PHENOLOGY ARTICLES, CARDS, & ART ACTIVITIES

Teacher: **Grade Level(s):** 3rd-6th

Time: 2+ hours (can be completed in small sections) **Author**: Blue Baldwin & Michelle Coe

Next Generation Science Standards:	**3-LS1-1**. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. **4-LS1-1**. Construct an argument that plants have internal and external structures that function to support survival, growth, behavior, and reproduction. **MS-LS1-5**. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
Enduring Understandings:	**LS1.B**: Organisms have unique and diverse life cycles. **LS2.C** Ecosystem dynamics, functioning, and resilience.
Content Objective:	Students will define the term *phenology* by reading articles, engaging in a life cycle card game, and participating in collaborative discussions. Students will use evidence from the garden to collect phenolology data for the national citizen science website, Nature's Notebook. Students will extend their learning by representing phenological events in an art piece.

Vocabulary	Materials
Life Cycle Flower Bud, Open Flower Fruit (ripe/unripe) Seed (pod/dried fruit) Phenology Mandala	Printed Articles Life Cycle Event Cards Trays or Containers (if available) iPads or Computers (if available) Watercolor Paper Pencil Compass Pencils, Erasers, Black Sharpie Colored Pencils, Markers, Crayons

Seasonality: Year-round.				
Monsoon July-Sept.	Autumn Oct.-Nov.	Winter Dec.-Feb.	Spring Mar.-Apr.	Dry Summer May-June

Engage: Pass out articles (attached at the end of this document) to groups of ~5 students. Each student should have their own article; each group should have 5 different articles.

Instructions: Students will read through their article individually at their table and circle any words that describe the key concepts or themes outlined in the article. Students will underline any unfamiliar words. Students will prepare to share their findings with the group. Each group will discuss their team members' themes and come up with one central theme as a group to share with the classroom. The term ***life cycle*** may emerge as a central theme.

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Explore: Provide each student with at least one Life Cycle Event card (front/back example below; cards downloadable on this website). *Teacher note: if students receive more than one card, make sure it is from the same plant species*

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Instructions: Students will stand up to find others with the same plant species represented on their card(s) and sit down with their new group. Each group will look carefully at their cards. They may be surprised to learn that this is all the same plant!

Challenge the student groups to place their cards in the correct order of the changes that this plant will go through during its life cycle. Student groups may walk around the room and look at other group's cards once they are done. As groups share their cards with the class, discuss any themes that emerge and help students re-organize their cards if necessary (flower bud, open flower, unripe fruit, ripe fruit, unripe seed, ripe seed).

Explain: Life cycles may be a familiar idea to many students. Guiding Question: When do these life cycles occur? Do all plants have the same life cycle at the same time?

Nature's Notebook is a national effort to track life cycle changes in plants and animals from season to season. Phenology: a scientific term that describes **life cycle** changes in plants and animals *in relation to* climatic and seasonal changes. Each of the articles you read previously were part of the national citizen science efforts by Nature's Notebook to track phenology. Use the power point (downloadable as pdf. on this website, to further explain).

Instructions: Review the Nature's Notebook website (https://www.usanpn.org/natures_notebook) and data sheets / data that Nature's Notebook asks its citizen scientists to collect. (see data sheets included in Google Drive; find TUSD data sheet templates here: https://schoolgardens.arizona.edu/natures-notebook-phenology-themed-citizen-science.

Elaborate: Students should work with their group outside to identify the location of the plant represented in their Life Cycle Event Cards. Once found, students will record data using a Nature's Notebook data sheet. Students may use iPads or phones to collect pictures of their plant.

