

Environmental Literacy Framework

Phenology: Step Together Step

Preview

Focus Question:

How does climate change affect food chains and food webs?

In response to spring temperatures, oak trees produce their new leaves in a process called budburst. For only 24 days, these leaves are usable for food by the caterpillar of the winter moth. After that, the leaves fill with tannins, a bitter substance, and are less desirable as a food source. The hatching of the caterpillars is timed with the budburst so that this food source is available during their growing period. When the oak leaves are no longer edible, the caterpillars transform into the pupae stage and prepare for transformation, or metamorphosis, into a moth. Caterpillars that hatch earlier than the budburst die because there is no food source. Caterpillars that hatch after the budburst are not ready to pupate when the leaves become inedible, and they also die. This is an example of synchrony in nature, when one species times its life cycle to another for survival.

In this oak-caterpillar forest, there are several birds that rely on the peak numbers of caterpillars during the time they must feed their young. The birds arrive in the forest to breed, lay their eggs and time the hatching of their eggs (21 days later) to the peak of the caterpillar population. Without this abundant food supply, the young will not survive to fledge, or fly from the nest. On the other hand, the young bird might fledge, but its low weight could make surviving the first year difficult.



Great Tit

<http://commons.wikimedia.org/wiki/User:Benjaminb>

Unit 4- Biosphere



Time

40 min.

Materials

Blackline Masters:

- Life cycle wheel
- Life cycle calendar
- Scissors
- Colored markers and pencils

Vocabulary (Terms)

Budburst
Fledge
Food chain
Food web
Metamorphosis
Migration
Phenology
Predator
Prey
Pupae
Pupate
Synchrony
Tannins

Activity 4-A Phenology: Step Together Step

Gyorgy Csoka, Hungary Forest Research Institute, Hungary

Prepare

Activity Steps:

Part 1. Life Cycle Calendar



1. Copy the 4 Life Cycle Calendar wheels.

2. Cut out the three Life Cycle wheels to represent the cycle for oak leaves, caterpillars and birds. Do not cut out the Life Cycle Calendar.

3. Decorate the wheels in a way to show what the wheels represent: oak leaves, caterpillars or birds. Use colors to indicate the period of time when the oak leaves are edible, and the time of highest food need for both caterpillars and birds. (See directions on the wheel models.)

4. Place the smaller wheels inside the larger wheel and place all three wheels onto the Life Cycle Calendar. Match the center holes.

5. Use a round-head fastener to punch a hole in the center of all four sheets, and secure them together.

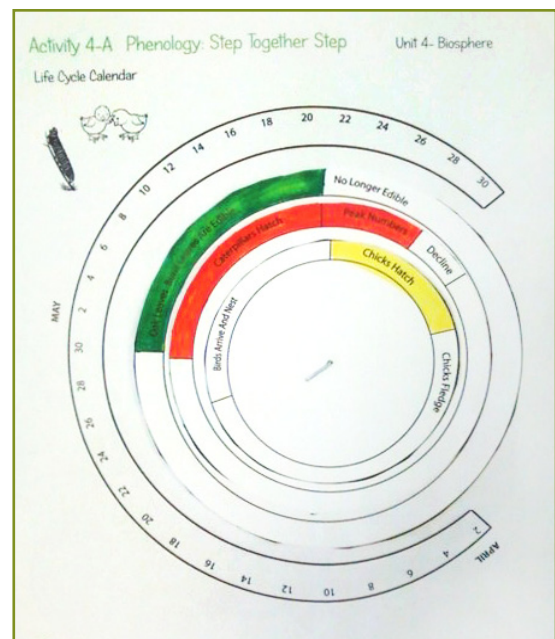
6. Move the oak budburst wheel so the beginning of budburst is aligned with April 30.

7. Move the caterpillar wheel so the beginning of hatching is over April 30. This will show the peak time and number of caterpillars to be around May 23.

8. Rotate the bird arrival date to April 24. This will show their peak need for food around May 23rd when they are raising chicks.

