

Changing Planet: Adaptation of Species (Birds and Butterflies)

Summary:	Students investigate how shape and structure of bird beaks affects the type of food that birds are able to eat. Students will view how global climate change is affecting many species of animals, including birds and butterflies.
Source:	<i>Developed by NESTA/Windows to the Universe team members Jennifer Bergman, Missy Holzer and Roberta Johnson. Includes an adaptation of the Bird Beaks Investigation (http://windows2universe.org/teacher_resources/teach_beaks.html).</i>
Grade level:	Grades 5-9
Time:	30 minutes prep time 60 minutes class time
Student Learning Outcomes:	<ul style="list-style-type: none"> • Students will learn and describe how different types of bird beaks have adapted to feed on different foods within a specific habitat. • Student will learn that birds with beaks that are better adapted will have a better rate of survival. • Students will learn how the finches of the Galapagos are an example of evolutionary processes. • Students will learn, discuss and research how global climate change is affecting many species of animals like birds and butterflies.
Lesson format:	Discussion with Powerpoint slides, hands-on activity, student worksheet
National Standards Addressed:	<ul style="list-style-type: none"> • 5-8: Content Standard A: Science as Inquiry • 5-8: Content Standard C: Populations and Ecosystems • 5-8: Content Standard C: Diversity and Adaptations of Organisms • 5-8: Content Standard D: Structure of the Earth System, Earth History • 5-8: Content Standard F: Populations, Resources, and Environments • All levels: History and Nature of Science: Science as a Human Endeavor, Nature of Science, History of Science • All levels: Science and Technology Standard: Understanding about Science and Technology • All levels: Science in Personal and Social Perspective Standard • All levels: Assessment Standard B: The Ability to Communicate Effectively about Science

Materials:	<p>For a class of 30 students (10 groups of 3):</p> <ul style="list-style-type: none"> • 6 pairs of tweezers • 6 dissection probes or toothpicks • 6 clothespins • 6 spoons • 6 drinking straws • 10 paper plates, pie tins, or cafeteria trays • 30 cups • student worksheet (one/student) (adaptation_worksheet2.pdf) • 10 quart-sized plastic bags full of an equal mixture of rice, sunflower seeds, marbles, and marshmallows • 5 quart-sized plastic bags that contain rice • 5 plastic bags that contain marbles • Duct tape • One summary data table (copied onto overhead transparency or shown on other projector) (beaks_data_summary.pdf) • Overhead projector or other projection device • Stopwatch or timer <p>Powerpoint presentation "Adaptation of Species (Birds and Butterflies)" to use for class discussion (adaptation.ppt)</p>
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DIRECTIONS:

1. For background information on species adaptation, watch Changing Planet: Adaptation of Butterflies (http://www.windows2universe.org/earth/changing_planet/adaptation_species_intro.html). (This movie is linked on the first slide of the Powerpoint presentation (adaptation.ppt)). Also explore these topics on the Windows to the Universe website at the links listed below.
2. Continue using the Powerpoint presentation "Adaptation of Species (Birds and Butterflies)" (adaptation.ppt) to facilitate class discussion. Show the images of different types of birds with different beak morphologies (slides 2-6) and ask students why they think the beaks are differently shaped. Lead students towards understanding that the beaks are specialized depending on the type of food that the birds eat. Ask students to guess how different types of birds (woodpecker, hummingbird, pelican, and others with extreme beak shapes) get food based on the shape of the birds' beaks. Explain what the word adaptation means and how adaptations that aid survival are more likely to show up in future generations. Explain that in the activity students are about to do, they will each play the role of a bird with a different beak shape. (At this point, leave the rest of the Powerpoint presentation to be covered after the hands-on investigation)
3. **First round of Activity** -- Organize students into groups and supply each group with beaks (tweezers, dissection probe, pliers, tongs, spoon, or straws) and a cup. Give each group a different type of "beak". Explain that each group is a population (a group of animals of the same species that all live within a particular area).
4. Have groups make a loop out of a piece of duct tape to attach the plate to the table (to keep it steady) and fill the plate with "food". (The food is the one plastic bag full of a mixture of rice, sunflower seeds, marbles, and marshmallows).
5. Explain to students that they will use their "beak" to collect as much "food" from the plate as they are able to in 30 seconds, placing the food particles into their cup (which represents their bird's stomach). They must use the beak with one hand only and must not touch the plate or food particles with their hands. (Have students hold their cup or put their free hand behind their back to stop them from using it.)
6. Have students:
 - Collect for 30 seconds.

