Sacred lotus (Photo by Ashley DeRousse)

China Educator's Guide

MISSOURI BOTANICAL GARDEN

P.O. Box 299 • Saint Louis, Missouri • 63166-0299 • (314) 577-5100
www.mobot.org

Dear Educator,

Missouri Botanical President, Peter Wyse Jackson (right) signs plant conservation and education agreement with representatives from China

China is home to an astounding number of species, 31,500, and 12 percent of these species can be found only in China. The Missouri Botanical Garden, working with an international team and the Chinese government for 25 years, is on track to complete the *Flora of China*, a 12-volume record of wild plant species within the country. Challenges such as climate change make it imperative to bring our countries' resources together to protect the biodiversity of plants. This collaborative work was the primary step in an ongoing relationship with China to protect its native plant species.

The Missouri Botanical Garden's *China Educator's Guide* encourages your students, who will become the decision makers of the future, to consider issues that botanists and agricultural experts from China and the U.S. will be solving, such as, "What plants are best for feeding the world's growing populations?" and "How do we conserve soil for the highest plant productivity and the least erosion?"

While big, worthy questions need pondering, our first goal with young learners is to spark interest and curiosity. For me, it was the stories connected with plants that drew me into the field of botany. In that spirit, this Educators' Guide features many stories of people, plants, places and perspectives—all designed to invite you and your students to discover remarkable plants and the critical roles they play today and throughout history. In addition, this guide encourages you to use your local environment as a learning lab. Hands-on explorations of plants and nature in your own schoolyard and community can sprout into student curiosity about plants and nature in China, leading to deeper thinking, connections and curiosities: "We have a plant in our schoolyard that originated in China? Why, how and when?" or "What was it about a plant, such as *Camellia sinensis* or *Ginkgo biloba*, that made explorers want to eagerly share it with the world?"

You and your students contribute to the mission of the Missouri Botanical Garden by making daily decisions to be good stewards of our environment. Use this guide to take a journey into nature outside your door and all the way to China! I am delighted to share this Missouri Botanical Garden *China Educator's Guide* with you and hope that as you and your students become more familiar with plants around the world and close to home, you will take steps to appreciate and care for them.

Respectfully,

Dr. Peter Wyse Jackson
President, Missouri Botanical Garden

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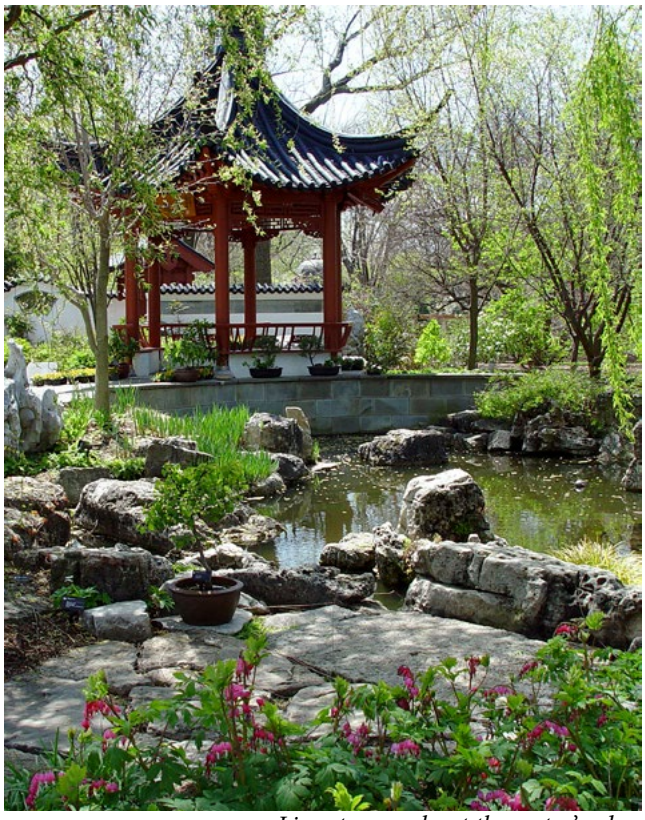
Snowy day in the Margaret Grigg Nanjing Friendship Chinese Garden