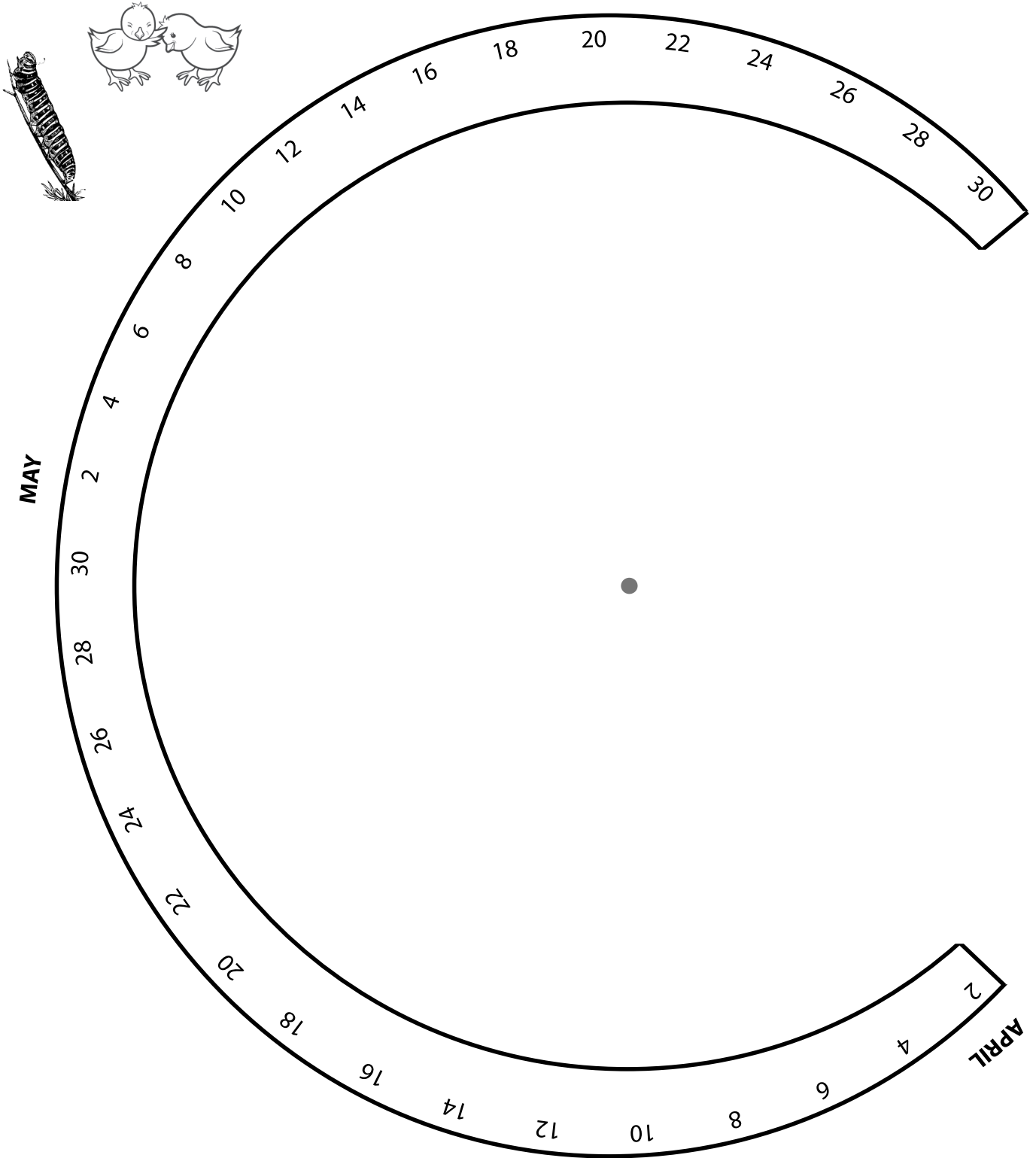
Your wheel should look similar to the photo on the right.

Templates and instructions for your Life Cycle Calendar are on the following pages.