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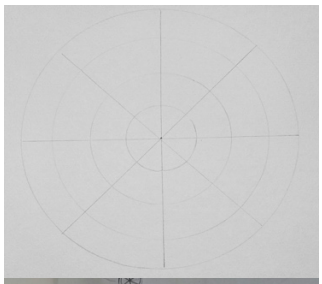
BREAK

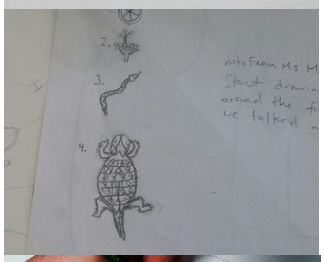
Evaluate: Students will extend their learning of life cycles and phenology of their plant by designing a mandala art piece representing various components, relationships, and phenophases of their plant. Use student's completed mandala art piece to assess learning. Have students share their work with someone that modeled a *different* plant's phenological events and verbally explain the various symbols in their art piece.

<u>Steps to Creating a Mandala Art Piece</u>:

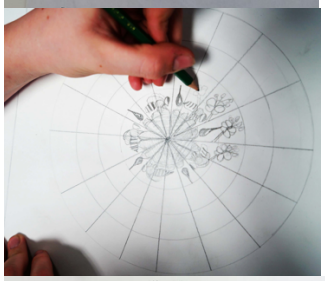
1) <u>Preparation</u>: Using watercolor paper and a pencil compass, prepare concentric circles (4) and lines, creating the outline of the mandala.



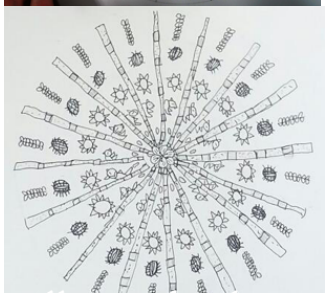
2) Give each student time to create a "key" to their mandala by drawing ~10 symbols they will include in their art piece.



3) Have students draw (in pencil) the symbols on their mandala piece using the pencil compass markings to help with spacing.



4) Students outline these symbols in fine-tip black sharpie and erase any excess pencil lines (including, at this time, the mandala outline).



5) Students fill in their symbols and mandala space with color, representing the changing phenophases of their plant.

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Seed Dispersing Bears Influence Plant Community Composition

Photo: Juneau Empire

In a new study, researchers at Oregon State University sought to quantify the role bears in Alaska play in dispersing seeds. The authors estimated that brown and black bears disperse over 200,000 seeds per hour per square km while foraging for fleshy fruits and then excreting them on the landscape. Brown bears disperse more seeds than black bears overall, and at different times of the year. Because bears disperse a large percentage of the seeds of fleshy-fruit bearing species, they have a great influence on the species composition of plants in their ecosystems. If populations of bears are reduced, the number of fleshy-fruited shrubs may also decline and be replaced by wind-dispersed plants.

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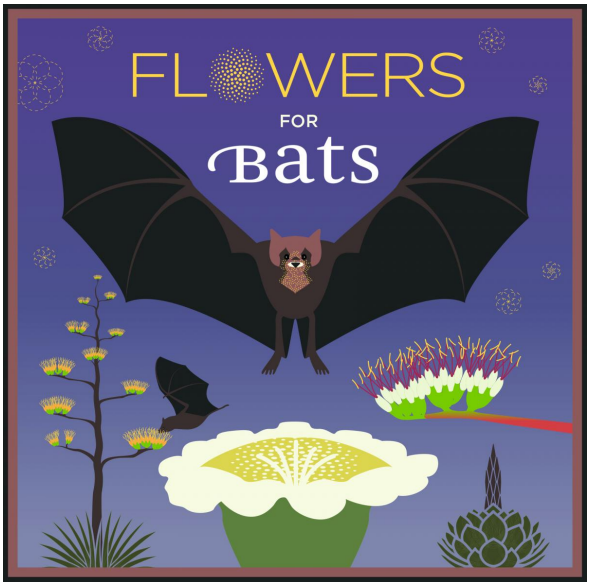
The lesser-long nosed bat (*Leptonycteris yerbabuenae*) travels north from Mexico to Arizona each summer on a journey that can cover almost 1,000 miles.



On this journey, the bats rely on nectar and pollen from agave and columnar cacti. These are also critical food sources for the bats when they arrive at their maternity roosts in Southern Arizona.
The US Fish & Wildlife Service is seeking to better understand where and when nectar sources are available for bats while they are in Southern Arizona raising their young.

