the ground. It may also be helpful to visualize your results by graphing them.

7. Follow the steps below to construct a line graph for the data in **Table 2**. This graph should show the *mean proportion of anoles on the ground over time*, for both the control islands and the experimental islands.
    a. Remember that the experiment investigated how the proportion of anoles on the ground changed over time in response to a predator. What is the **independent variable** for the experiment?
    b. What is the **dependent variable** for the experiment?
    c. What will be your label for the ***x*-axis**? Make sure to include units.
    d. What will be your label for the ***y*-axis**?
    e. What will be your **title** for the graph?
    f. Create your graph in the space on the next page, making sure to add the axes labels and title you described. On your graph, plot the mean proportions for the control islands and connect the data points with lines. Do the same for the experimental islands, but with a different line color or style. Add a **legend** that distinguishes between the data for the control and experimental islands.

8. Describe any trends or patterns you see in your graph. Make sure to compare the control and experimental islands.

9. Do these data support the hypothesis you formulated in Part 1? Explain your answer.

10. Use the data you collected in Tables 1 and 2 to complete the following statement, filling in each blank with one of the following words: "smaller," "bigger," or "similar."

Compared to the control islands, on the experimental islands, a _____ number of anoles from the initial populations survived, and a _____ proportion of survivors were found primarily on the ground.

PART 4: Conclusions

In Part 3, you determined the survival rates of anoles on different islands and how the survivors used their habitat. Losos and colleagues also collected data on the lengths of the anoles' **hindlimbs**, or back legs.

11. Based on your findings in Part 3, would you predict a difference in the *average hindlimb length of surviving anoles* on experimental islands compared to those on control islands? List your predictions for each time point on the next page and explain your reasoning. (*Hint:* Think about the connection between hindlimb length and habitat use described in the film *The Origin of Species: Lizards in an Evolutionary Tree*.)

Start of experiment:

After 6 months:

After 12 months:

12. After listing your predictions, watch the short video *Selection by Predation*, in which Losos describes what he and his colleagues discovered from their experiment. Use this video to answer the following questions.
    a. What did Losos and his colleagues discover about the average hindlimb length of survivors after 6 months and after 12 months?

    b. According to the video, why did the average hindlimb length change in this way?

    c. Were these findings different from what you expected? Explain your answer.

Losos and his colleagues originally set out to study how predation affected **evolution by natural selection**. But because of the hurricane, they were able to take measurements for only one year and one generation of anoles. For evolution by natural selection to occur in a population, there has to be *variation* in a trait in that population, the variation must be *heritable*, and individuals who possess a particular version of the trait have to have a *fitness advantage* (i.e., be more likely to survive and produce more offspring) over other individuals.

13. Determine whether the predation experiment supports each of the following claims for the trait of *hindlimb length*. For each supported claim, list the evidence from the experiment that supports it. If a claim was not supported by the experiment, explain why not and what additional evidence would be needed to support the claim.
    a. There was variation in the trait among individual anoles in the population.

b. Variation in the trait was heritable.

c. Some anoles had a fitness advantage over other anoles.

d. Natural selection favored certain trait variations.

e. Beneficial trait variations were passed on to future generations, and the population evolved as anoles with traits better adapted to living on trees became more common.

14. If the scientists had been able to continue their experiment and measure the anoles on these islands over many generations, what do you predict they would have found? How might the populations have changed over many generations?