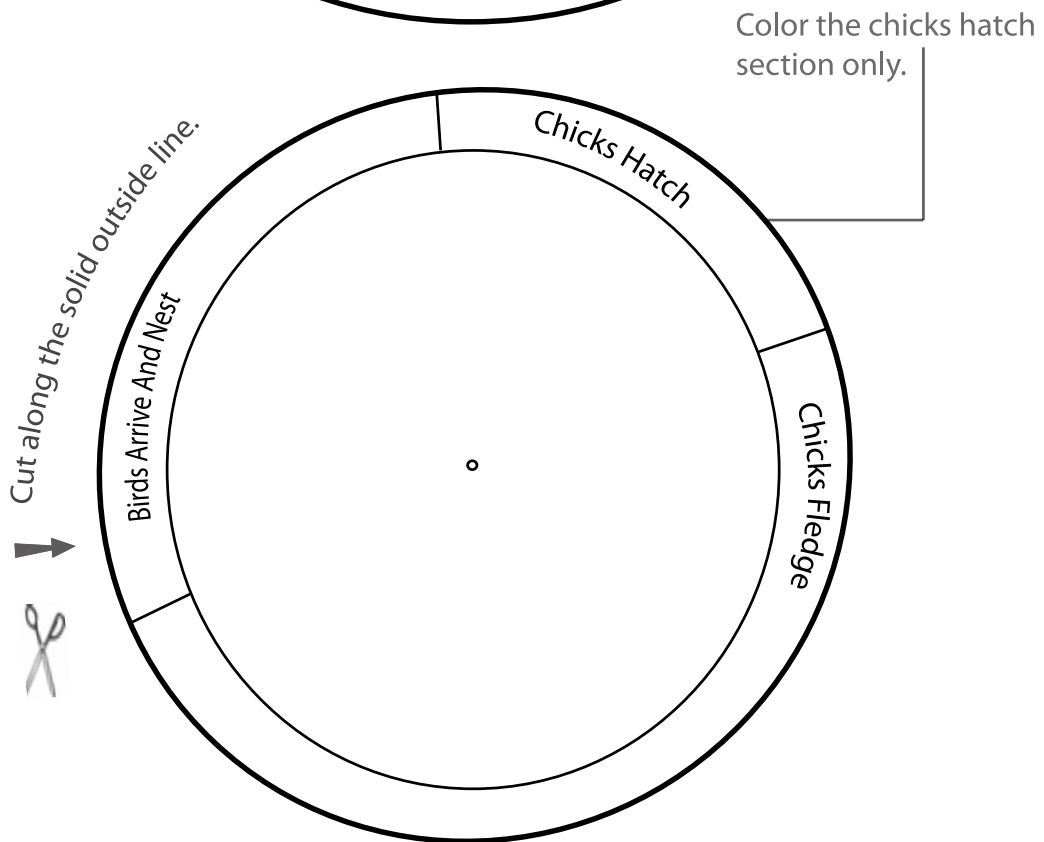
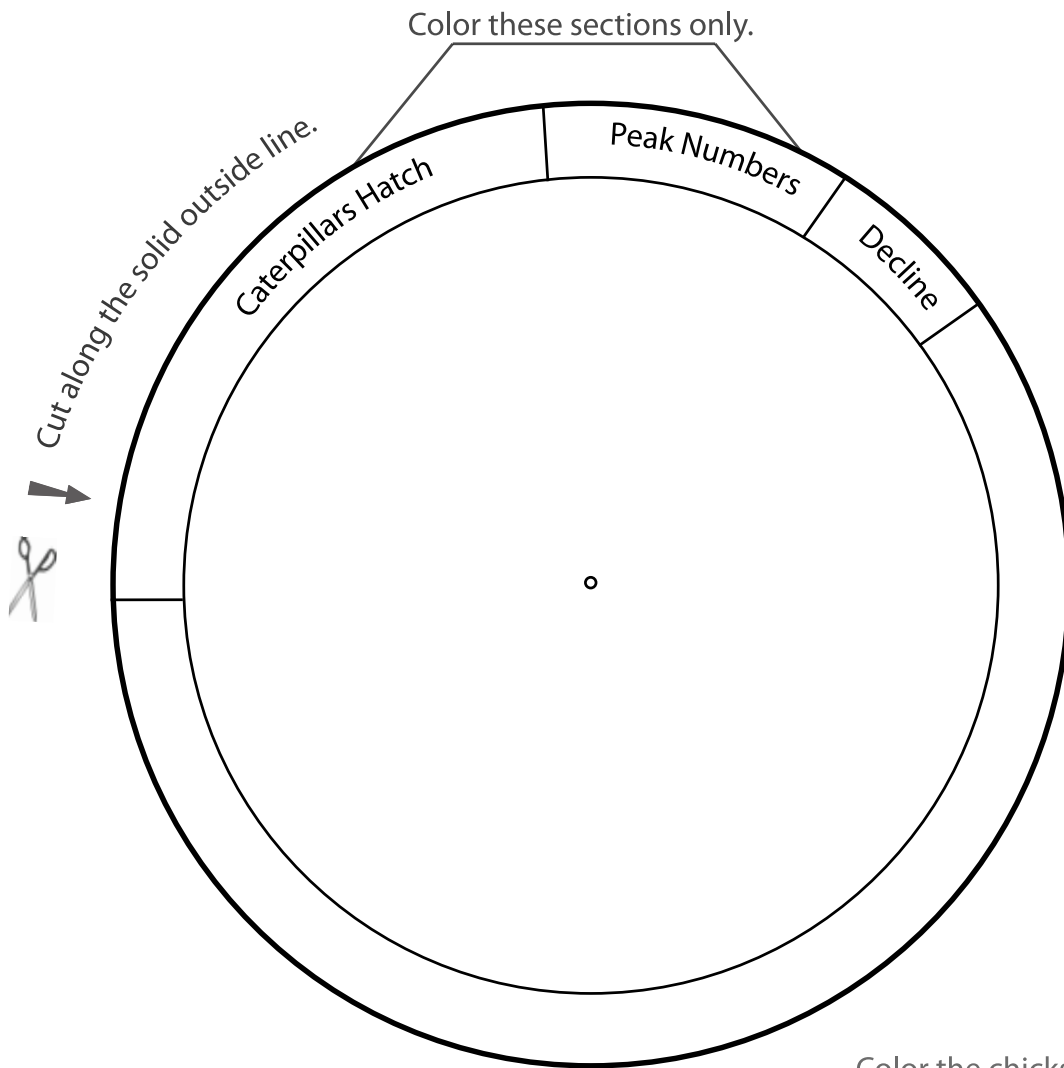