You can help the USFWS document flowering of Parry's, Palmer's, and desert agave and saguaro cactus during the spring and summer flowering periods through the **Flowers and Bats Program**. This information will be used by the USFWS to conserve and promote habitat for lesser long-nosed bats.

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ADVANCING SCIENCE

Parasitic plants derive nutrients from other living plants, typically to the detriment of these hosts. Though these plants are widespread and diverse, their ecology is generally poorly understood.

Left: photograph of mesquite tree with desert misteltoe by Kelsey Yule. Right: photograph of desert misteltoe by Sundry Photography

Researchers from the University of Arizona evaluated the timing of flowering and fruiting in desert mistletoe (Phoradendron californicum) across five host plant species: desert ironwood, blue palo verde, foothills palo verde, catclaw acacia, and velvet mesquite to better understand the reproductive biology of this common desert parasite. By combining their observations of mistletoe life cycles with citizen scientists' observations of leaf, flowering, and fruit-timing of host plants, the researchers revealed unique patterns in the timing and sequence of flowering in mistletoes and their host plants. Specifically, peak flowering for mistletoe plants found on mesquite plants occurred weeks later than mistletoes on all other host plants. However, mesquite was among the earliest host plants to flower. This work enhances our basic understanding of parasitic plants by highlighting the diversity of strategies these plants utilize to maintain reproductive success. It also depicts the type of discoveries that are possible because of the data being collected, maintained, and delivered by citizen scientists.

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INCREASING UNDERSTANDING

Golden crownbeard (Verbesina encelioides) is a troublesome, invasive plant at Midway Atoll National Wildlife Refuge. This fast-growing plant forms dense stands that disrupt and degrade surface-nesting seabird habitat, and has been linked to decreased reproductive success and survival in albatross.

Photograph of golden crownbeard by RukiMedia.

Refuge staff at Midway Atoll have undertaken aggressive control efforts in recent years, reducing the cover of the plant by 99%. However, control efforts must be continued to minimize the spread of the remaining plants. Using the help of citizen scientists, refuge staff are tracking crownbeard life cycle events to time herbicide treatment. By targeting the window between leaf out and seed development, the efficacy of treatment can be maximized. This effort is an outstanding example of management decisions that can be enhanced by the capacity and information offered by citizen scientists.

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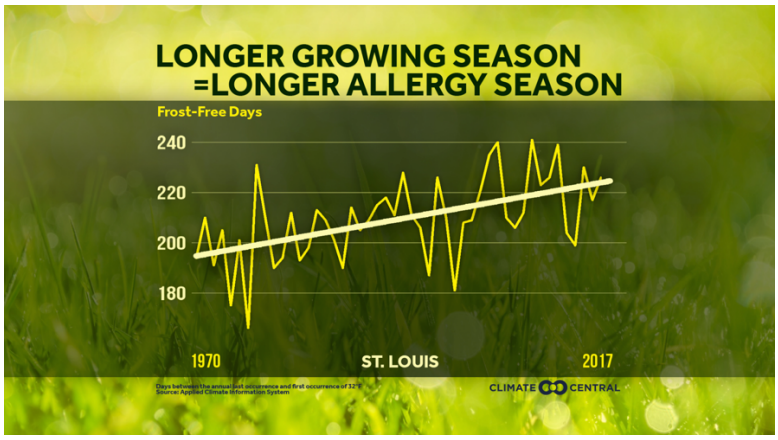
Here's How A Frost-Free Season Affects Allergy Season

Apr 4, 2018



By Climate Central

Despite late-season snow and chill, spring is blossoming. Leaves are arriving early this year in the West, Southwest, Ohio Valley, and parts of the Mid-Atlantic. As the climate warms from the increase of greenhouse gases into the atmosphere, the last spring freeze is trending earlier and the first fall freeze is coming later. This means the growing season is getting longer, and so is the pollen season— whether it is from tree pollens in the spring, grass pollens in the summer, or ragweed in the fall. A study sampling 10 locations from Texas to Saskatoon, Canada indicated that pollen seasons lengthened between two to four weeks from 1995 to 2009, with the largest increases in the northernmost areas.