- Count the number of different food items they each got into the cup.
 - Write their data in a data table on their student worksheet.
 - Have each group calculate the average (mean) number of rice, seeds, marbles, and marshmallows that their population of birds ate in the 30 seconds.
7. Ask one member of each population call out their data as you record it on projected class data table, so that the data from the entire class is shown. (If time allows or interest dictates, you could have students make a bar graph of this data table and then answer follow-up questions on their student worksheet.)
 8. As students look at the summary data on the overhead, have them answer the follow-up questions on their student worksheet.
 9. Have students dump all the bird food back into the plastic bag. Students should keep their "beaks".
 10. **Second round of activity** -- To prepare for the second round of the activity, explain to students that global climate change has affected the regional climate where the birds live. It has brought extreme drought and most food types have died. Allow students to keep their beaks from the first round of activity. Distribute the plastic bags of either rice or marbles - one to each group. Repeat step five. Students are asked these questions on the student worksheet : *Did all the birds survive the season of drought? Which birds were best adapted to survive?* These questions are also appropriate for class discussion if time allows.
 11. Finish with a class discussion of the different types of finches on the Galapagos Islands, their different beak shapes and distributions, and the observations of Charles Darwin as he explored the area (see background section below for more information and use Powerpoint slides provided). Use the remainder of the Powerpoint slides to end a class discussion on how climate change is affecting different animal species and to explore conservation biology as a career.
 12. Have students finish the student worksheet.

ASSESSMENT:

Assess student abilities to work together as a team, as well as apply learned information to make solid deductions about the future implications of global warming on species such as birds and butterflies.

LAB SAFETY:

Use safe laboratory practices at all times.

CLEAN-UP:

Have students help clean up their lab areas and properly store materials for future use.

EXTENSIONS:

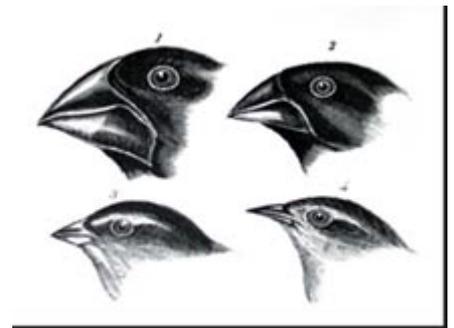
- As a classroom, participate in one of the following Citizen Science campaigns to learn more about butterflies and the plants and flowers they depend on:
 Project Butterfly Wings (<http://www.flmnh.ufl.edu/wings/index.asp>)
 Monarch Butterfly - North America's Migrating Insect (MLMP)
 (<http://www.fs.fed.us/monarchbutterfly/citizenscience/index.shtml>)
 Monarch Watch (<http://www.monarchwatch.org/>)
 Project Budburst (<http://www.neoninc.org/budburst/index.php>)
- Have students complete the NOAA Activity Climate Change and Ecosystem Response ([http://www.esrl.noaa.gov/gmd/education/lesson_plans/Climate%20Change%20and%20Ecosystem%](http://www.esrl.noaa.gov/gmd/education/lesson_plans/Climate%20Change%20and%20Ecosystem%20)

BACKGROUND INFORMATION:

On Darwin's Visit to the Galapagos

During his five-year trip aboard the H.M.S. Beagle, Charles Darwin discovered that birds called finches were found on all of the Galapagos Islands. He arrived in the Galapagos in 1835 and found 13 species of finch living on different islands. The finches were similar in size and coloration, but had very differently sized and shaped beaks. The beaks of these finches were adapted to the island where they lived and the food that they ate.

Darwin believed that the process of evolution took too long for us to observe it happening. But the finches of the Galapagos were an example of evolution taking place and he wrote about them in his book called "The Voyage of the Beagle" (he did not publish the basic tenets of Natural Selection in "The Origin of Species" until 1859). Darwin decided that these finches all used to have bills like other finches, but when they came to live on the Galapagos and started eating different things, their beaks changed over thousands of years. This is called divergent evolution. Since he described the finches, a number of researchers, including Peter and Rosemary Grant (who wrote "The Beak of the Finch") have traveled to the Galapagos Islands to conduct more detailed research.



Each finch species has evolved according to its particular food source. For instance:

- *Long beaks are for probing trees and cacti.* Cactus finches have long beaks adapted for reaching into cactus flowers and eating the nectar. Warbler and woodpecker finches have long beaks for probing into trees to find insects and other small animals to eat.
- *Thick, wide beaks are for crushing hard seeds.* Ground finches have beaks adapted for crushing seeds. Medium finches are better adapted at eating small seeds than large ones, so they are not likely to be found on islands with variation in seed size like large ground finches that are able to eat larger seeds. Wide beaks allow these finches to take in more food.

