Lizards in Hurricanes

HOW TO USE THIS RESOURCE

The images for this resource show a series of anole lizards subjected to strong winds, similar to those in hurricanes. These images can serve as phenomena to explore the key concepts described below.

The pedagogical practice of using phenomena to provide a context for understanding science concepts and topics is an implementation practice supported by the Next Generation Science Standards (NGSS). Phenomena are observable occurrences that students can use to generate science questions for further investigation or to design solutions to problems that drive learning. In this way, phenomena connect learning with what is happening in the world while providing students with the opportunity to apply knowledge while they are building it.

The "Implementation Suggestions" and "Teaching Tips" sections provide options for incorporating the images into a curriculum or unit of study and can be modified to use as a standalone activity or to supplement an existing lesson. The student handout includes reproductions of the images and the "Background Information" section.

KEY CONCEPTS

A. Variations in one or more traits may provide some individuals in a population with a survival and/or reproductive advantage over other individuals.
B. Natural selection acts on variations of a trait. It is a process by which, under certain selective pressures, some individuals are more likely to survive and/or reproduce than others.
C. Selective pressure depends on the environment in which an organism lives.

NGSS PERFORMANCE EXPECTATIONS

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

BACKGROUND INFORMATION

In 2017, a team of scientists in the Caribbean was presented with a rare opportunity. The scientists were studying lizard populations on two small islands, Pine Cay and Water Cay, when hurricanes struck. The first hurricane, Hurricane Irma, brought wind speeds of up to 165 mph (miles per hour), or 265 kph (kilometers per hour). The second, Hurricane Maria, had wind speeds over 124 mph (200 kph).

Extreme climate events, such as these hurricanes, can select for certain traits. As the environment changes, selection for or against various traits can change the composition of a population. The scientists could now investigate whether the lizard populations they were studying had experienced any selection from the hurricanes. In other words, did lizards with certain trait variations have a greater chance of surviving the hurricanes?

The scientists focused on one type of lizard, an anole species called *Anolis scriptus*. They thought that the hurricanes might have acted as a selective force on the anole populations of Pine Cay and Water Cay. They hypothesized that the anoles that had survived the hurricanes would have larger toepads (the "sticky" undersides of an anole's toes), longer forelimbs, and longer hindlimbs than the anoles surveyed before the hurricanes.

To further investigate this idea, the scientists conducted an experiment with anoles in the lab. First, they placed individual anoles on wooden rods, which modeled the branches that wild anoles perch on. They then turned on a leaf blower in front of each anole to simulate strong winds, similar to those in hurricanes. The speed of the wind from the leaf blower was slowly increased until the anole let go of the rod and landed, unharmed, in a nearby net. At that point, the leaf blower was turned off. The scientists repeated this process for 47 anoles, then released all of the anoles back into the wild.

The image contains a series of snapshots from the scientists' experiment. It shows five different anoles (labeled Lizards A–E) experiencing strong winds from the leaf blower.

IMPLEMENTATION SUGGESTIONS

The following suggestions outline several options for incorporating the images into a unit of study as phenomena:

Engagement, establishing prior knowledge, and providing context:

- Begin the lesson by telling students they will be examining images of anoles, a type of lizard. These images are from an experiment that looked at how strong winds, such as those in hurricanes, might affect lizard populations. Each anole began the experiment perched on a wooden rod. It was then subjected to high-speed wind from a leaf blower.
  - Explain that the images are representative sequences of snapshots for five different anoles (labeled Lizards A–E) over time. The wind speeds at each time point are given in MPH (miles per hour) and KPH (kilometers per hour) in the top right corners of the snapshots.
  - Share with students that high-speed video was used to record each of the sequences. Examples of the footage are shown in the short *Nature* video *Natural selection in a hurricane*. Consider showing this video to students to help them visualize what is happening in the image sequences.
  - Point out that no anole was harmed by the experiment. Lizards that fell off the rods were caught in nets with protective padding. All lizards were returned to the wild unharmed at the end of the study.
- Divide students into groups of two or three and provide each group with a copy of the images. Ask the groups to list their observations for each of the image sequences. Encourage them to use the sentence stems "I notice …", "It reminds me of …", and "I wonder …"
- Use a think-pair-share protocol to have students share their observations and questions about the images. Record class observations, noting when students make similar observations and drawing attention to the range of student-generated questions.
  - Students may observe that some lizards let go of the rod at lower wind speeds than others.
  - Students may observe that the lizards' tails and hind limbs are released from the rod first.
  - Students may wonder how the lizards are able to grip the rod.
  - Students may wonder about the average size of this species and the sizes of the lizards used in the study.
  - Students may wonder how long each lizard was exposed to the wind from the leaf blower, and how long it took for each lizard to let go of the rod.
  - Students may wonder how well the leaf blower simulates the high-speed winds in hurricanes.
- Ask students to suggest one or more questions that the scientists might have been testing through this experiment. Record and discuss these questions as a class. Sample questions may include:
  - Does the size of a lizard affect its ability to cling to a surface in hurricane conditions?
  - How does the ability to cling to a surface in hurricane conditions vary within a population of anoles?
- At this point, have students read the "Background Information" for the images.

Exploration, assessment, and extension:

- Exploration/Investigation:
  - Ask students to review the image sequences for each anole. Discuss whether it is possible to confirm the scientists' predictions using these images. Can you tell whether the lizards with the larger toepads, longer forelimbs, or longer hindlimbs are able to hang on longer as wind speed increases?