The Margaret Grigg Nanjing Friendship Garden



Limestone rocks at the water's edge, Margaret Grigg Nanjing Friendship Garden

The Margaret Grigg Nanjing Friendship Garden at the Missouri Botanical Garden is modeled on the "scholar's gardens" of the southern provinces of China, near Nanjing, which are smaller and less ornate than the Imperial gardens of the north. Designed by Chinese-born architect Yong Pan, this garden is a showplace of extraordinary craftsmanship.

It is often said that a Chinese garden is built, not planted. The architectural elements were designed and built by Chinese artisans in Nanjing, China using the traditional colors indicative of a southern Chinese Garden: black, white, gray and reddish brown for the different elements such as the walls, pavilion, bridges, and blue stone pavings with their exquisite mosaic designs. The garden commemorates the longstanding scientific and cultural exchanges between the Missouri Botanical Garden and Chinese botanical institutions, and honors the sister city relationship between St. Louis, Missouri and Nanjing, China.

Many Chinese pavilions are noted for their elaborate and fanciful carvings of animals, dragons, and sea monsters, but a "scholar's garden" pavilion serves not only as a retreat where one can study in solitude, but as a place for delightful social gatherings, often featuring poetry contests. Its massive ceramic tile roof with its dramatic swooping shape and "smiling curves" seem to echo the upward sweep of tree branches behind the pavilion. The intricate artistry and exquisite detail of the pavilion, the focal point of the garden, creates a subtle elegance in the landscape.

The Chinese term for landscape is shan shui, literally "mountains and water." Water is the yin, the calm, nurturing, yielding element; mountains are the complementary yang, vertical and powerful. The garden is completed with a body of water, its spiritual heart, and monumental Tai Hu stones, from the Tai Hu region of China and other nearby regions. These fantastically shaped boulders of eroded limestone serve as nature's statuary, evoking the awe of ancient mountains, seeming at once solid and transparent, suggesting faces, animals, or spiritual forces that have been influenced by traditional folk religious symbols. Examine the clean delicate lotuses that emerge from muddy pond bottoms.

In the Nanjing Friendship Garden a hand-carved white marble bridge with a moon arch beneath traverses a narrow mountain stream that cascades over several small falls, feeding into the central pond at the heart of the garden. The hand carved white marble balustrade sits across the pond complementing the bridge. Five stones are strategically placed in the pond, symbolizing the five sacred mountains in China, while rocks from both China and Missouri have been selected for placement at the stream and water's edge.

Pendulous Lotus Gate,
Margaret Grigg Nanjing Friendship Garden

The garden's surrounding walls have a "dragon ripple" configuration with inset ornate windows. These windows are the "eyes" of the garden allowing the visitor to look out upon a grove of bamboo just beyond the southern wall. The designer of the garden has carefully chosen traditional plantings, many of which have spiritual significance or value in Chinese culture. Plantings include pines, bamboos, willows, plum trees, forsythia, hibiscus, wisteria, peonies, lotuses, rhododendrons, and azaleas, with gardenias, citrus and pen-jing in containers. Many of these plants originated in China, which has the world's largest temperate flora. A number of them were grown from seed collected in China.

A garden without an inscription would be as unthinkable as a Chinese painting without its rows of calligraphy in one corner. On the wall beside the exit, Pendulous Lotus Gate, is a stone tablet with calligraphy of an ancient Chinese poem by Wang Wei (699–759 CE) inscribed around 1900 by Pu Jie, brother of the last Chinese emperor, Pu Yi:

> *Sitting alone in a secluded bamboo grove,*
> *I was singing while playing the qin,*
> *Before realizing, in the deep grove,*
> *The moon had already joined me*
> *With her beautiful light.*[1]

1 Information on Chinese gardens was researched from *The Chinese Garden: History, Art & Architecture* by Maggie Keswick. (New York: St. Martin's Press, 1986); Juliana Yuan, lecturer in Asian Art at University of Missouri—St. Louis; and Joanne Fogarty.