Many of the finches in the Galapagos are not yet distinct species because they are still able to reproduce. However, as they are separated onto different islands, physical barriers prevent groups from reproducing. Different species may develop when a population is divided and then the groups evolve in separate ways. This is called allopatric speciation. If the two parts of the population evolve in different ways and then are able to come back together (if the geographic barrier is removed), the two populations may compete with each other. Or, they may have developed specializations that allow them to no longer need the same food type or nesting space, so they may be able to live in the same space without competition.

On Global Climate Change and Species Adaptation

The term "global warming" often evokes images of unbearably hot summers. While it is true that summertime high temperatures are rising worldwide, it often surprises people to learn that in seasonal environments around the world - those characterized by cool or cold winters and warm or hot summers - winter is the most rapidly warming season. In fact, by many measures winters are warming at nearly twice the rate of summers.

One direct consequence of a warmer and shorter winter is the earlier onset of spring temperatures.

Across the entire Northern Hemisphere, spring is arriving earlier at a pace of approximately 1.2 days per decade. Land surfaces are also retaining more heat during the summer, leading to persistent summer temperatures that linger into the fall. Thus, with regard to the temperatures that permit plants to grow, an earlier spring and a persisting summer means that the growing season is expanding (whether plants will receive enough rainfall to take advantage of these warmer temperatures is an unresolved question of great concern). Across Europe, for example, the growing season expanded 10.8 days during the period 1960-1999 (6 days toward an earlier spring, 4.8 days toward a persisting summer).

While these might seem like small changes, the natural world is actually responding in observable, dramatic, predictable (and in some cases, unpredictable), and potentially problematic ways. Summarizing more than 29,000 observational data series that demonstrate significant changes in physical and biological systems, the IPCC reported in 2007 that more than 89% (25,810) of those changes are in the direction expected as a response to climate change. In the biosphere, these changes tend to fall into two categories: responses in space and in time.

-Geographic responses to climate change



On a spatial scale, many species of animals and plants have expanded their geographic ranges poleward in latitude (northward in the northern hemisphere; southward in the southern hemisphere) and upward in elevation over the last century, following shifting temperatures. As higher elevations experience more mild winters, for example, species from lower elevations may expand their range towards higher elevations because they can now tolerate the winters there. The same may be true across latitudes; species from lower latitudes (i.e., closer to the equator) may expand their range toward higher, or poleward, latitudes. These "range expansions" can be advantageous for species that can disperse easily, but they can threaten the existence of less mobile or more sensitive species. In general, butterflies are following these trends (moving poleward and upward), but keep in mind that means butterfly species experience dramatic patterns of extinction along the edges of their range (the edge they are moving away from).

Of course, migration into new territory is often impossible, as habitat fragmentation due to human activities (such as the building of housing developments, golf courses, highways, or shopping malls) or the existence of natural barriers such as rivers or mountain ranges can prevent the movement (or dispersal) of seeds and fruits, and of young, pregnant or nursing animals.

-Temporal responses to climate change

On a temporal scale, living organisms respond to the expanding or shifting growing season by changing their phenological schedules (remember phenology is the study of periodic plant and animal life cycle events and how these are influenced by seasonal and interannual variations in climate).

Thousands of biological records spanning both the globe and the 20th century indicate a nearly ubiquitous shift in spring phenology toward earlier calendar dates. Organisms are tracking an earlier start to the growing season by emerging from dormancy earlier (mammals, insects), migrating earlier (birds, insects, mammals), developing new leaves and stems earlier (plants), and breeding earlier (mammals, insects, birds, plants). Not surprisingly, similar delays in autumn phenology are occurring due to a persisting summer- deciduous trees are shedding their leaves later than they used to, and birds and mammals are migrating later in the autumn than they used to.

As you can imagine, the consequences of phenological shifts will depend on the level of biological organization that we investigate. For a long-lived individual tree, for example, leafing out several days earlier each spring may allow it to get a rapid head start in its annual growth, especially if neighboring trees remain leafless, which would allow its leaves to receive a great deal of sunlight. On the other hand, if it produces its leaves earlier than any of the other members of its population, it may be particularly vulnerable to leaf-eating insects (e.g., moth and butterfly larvae, leaf miners, and leaf-cutting ants) simply because it will be a rare and limited resource for them.