In addition, increasing atmospheric carbon dioxide enhances photosynthesis in plants, meaning that they produce more pollen. Lab studies have confirmed this, with timothy grass producing twice as much pollen for a doubling of carbon dioxide, and ragweed producing twice as much pollen even before a doubling of carbon dioxide is reached. And the lab studies are supported from the field. One study in Baltimore, where carbon dioxide concentrations were 30 percent higher than outside the city, found that ragweed grew faster and produced more pollen than in the city.

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Timing of spring birdsong provides climate insights

January 17, 2018, American Ornithological Society

Hermit Warblers are among the species included in a new study of how spring birdsong timing is changing in the mountains of California. Credit: M. McGrann

Climate change has scientists worried that birds' annual migration and reproduction will be thrown out of sync with the seasons. Because birds' songs are correlated with their breeding behavior and are easily identifiable to species, monitoring birdsong can be a good way to keep tabs on this possibility, and a new study from *The Condor: Ornithological Applications* takes advantage of this approach to provide new baseline data for the birds of northern California.

The California Department of Fish and Wildlife Brett Furnas and William Jessup University's Michael McGrann analyzed data from two bird survey programs from California's Klamath Mountains and Southern Cascades, both of which used automated recorders to monitor bird sounds between 2009 and 2011. In addition to providing the first comprehensive assessment of songbird occupancy over a 40,000 square kilometer region of northern California, they were able to identify the precise dates of peak vocal activity for eight songbird species, and their work shows that this will be a feasible method to track advances in the timing of vocal activity over the coming decades. Species characterized by strong single peaks in vocal activity already tended to reach those peaks later than other species, perhaps because birds with tightly constrained timing are less able to adapt to changing climatic conditions.

"Climate change is disrupting songbird populations, distributions, and breeding behaviors in our mountain ecosystems. Mountains are particularly sensitive because temperature and precipitation interact in complex ways on mountains," says McGrann. "If Neotropical migrants are unable to adjust their breeding behaviors, then there may be a mismatch in the timing of raising their young to the peak availability in food resources, namely insects. Our technique should allow us to track shifts in elevation, changes in the state of the population, and changes in breeding behaviors in response to climate change over the next ten to twenty years." This is a textbook example of how to detect differences in the timing of nesting among bird species using information on the peak date of singing derived from surveys and automated recorders. Their results support recent findings of a five to twelve day shift forward in the timing of peak singing by California birds in the nearby Sierra Nevada and coastal ranges in response to climate change.

LINKING TIME-LAPSE CAMERA DATA TO CITIZEN SCIENCE OBSERVATIONS

Digital time-lapse cameras are an inexpensive way to capture frequent observations of plant and animal life cycle events, though the images need to be validated with in-person observations. To better link these two data sources, authors of a new study in *Ecosphere* compared digital images of tree foliage color from spring to autumn to life cycle observations made by citizen scientists.

The authors also compared how timing and intensity of fall foliage color in eight species of trees is affected by environmental factors. Their results suggested that chill and minimum temperature in autumn, drought stress in autumn, and heat stress in summer are all important factors to the timing of peak fall foliage color. They also found that for sugar maples, lower chilling condition and less frost stress in autumn are linked to higher intensity of red coloration in leaves.

What is special about this study?

This was the first study to investigate the interactions between autumn life cycle events of plants and animals and environmental variables on multiple deciduous tree species. Once there is an established link between photographs and on-the-ground observations, future researchers can use digital cameras to more easily and inexpensively document this data.

What does this mean for YOU?

This study provides insight into which environmental factors influence the onset, duration, and peak in autumn leaf color. With the help of digital cameras and on-the-ground observations, researchers can better understand the impacts of changes in climate on leaf color in fall.