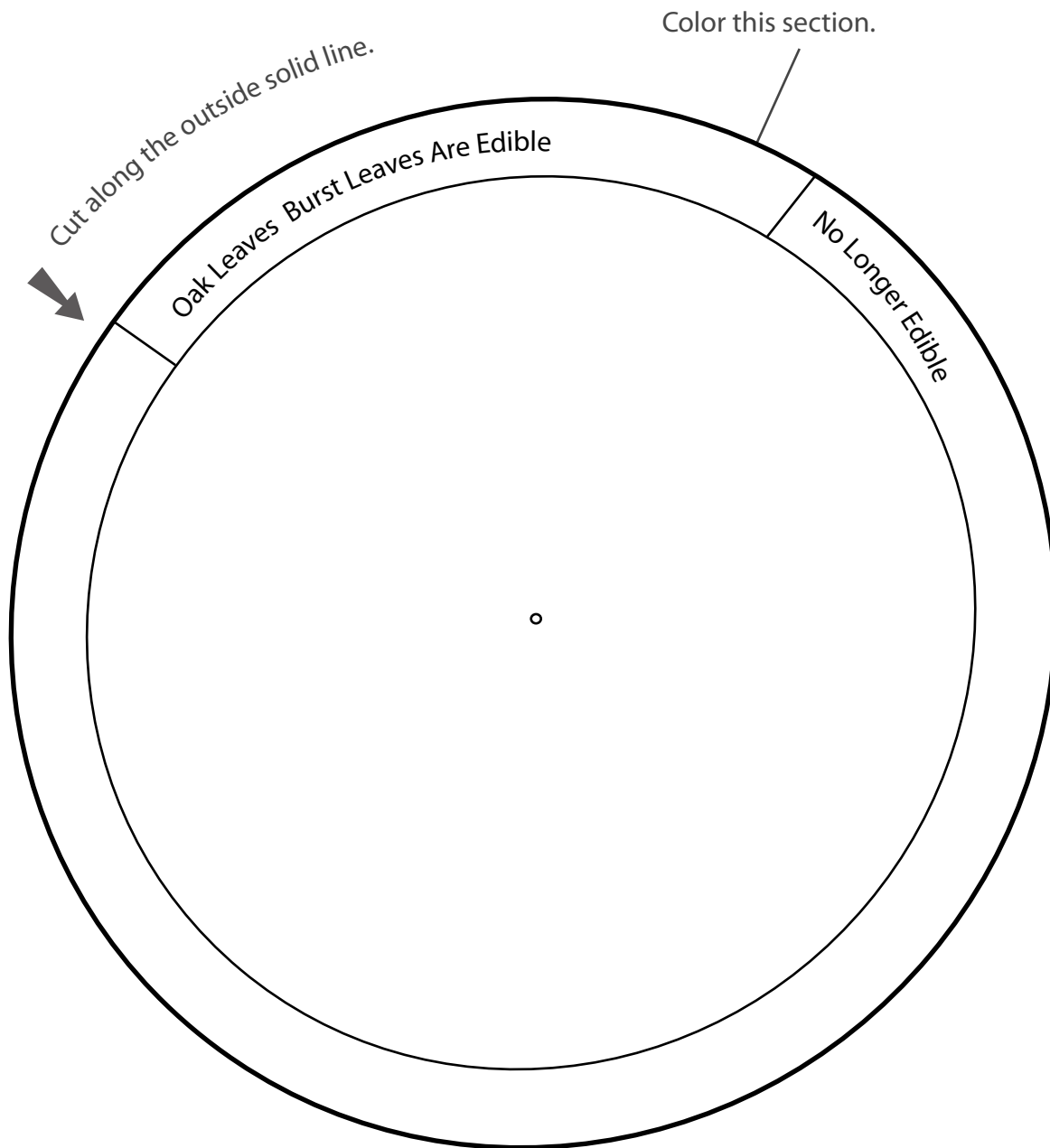
Activity 4-A Phenology: Step Together Step

