HOW TO USE THIS RESOURCE

The images for this resource, photographs of bats with white-nose syndrome, can serve as a phenomenon 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. Bat species in North America are experiencing population collapses due to an infectious fungal disease called white-nose syndrome.
B. Bats control populations of insects such as mosquitoes. Decreases in bat populations will likely lead to increases in insect populations, as well as other negative ecosystem effects.

NGSS PERFORMANCE EXPECTATIONS

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

BACKGROUND INFORMATION

White-nose syndrome (WNS) is a fungal disease that affects bat species in North America. Bats infected with the fungus that causes WNS wake up from hibernation too early, leading them to use up their energy stores and even die. One bat species affected by WNS is the little brown bat (*Myotis lucifugus*). Little brown bats eat insects, which also hibernate during winter. Because bats with WNS wake up from hibernation early, they cannot find any insects when they wake up and often starve to death. Figure 1 shows a bat with WNS, with fungus present on its wings, ears, nose, and other exposed skin tissues. Figure 2 shows the remains of bat skulls and bones in a bat hibernaculum, the location where bats hibernate, after multiple years of infection.

Since being identified in 2006 in New York, the fungus that causes WNS has killed many bats across the United States and Canada. Because bats play an important role in ecosystems by controlling insect populations, WNS may have far-reaching negative effects. Knowing how WNS affects bat populations will help researchers better understand how to control the spread of the disease and lessen its effects.

IMPLEMENTATION SUGGESTIONS

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

Engagement, establishing prior knowledge, and providing context:

- Begin the lesson by showing students Figure 1, an image of a single bat infected with WNS. Ask students to make observations about what's happening in the image, using the sentence stems "I notice …", "It reminds me of …", and "I wonder …"
- Have students use a think-pair-share protocol to share their observations about Figure 1. Record class observations, noting when students make similar observations and drawing attention to the range of student-generated questions.
  - Students may notice that only one bat is shown, that the bat appears to be sleeping or hibernating, and that the bat has white fuzz around its nose, ears, and wings.
  - Students may mention that the white fuzz reminds them of mold growing on food. (The fuzz indicates that the bat is infected by the fungus that causes WNS.)
  - Students may wonder how many other bats are infected, whether this particular bat will die as a result of its infection, how long it's been infected, etc.
- Tell students that they're going to be examining images of the effects of WNS on a bat colony. Repeat the procedure above with Figure 2, an image of bat carcasses on a cave floor after multiple years of infection.
  - Students may notice that a large number of bats are shown, that all of the bats shown appear to be dead, and that no survivors are present.
  - Student may wonder what proportion of bats in the colony are affected, where the infected colony can be found, if WNS has spread to other colonies in the area, and what the effects of removing bats from an ecosystem would be.
- Ask students to consider how the size of a bat population exposed to WNS might change over time compared to that of a population not exposed to WNS. Have them graph their predictions for both populations, with the relative number of bats on the *y*-axis and time on the *x*-axis.
  - For the population exposed to WNS, students may graph a decreasing curve.
  - For the population not exposed to WNS, students may graph a relatively steady line. They may include some minor fluctuations due to variations in birth and death rates or as a result of other factors such as predation or food availability.
- At this point, have students read the "Background Information" for the images. Afterward, ask students to make any revisions they have to their graphs based on reading this information.

Exploration, assessment, and extension:

- Explore/Investigate:
  - Have students examine the "White-Nose Syndrome in Bat Populations" Data Point. The graph in this Data Point shows cumulative probabilities of regional extinction for the little brown bat population in the northeastern United States. These probabilities are projected for various rates of population decline under WNS.
    - Students may struggle with relating this graph, which shows cumulative extinction *probabilities*, to their predicted graphs, which show population *sizes*. To bridge the Data Point graph and the students' graphs, it may be helpful to show Figure 3 or 4b from the paper that the Data Point is based on, Frick et al. (2010). This paper is accessible via a free registration with the AAAS site. Additionally, an annotated version of the paper is available through the Science in the Classroom resource "A tiny fungus is causing big problems."
    - Have students compare their predicted graphs with Figure 4b from Frick *et al*. (2010). This figure projects the size of a little brown bat population over time, modeled under different rates of decline due to WNS. Have students identify and discuss the differences between their predicted graphs and the projections in the figure.

- Assessment:
    - Ask students to construct an explanation of how WNS affects bat populations based on their previous learning experiences, including their predicted bat population graphs and the "White-Nose Syndrome in Bat Populations" Data Point linked above.
        - Prior to constructing their explanations, it may be helpful for students to compare their predicted graphs with Figure 3 or 4b from Frick et al. (2010), as suggested above.
- Extension:
    - Ask students to predict the effects of changes in bat populations on insect populations. Students can represent these predictions in words, graphically, or through diagrams.
        - Tell students they will watch a short video about bats found in Gorongosa National Park in Mozambique. These bats prey on moths, a kind of insect.
        - Have students watch the BioInteractive video *Moth Mimicry: Using Ultrasound to Avoid Bats*. This video and accompanying worksheet describe how moths evade capture by bats through either being distasteful or mimicking species that are distasteful.
        - Afterward, ask students to predict the effects of changes in bat populations on three types of insect populations: insects that are neither distasteful nor mimics, those that are distasteful, and those that are mimics. It may be helpful to divide this task among groups of three students and then have them combine their predictions.
    - Have students explore how bats use echolocation to locate prey.
        - In the "Bat Echolocation" Data Point, students compare bat echolocation signals in response to prey removal.
        - In the "How Animals Use Sound to Communicate" Click & Learn, students examine communication methods for a variety of animals, including bats. The accompanying student handout includes several graphic organizers to help compare varieties of communication, interpret animal behaviors as signals, and explore the physics of sound.
    - Have students read Frick et al. (2010), which is the primary source for many of the images and graphs discussed above.
    - As mentioned above, the Science in the Classroom resource "A tiny fungus is causing big problems" provides additional annotations and videos to supplement this paper. In particular, the accompanying Educator Guide highlights specific areas within the article that you may want to discuss with your students, such as the researchers' previous work and connections to news and policy.

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.

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