Plants and People: China Interactive Exhibit

Explore China without ever leaving St. Louis! Enter Brookings Center at the Missouri Botanical Garden and emerge into the world of China! Discover its rich ecosystems and flora. What role do these plants play in the lives of China's people and how have these plants influenced our world?

Students of all ages are invited to explore the wonders of China, a country rich in natural landscapes, habitats and plant species diversity. Enjoy interactive displays, images, artifacts, costumes, puppets, games, puzzles and books as you discover the vast flora of China and the important role its plants and ecosystems play in the lives of people—both in China and around the world. Learn about Chinese medicine, food, clothing, shelter, and transportation methods that are derived from plants. Experience Chinese art, literature and symbolism, all of the cultural aspects influenced by nature.

The exhibit is located in the Brookings Interpretive Center at the Missouri Botanical Garden. It is on display March 31, 2012 through January 1, 2013.

Plants and People: China *exhibit*

Lessons

Peonies in Margaret Grigg Nanjing Friendship Garden

China is vast in geographic scope, from the variety of landforms to the varying climates of the different regions. China has more plant species than almost any country in the world and has contributed beautiful, economically useful and nutritious plants to the U.S. Every lesson in this guide speaks about or includes plants. All lessons correspond to content area grade-level standards for Missouri for the grades listed. Many of the hands-on activities can be conducted over multiple days, in or outside of the classroom.

Lessons for K–8 sorted by Grade Level

K–2	3–5	6–8
Tale of a Chinese Dragon		
Insects: From Silkworms to Crickets		
	Plant Adaptations: From Chinese Lights to Plant Scents	
	Mapping, Money and Ecosystems: Protecting China's Plants—Protecting the Plants in Our Schoolyard	*Mapping, Money and Ecosystems: Protecting China's Plants—Protecting the Plants in Our Schoolyard*
	Worth All the Trees in China	*Worth All the Trees in China*
	Loess Soils: a Study of Weathering and Erosion in China and in the Midwest	*Loess Soils: a Study of Weathering and Erosion in China and in the Midwest*
	Characters and Couplets: Poetry and Botany	*Characters and Couplets: Poetry and Botany*
		Feeding the Future: China and the U.S.
		Ancient Rivers and their People: the Yangtze and Mississippi Rivers ca. 770 BCE–400 CE

Tale of a Chinese Dragon

Language Arts, Reading

Dragons in China are associated with intelligence, bravery, long life and strength, but were often friendly, too, unlike many Western depictions of dragons. Students will illustrate, provide a title and retell the story of a Chinese dragon.

Insects: From Silkworms to Crickets

Science

How do insects use plants? Students will explore their local environment, observe insects over time, collect data and notice patterns. Students will learn about insects, like the silkworm and cricket in China or the honeybee in Missouri, that can make a positive contribution to people's lives. This lesson complements the Garden's outreach program called *Honeybees Abuzz* and all of the Sophia M. Sachs Butterfly House insect programs for young students.

Plant Adaptations : From Chinese Lights to Plant Scents

Language Arts, Art, Science

Students decorate lanterns with beasts and riddles, just like children in China. Students design their own experiment with insects and plants to see what kind of plants or plant extracts repel insects. Historically, some Chinese used torches to keep insects off of crops, and this practice may have been the precursor to the Lantern Festival. This lesson aligns with the Garden's three-part *Survivor MBG: Plant Adaptations* class, the Sophia M. Sachs Butterfly House's *Insect Ecology* and *Wings of Wonder*, or Shaw Nature Reserve's *Bugs, Beaks and Beasties: Animal Adaptations* class offerings.