Life Cycle Calendar



Activity 4-A Phenology: Step Together Step





INSTRUCTIONS: *Step Together Step, Life Cycle Calendar*

Photocopy and cut out the parts that are labeled to create your 'Life Cycle Calendar.' Color the parts indicated with the colors of your choice. When you have finished join the parts together at the center with a reshaped paperclip or a round-head fastener.



Ponder

Your model indicates a synchrony between the three species. As the budburst increases, so do the numbers of caterpillars which are timed to the need of the birds to feed their young. Notice that the peak of the caterpillar numbers aligns with the peak time of the budburst, which is also timed to the need of the birds for food.

This simple food chain that includes the primary producer (oak trees), primary consumer (caterpillars) and finally the secondary consumer (birds) is in sync. The timing for each event serves the others as you move up the food chain. As the leaves mature and become inedible, the caterpillar numbers decline as they move into their pupae stage. At this time the birds have fledged their young. The cycle and timing of the oak budburst is important for the survival of the caterpillars: the timing and cycle of the caterpillars is important for the survival of the birds.

What would happen if the timing of one of these cycles changed?

Part 2:

For hundreds of years this system has worked to the benefit of the caterpillars and the birds, but with global climate change, the patterns have altered. Over the last 20 years, the spring temperatures in the forest region have begun sooner. The date of oak budburst has moved from April 30 to April 26.

Influenced by early warming temperature as well, the caterpillars' hatching date is now 11 days earlier, but not all species respond to climate change in the same way or at the same speed.

1. Move your oak budburst wheel to indicate a beginning budburst of April 26.
2. Move your caterpillar wheel to show a caterpillar hatch date of April 21.

Predict how this change in budburst and caterpillar hatching will affect the birds. Write your thoughts in your science journal.

How did this shift in caterpillar hatching date change the date of peak caterpillars numbers?

How will the change in caterpillar hatch date affect the number of caterpillars that will survive? Remember that the caterpillars need to eat the young leaves. Without these leaves they do not have anything to eat.

Part 3:

1. Move your budburst wheel so the date is now April 26.
2. Move your caterpillar hatch date to April 21.
3. Leave the bird wheel in its original position (bird arrival April 24).

The birds' migration to the forest is not linked to temperature. They begin the migration to the forest from their wintering area based on day length cues from the Sun that do not change. They cannot know that climate change has caused spring to happen earlier in their breeding grounds. They have little control over the date they lay their eggs once they arrive or the hatching date for their chicks.

Your model now shows species that are out of sync with each other and mistimed for survival. Food source levels have changed during their time of highest need.

Explain what might happen to the population of birds in this forest.

If the population of birds decreases due to lack of food for their chicks, what will happen to the population of caterpillars in following years? How would this affect the trees?

Part 4:

Use your Phenology Wheel model to predict what would happen if global climate continues to change at the current rate and the spring continues to advance (start earlier). With earlier spring temperatures, trees and insects respond by advancing their budburst and hatching time, but not at the same rate.