- Students will likely say that it is difficult to tell from these images. The lengths of the lizards' limbs are hard to compare, and the toepads aren't visible at all. The images also do not show any time information, so you can't tell how long each lizard hung onto its rod.
- Ask students to discuss what other data they would need to better evaluate the scientists' predictions.
- If students are comfortable with graph interpretation, they can examine some of the scientists' actual data in Figure 2 of the original paper. This figure plots toepad area, forelimb (humerus) length, and hindlimb (femur) length in the anole populations before and after the hurricane.
  - These data show that the hurricane survivors had proportionally longer forelimbs and larger toepads, which confirms two of the scientists' predictions. But the survivors also had proportionally *shorter* hindlimbs, contrary to the scientists' expectations.
  - Ask students to review the images and consider why shorter, rather than longer, hindlimbs may have been advantageous for the surviving anoles. (The scientists suggest that since the hindlimbs are often released first, longer hindlimbs may present more surface area to the wind and make it more likely for a lizard to be blown off its perch.)
- Ask students why the timing of the scientists' original investigation was so important. Why was it useful for the scientists to have data on the lizards both before the hurricanes and a few weeks after the hurricanes?
- Discuss the importance of measurements made in the lab supporting data collected in the wild.

- To further discuss adaptation and selection in anoles, have students explore some or all of the following BioInteractive resources:
  - The *Lizard Evolution Virtual Lab* allows students to explore the evolution of anole lizards in the Caribbean by collecting and analyzing their own data, including data on limb length and toepad size. This lab includes four modules that investigate different concepts in evolutionary biology, including adaptation, convergent evolution, phylogenetic analysis, reproductive isolation, and speciation.
  - The *Phenomenal Image* activity "The Lone Anole" addresses both structural and behavioral adaptations. Students are asked to identify structures or features of the anole that they would consider to be adaptations and must explain their choices. Attention is drawn to the anole's dewlap.
  - The *Data Point* activity "Lizards in the Cold" uses published scientific figures to explore how anoles can adapt to extremely cold temperatures. Students interpret graphs showing cold tolerance in anole populations before and after winter storms. This activity demonstrates how extreme climate events, such as storms, can drive natural selection.
  - The hands-on activity "Look Who's Coming for Dinner: Selection by Predation" illustrates how predation can also be an agent of natural selection. This activity is based on a field study that introduced a large predator to islands inhabited by anoles. It emphasizes that strong selective pressure can have measurable effects on trait variations in a population within a short time.
  - The animation *Reproductive Isolation and Speciation in Lizards* discusses how the 150 anole species of the Caribbean all evolved from a single colonizing species within the past 50 million years. It also discusses how different processes, including geographic isolation, adaptation to different environments, and reproductive isolation, have played a role in anole speciation.

- Assessment:
  - Ask students the following question: "In order to determine if extreme climate events such as hurricanes can drive evolution, what further studies would the scientists need to conduct?"
    - Have students work in groups of two or three to brainstorm next steps for this investigation. They should explain how each of their proposed steps might be accomplished and how the data obtained would inform scientists about the potential for hurricanes to drive the evolution of species.
    - As part of the assessment, students could use the *How Science Works* Click & Learn to outline the process for their proposed investigation.

- Extension:
  - Have students complete the activity “Beaks As Tools: Selective Advantage in Changing Environments,” which explores the evolution of beak size in finches due to two major droughts. This activity simulates the food availability during these droughts and demonstrates how rapidly natural selection can act when the environment changes. Students collect and analyze data, then draw conclusions about traits that offer a selective advantage under different environmental conditions.
    - Ask students how what they learned from this activity relates to the effect of hurricanes on the anoles of Pine Cay and Water Cay. Based on what they’ve learned, what would they predict for the evolutionary trajectory of the anoles?
      - Students might respond that if the number of hurricanes increases, the anoles may develop even larger toepads, longer forelimbs, and shorter hindlimbs. If the number of hurricanes stays the same, these traits would not continue to be selected for in the anole population, so the evolutionary trajectory would be different.
    - Ask students to compare what was observed with the beaks of the finches to what was observed in the anole populations.
      - Students should note that extreme climate events selected for specific traits in both populations.
  - Have students watch the *Scientists at Work* video *Selection for Tuskless Elephants*, which explores why the proportion of tuskless individuals has increased in some African elephant populations. Most African elephants have tusks because there is usually strong natural selection for this trait. In certain cases, however, poaching makes tuskless elephants more likely to survive, reproduce, and pass on their genes.
    - Ask students how what they learned from this video relates to the effect of hurricanes on the anoles of Pine Cay and Water Cay. Based on what they’ve learned, what would they predict for the evolutionary trajectory of the anoles?
    - Ask students how selection for the tusklessness trait in elephants is an example of selection driven by humans rather than by nature.

TEACHING TIPS

- Present students with the images first, before they read the background information.
- Background information may be edited to support student proficiency, course sequence, etc.
- The images may be projected in lieu of handouts.
- Printed images can be laminated for use in multiple classes.

RESOURCE-PAIRING SUGGESTIONS

Use these images to introduce a lesson on:

- Natural selection or artificial selection
- Impact of climate change on species

SOURCE

Figure 1 in the “Supplementary Information” from:

Donihue, Colin M., Anthony Herrel, Anne-Claire Fabre, Ambika Kamath, Anthony J. Geneva, Thomas W. Schoener, Jason J. Kolbe, and Jonathan B. Losos. “Hurricane-induced selection on the morphology of an island lizard.” *Nature* 560, 7716 (2018): 88–91. https://doi.org/10.1038/s41586-018-0352-3.

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