Mapping, Money and Ecosystems: Protecting China's Plants—Protecting the Plants in our Schoolyard

Social Studies, Science

Outside the classroom door, students make observations and map their own schoolyard. By collecting data, students learn about the usefulness of China's plants for the U.S., but also about a few that were introduced and became invasive. Shaw Nature Reserve's *Forest Ecology* class enhances this lesson in an amazing nature reserve!

Worth All the Trees in China

Language Arts, Social Studies

Which tree is the most valuable? How do people we know define the most important tree in their life? In their community? Students conduct interviews, then study different trees from the U.S. and China and their impact on the economy. Build on lesson concepts with these classes: *Forest Ecology* at Shaw Nature Reserve, and EarthWays' *Fifty Words or Less* and *The Sustainability Game*!

Loess Soils: A Study of Weathering and Erosion in China and in the Midwest

Science, Social Studies

Students identify rocks common to both Missouri and China and learn about the causes of weathering and erosion, especially on the unique loess soils found in the Midwestern U.S. and China. Our *Dr. Carver: Soil Scientist* class complements this lesson by relating soils to plants.

Characters and Couplets: Poetry and Botany

Language Arts

How are English and Chinese written languages different? Students write a couplet similar to those written for a Lunar Spring Festival in

China, using plants as inspiration. Visit the Chinese and Japanese Gardens where students will be inspired to write more poetry during our *Asian Gardens: Science and Culture* class.

Feeding the Future

Science

China and the U.S. are working towards more sustainable practices in the growth and preparation of foods. Both countries are studying the ocean's plants for nutritious filling foods for growing populations. Future scientists are developing plants that have high nutritional value and can produce high yields. In this lesson, a tissue culture experiment and students' research of a plant will encourage discussion about the future of agriculture in sustaining the land and people of both countries.

Ancient Rivers and their People: the Yangtze and Mississippi Rivers ca. 770 BCE–400 CE

Social Studies

The Yangtze and Mississippi Rivers served as resources for ancient peoples. Students will determine what constitutes a civilization, what archeology is, and discover how archeologists come to understand ancient civilizations. Lastly, students can learn about plants and how they were used by ancient civilizations. Focus on the Zhou and Han Dynasties in ancient China and the Early and Middle Woodland peoples along the ancient Mississippi/Missouri/Ohio Rivers in the Midwest. The *Asian Gardens: Science and Culture* class complements this lesson.

Start the new school year off with a Garden of Learning!

Concentration and reflection are important in learning. Whether it is the martial art of T'ai Chi, gardening, or brush painting, it is typical for someone following Zen practices to approach the activity by first consciously clearing one's mind and opening the heart, such as by taking a few deep breaths.

Zen gardening is an avenue toward reflection. A person who is raking a shoreline into the sand can clear their mind with repetitive strokes. They can take time to just think about the garden itself, the sand, raking movement and sound, and the waves being made in the sand. This task can relax someone and prepare that person to concentrate, to be methodical and to reflect.

DO: Talk about Chinese culture and Zen as one of its peoples' belief systems. Use shoebox lids, white sand, dark rocks (wisdom) and limestone to create Zen gardens while talking about concentration and reflection for the school year.

Be sure to start or follow-up your lesson with **a visit to one of Missouri Botanical Garden's sites** to bring the concepts to life and make further connections! Programs include ***Asian Gardens: Science and Culture***, our unique interdisciplinary class that immerses your students in Chinese culture and allows you to take a Zen Garden back to school! Check online for class details and sign up early! Learn more at *missouribotanicalgarden.org/learn-and-discover/*.

If you are interested in **checking out one of our videos or kits**, visit *missouribotanicalgarden.org/learn-and-discover/* for a listing. Call (314) 577-9501 to make a reservation.

Student Objectives

Students will:

- recognize that a story has a beginning, end, and title.
- use senses in describing flowers: scents, colors and textures.
- create illustrations to match a story and understand the role of an illustrator.
- retell a story using pictures.
- descriptively compare the features of dragons from Europe and China.