Long-term observations show that for every decade (ten years), budburst advances 2 days and caterpillar hatching advances 6 days.

1. Calculate the date of budburst and caterpillar hatch if the rate of climate change stays the same for the next 20 years. Turn your wheel to indicate your prediction.

Explain what might happen to the population of oak trees, caterpillars and birds.

2. Move your wheel to show budburst and caterpillar hatching 50 years from now; 100 years from now. Predict what you think will happen to the bird population in 50 years; 100 years

3. Predict how this change in budburst will affect the caterpillars.

Ponder

The study of plant and animal cycles is called phenology. There are many examples of how climate change is affecting phenology around the globe and how interactions of plants and animals that historically have been in sync for survival are now mistimed.

What advantages and disadvantages are there for a predator's food demands?

Practice

Got the Big Idea?

Over time, successful organisms have timed their need for food to the life cycles of their food source.

Some life cycles are triggered by the arrival of spring temperatures, rainfall or other changeable factors, and others are triggered by seasonal clues that do not change such as day length.

How does your Life Cycle Wheel model show how different organisms respond to climate change?

Getting ready to present

Make a list of statements or questions to engage your visitors in the Life Cycle Wheel model. Practice explaining how the three organisms are related and how they depend on each other, and how changes in climate patterns affect each one differently.

Present

Use your Life Cycle Wheel to explain to your visitors how organisms depend on each other. Invite them to move the wheels and predict changes in the patterns as climate change alters budburst, caterpillar hatching and bird nesting. Ask them to predict what will happen to the bird population as spring continues to arrive earlier in this forest.

Optional Extension

Look around your community for organisms that respond to seasonal changes in their life cycle. Describe their place in the food chain. Create a visual to explain to your visitors how climate change may alter the life cycle of these species and the plants and animals that depend on them.

Here are some questions we still do not know the answers to about climate change and how it affects the phenology of organisms:

1. How is the pace of growth and development regulated in organisms?
2. How are the cycles of water and energy influenced by climate change? How are phenological patterns influenced by change in water and energy?
3. What critical plant and animal species can we study to help us understand how phenological patterns are changing worldwide?
4. The phenological change in organisms is not equal; how is it regulated?
5. How does a bear know when it is time to hibernate?

Background Information for the Teacher

Activity	NSES 5-8	CLEP	ELF
<p>In this hands-on activity, learners create a model to show how timing in the cycle of tree budburst, caterpillar hatching, and nesting birds is being altered by climate change.</p> <p>With a change in the date of budburst, the food availability for birds and caterpillars has been altered.</p>	<p>Life Sci Standard C: A population consists of all individuals of a species that occur together at a given place and time. All populations living together and the physical factors with which they interact compose an ecosystem. The number of organisms an ecosystem can support depends on the resources available and abiotic factors such as light, water, temperature and soil. Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival.</p>	<p>3a: Individual organisms survive within specific ranges of temperature, precipitation, humidity and sunlight. Organisms exposed to climate conditions outside their normal ranges must adapt or migrate, or they will perish.</p> <p>3c: Changes in climate conditions can affect the health and function of the ecosystem and the survival of entire species.</p> <p>4a: Climate descriptions can refer to areas that are local, regional or global in extent.</p> <p>4c: Climate change is a significant and persistent change in an area's average climate conditions or their extremes.</p> <p>6e: Scientists and economists predict that there will be both positive and negative impacts from global climate change.</p> <p>7e: Ecosystems will continue to be disturbed by climate change. [Organisms] will migrate to new areas with favorable climate conditions.</p>	<p>Biosphere 5: Life's relationship with climate consists of a web of complex interactions and feedbacks. All life on Earth is affected by climatic conditions while simultaneously impacting those conditions.</p>

NSES: National Science Education Standards (<http://www.csun.edu/science/ref/curriculum/reforms/nses/index.html>)

CLEP: Climate Literacy Essential Principles (<http://www.climatescience.gov/Library/Literacy/>)

ELF: Environmental Literacy Framework (www.andrill.org/education/elf)

Background Information

Phenology is the study of the natural seasonal cycles in nature in relationship to day length, temperature, and rainfall.