The effects of a phenological shift on a given population of a species will also depend on whether the other species on which it relies - for food, pollination, or seed dispersal - change with it. For example, if populations that benefit from each other respond differently to climate change (e.g., if a plant population flowers on average five days earlier but its pollinators haven't arrived), then one or both of them may exhibit population declines. On the other hand, if a population flowers early enough to "escape" one or more of its "natural enemies" (e.g., flower bud-eating beetle larvae), it may reap the benefits of high flower and fruit production.

At the community level, predictions are highly elusive. We've learned from radio-tracking and bird-banding efforts that birds are returning to spring and summer breeding grounds earlier and earlier, but the effects of these altered migration patterns on both the birds and the species with which they interact (as predators or as seed dispersers) are likely to be highly species- and community-specific. Nevertheless, there are several rules of thumb that probably apply.

First, the more specialized the relationship between species, the more vulnerable each of them is likely to be to the phenological effects of climate change. For example, plant species that are pollinated by only one species of pollinator are more vulnerable to losing these pollinator services than are species that are visited by a wide range of pollinator species. Similarly, insects that rely on a single plant species as their food source may experience severe population declines if their emergence times are mismatched with the growing or flowering season of their host plant.

Second, animals that habitually migrate between geographically distant biomes to complete distinct portions of their life cycles (e.g., growth and sexual maturation vs. breeding) are particularly vulnerable to the phenological effects of climate change simply because there are more inter-specific interactions that may be disrupted. Such species must continue to exhibit a phenological schedule that is viable given the co-occurring species and the climate in each of their "home" habitats. For example, species of birds that migrate over long distances must co-occur with their food sources (while avoiding their enemies) in the biome in which they grow and reach sexual maturity, and then, following migration to their breeding grounds, they must be in synchrony with the food sources that they feed to their newborns. Migratory animals must meet these demands while also avoiding the natural enemies that destroy them.

These shifts in spatial and temporal range are what scientists call the "fingerprint of climate change." Phenological schedules are changing rapidly and at different rates for co-dependent species such as plants and pollinators. There is an increasing number of reports in recent years of population crashes in the wild due to such asynchronous responses to climate change among co-dependent species, but

scientists are only beginning to learn how widespread they are and in how many different kinds of organisms they occur.

Within this century climate change and other global changes such as change in land use and pollution will collectively be too much for many ecosystems to handle and they will not be able to adapt. Twenty to thirty percent of plant and animal species will become extinct if global average temperatures increase 1.5 - 2.5°C, which is within the range estimated by computer models for 21st Century.

Given these grave predictions, it is obviously essential to encourage students to think deeply and creatively about these issues - big problems demand big solutions!

RELATED SECTIONS OF THE WINDOWS TO THE UNIVERSE WEBSITE:

- Evidence of Evolution (http://www.windows2universe.org/cool_stuff/tour_evolution_1.html)
- How Many Species Have There Been on Earth?
(http://www.windows2universe.org/headline_universe/olpa/speciation_3july08.html) News story originally written on July 3, 2008
- Climate Change Impacts, Adaptation and Vulnerability - Present and Future
(http://www.windows2universe.org/earth/climate/ipcc_april2007.html)
- Life on Earth (<http://www.windows2universe.org/earth/Life/life.html>)
- Climate and Global Change (<http://www.windows2universe.org/earth/climate/climate.html>)

OTHER RESOURCES:

- Understanding Evolution (<http://evolution.berkeley.edu/>) Resources from UCMP
- Climate Extremes: Observations, Modeling, and Impacts
(http://www.biosci.utexas.edu/ib/faculty/parmesan/classes/Eastl_Ntr_00.pdf) An Article in Science's Compass with Camille Parmesan as one of the authors
- Butterflies Across Europe Face Crisis As Climate Change Looms
(<http://www.sciencedaily.com/releases/2009/01/090126102043.htm>) Climate news from Science Daily
- Jessica Hellmann, Associate Professor at the University of Notre Dame (Indiana, USA)
(<http://www.evoltree.eu/index.php/evoltree-final-conference/interviews/5358-interview-hellmann>) Presentation of her views on the issue of assisted migration
- Journey North (<http://www.learner.org/jnorth/>) A global study of wildlife migration and seasonal change
- Monarch Teacher Network
(<http://www.eirc.org/website/global-connection/monarch-teacher-network/>) A network of teachers and other people who use monarch butterflies to teach a variety of concepts and skills