Materials

- Flowers with origins in China
- Permanent marker
- Crayons, markers and pencils
- Double-sided tape
- Large chart paper for t-chart
- Sheets of 8.5" x 11" paper, one for each student (see pre-lesson preparation for how to prepare sheets)

Girl with dragon at a Chinese festival

Lesson 1:
Tale of a Chinese Dragon

Grades K–2

LESSON SUMMARY/PURPOSE

Young children are often exposed to media and games that present **dragons** in fearful ways, aligned with a more European conception of dragons. Pre-kindergarten and young elementary students do not always distinguish real from fantasy, and thus dragons may scare them, day or night. In television, movies, and books they have seen dragons capture princesses, rise from smoky swamps, destroy towns and shape-change.

In *Mulan*, a fictional movie based during the Han dynasty in China, the heroine's sidekick was a small but cheeky and intelligent dragon-like creature. In China, dragons have traditionally been symbolic of luck, intelligence, bravery, long-life and strength. Young children will enjoy the story of the Chinese dragon, learning how to illustrate and retell a story. Dragons, as fanciful creatures, enable the children themselves to use their imagination in creating their own dragon and its story. The story for the lesson provides opportunities for young children to make comparisons between and learn about story components. Students can learn about flowers and their parts (stem, flower, roots) at the same time, noting why some flowers would be named after dragons.

PRE-LESSON PREPARATION

- Find a variety of English and Chinese versions of dragon pictures. Many fairy tale books have pictures of dragons.
- Bring in plants native to China showing the different scents, colors, and textures. The story in this lesson uses plants from China that are also seen in the St. Louis region in autumn, but teachers can substitute the spring flowers and shrubs listed on pages 14–16. Have pictures of flowers to help children visualize them.
- Provide a variety of stories about Chinese dragons and flowers in your reading area.
- Lay the 8.5″ × 11″ sheets of paper (one per child) in a line as shown in the diagram below. Number each sheet. Now flip the pages over and draw the outline of a dragon (mostly a long body with a head) on the other side.

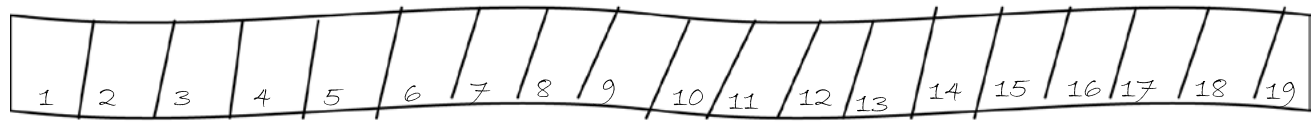
  On the numbered side of the papers the children will **illustrate** the story found on page 12; each child will use one sheet of paper to illustrate one sentence in the story. You can later write the sentences on each sheet. After the activity the papers can be reassembled and taped together for a dragon storyboard.

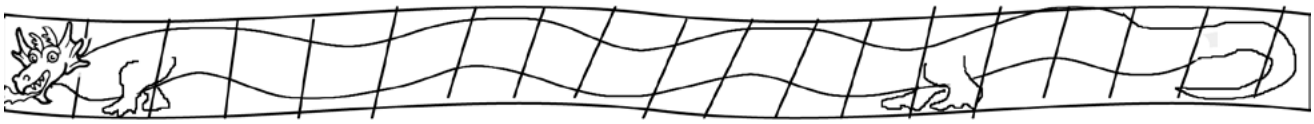
PROCEDURE

Ask students if they have heard of dragons. Use a t-chart to write down descriptive words. Explain that students will be listening and drawing today as you are telling the story. This short story may need more than one reading, so students will just listen the first time.

Ask the students to go sit on the floor next to the paper where their number is. Take their crayons or markers.

Read the story on page 12. This story has no pictures and no **title**—the class will illustrate the story! As you tell the story, before each line, tap the head of the student who will then draw the picture about that line as you continue to read. When their head is tapped, they have permission to open their crayon/marker box and draw only on their sheet of paper. At the end of the story, students will create a title.