- When temperatures warm in spring, flowers bloom and the leaves on trees unfold (budburst).
- When the temperatures cool in the fall, leaves turn color and fall from the trees.
- Hibernation patterns, insect emergence, bird, fish and mammal migration, the greening of fields, and the songs of the first robins all are indicators of the seasonal cycles of nature.

There are numerous synchronous relationships in nature between organisms that depend on each other for survival. Leaf budburst, flowering, fruiting, hatching (both insect and bird), arrival of migratory species, and hibernation cycles linked to climate variables and seasonal variations are just a few. Almost every food chain will provide an example.

The study of phenology is not new. Written phenological records date back to 1000 BC when the Chinese and Japanese were keeping records of peak flowering of cherry trees and other natural phenomena.

In recent years, satellite data have added much to the collection of information about phenology cycles. Trends in crop growth, spring greening, the movement of migrating animals, and insect pests are among the cycles studied. Many of these affect human food supplies.

Life cycle changes differ with latitude and region. The same tree species may bloom in April in one region and bloom in May in another. A region's climate usually controls these differences.

Changes in the Earth's climate have begun to change the phenological patterns of many species. With warming temperatures in some areas, insects are emerging earlier, flowers bloom earlier and trees leaf out earlier. For migratory insects, birds, and mammals, these changes are beginning to disrupt food sources and breeding success.

In all climate change events there are winners and losers. For example, when trees' cycles of life advance (occur earlier in the season) their budburst begins sooner. This may allow them to gain an advantage of sunlight over the other trees, which are slower to leaf out. The disadvantage of earlier budburst is they may become vulnerable to leaf-eating insects and animals, as their leaves are the only food available early in the season.

Activity 4-A Phenology: Step Together Step

Unit 4- Biosphere

A flower may escape its predator by blooming earlier than normal, or it may lose advantage by being off-synchronous with its pollinator, who has not changed its timing to keep up with the flower's. Population crashes have been reported throughout the world as co-dependent plant and pollinators become out of sync.

In this activity, students focus on the recent recorded asynchronous timing of oak tree budburst as it relates to the emergence of a caterpillar species that is specific to the leaves of the oak tree, and the migratory birds that depend upon this forest to nest and raise their young. These birds have adapted their cycles to the timing of the peak numbers of caterpillars which they feed their chicks during nesting time.

Students create a model showing the relationship between each of these organisms and what happens as their cycles become out of sync due to changes in the regional climate.

Oak tree budburst



<http://www.forestry.gov.uk/fr/INF5ZYFPW>

Winter Moth caterpillar eating oak leaf



Great Tit hatchlings



<http://commons.wikimedia.org/wiki/User:Eaglestein>

Glossary

Unit	Activity	Vocabulary Word	Definition
Biology	Phenology	Budburst	When the leaves of trees open. Budburst is a seasonal event and generally linked to the spring increase in temperatures.
Biology	Phenology	Fledge	To fly from the nest; capable of flight.
Biology	Phenology	Food chain	The sequence of who eats whom in an ecosystem. Primary producers (plants) use the energy from the sun to create food; primary consumers (animals) eat the plants; and secondary consumers eat the primary consumers (E.g., grass-rabbit-fox is a simple food chain.).
Biology	Phenology	Food web	A complex system of who eats whom in an ecosystem – more than one consumer may eat an organism, giving rise to a web of food chains.
Biology	Phenology	Metamorphosis	When referring to animals, an abrupt developmental change in their structure or form occurring after birth or hatching (e.g., a caterpillar to a butterfly, a tadpole to a frog).
Biology	Phenology	Migration	To move from one region to another usually seasonally for breeding or feeding.
Biology	Phenology	Phenology	Periodical natural events that are correlated with climate and seasonal cycles (e.g., flowers blooming, insects hatching, fish spawning, leaves turning color.)
Biology	Phenology	Predator	An animal that eats another animal (e.g., wolves, hawks, sharks).
Biology	Phenology	Prey	An animal used as food by another (e.g., rabbits, mice, and insects).
Biology	Phenology	Pupae	An intermediate state of a metamorphic insect between larva and adult. Frequently includes a protective covering such as a cocoon while the insect undergoes the change.
Biology	Phenology	Pupate	To undergo the pupae stage.
Biology	Phenology	Synchrony	When events occur at the same time.
Biology	Phenology	Tannins	A substance produced by plants. In some leaves it makes the leaves undesirable as food for insects, birds, or mammals.