Story

China Dragon sadly dropped into the valley below, wrapped her tail around a dogwood tree and sighed. Her cousins from England had been visiting her mountaintop cave—a cave so high above the ground it rested in the clouds. Usually it was a bright peaceful place, but not today.

*Her **rowdy** cousins crashed her lamps and tables by flying about inside her cave. They'd made a mess, leaving barbeque all over her floor. She loved board games and they didn't even play games with her—well maybe because she always won. Then they broke her favorite picture of children flying kites with her.*

*Worse, they breathed fire inside the cave. She tried to put out all their flame puffs, but her bed sheets and furniture were still **smoldering**. Her cousins had even **singed** the tip of her ear and it hurt—she needed to put some cool water on it!*

When she left her cave with tears in her eyes and floated to the valley floor, she gazed over the kingdom. Far in the distance was a giant lake that looked refreshing. She wished she could fly as fast and furious as her winged cousins, but her long body slowed her down. She grabbed her sunglasses and began walking over the hills, dreaming about a dip in that blue lake. But when she got to the lake, it wasn't a lake at all; it was a huge field of bluish purple aster flowers! White astilbe flowers, moving like waves in the breeze, looked like the lake's edge meeting the trees. Rabbits nibbling on the many flowers played hide and seek with her among the flowers, but the hot day made them thirsty. It had not rained for days! Suddenly, she remembered just how much her ear hurt. She blew cool air into the clouds and made a rain shower. The flowers sparkled with the fresh rain; the rabbits took cover, but thankfully drank from the many puddles. With her spirit and her ear feeling much better, she was hungry.

She thought she saw some brown sparrows flying around a big white and red tent in the distance. She waved goodbye to the rabbits, gracefully shook out her long body and began flying, like a kite drifting on the wind, stopping to catch her breath at each cloud. Each breath made a deep fog settle on the land below.

Through the clouds she drifted down only to see that the sparrows were really the branches of the red hibiscus and cotoneaster shrubs. The tent was a vast field of fragrant red roses, chrysanthemums and peonies. The white of the tent was a pond covered with the sacred lotus flower. She lay down by the lotus blossoms and put her tail in the water to make the blossoms ride her waves.

She forgot her hunger and sadness as she danced over to the roses. She gathered a handful to her nose and laughed—a sound that filled the valley with the gentle tinkling of bells. Feeling full of life, she flew back to her mountaintop, breathing the colors of the flowers into the clouds as she breezed by them, and brought order back to her home.

Retelling

Ask the students to retell the story with their pictures, from the beginning to the end, thinking about how the dragon was feeling, and the story sequence (note how the dragon flew at the end compared to the start of the story).

Discussion

Ask some students how they showed the dragon's feelings or described the flowers/mountain, etc. in the story. Use some new words and talk about how those might look: smoldering, drifting, flame puff, sparkling. Have students move their arms like a wave on the breeze. Illustrators are good at drawing pictures that capture a feeling or a description in colors, shades of color, and textures of their paint, chalk, or computer tools. Talk about an illustrator and how they work with the **author** of a book to make the best pictures. Read the story again and, if they want to, have students add to their pictures based on the words of the story.

Discuss their emotions: Students may have experienced problems with friends, and had to find something that made them feel better afterwards. You might mention that the dragon returned "order" to her cave, and comment that in China some of the people believe that completing a repetitive task, like polishing furniture, helps clear one's mind and bring order to one's thoughts (see *Taoism* in the Teacher Background Information section).

Talk about possible titles. Authors must talk with their **editors** before creating a title that best describes the story. Vote on one title.

After students are finished, you can write the title on the "dragon storyboard" and write each line of the story on its appropriate page.

EXTENSIONS

- Science centers may include flowers and tools to take apart flowers. Students can sort the different parts: stem, flower, roots, etc.
- Students may sort the flowers or pictures of flowers by color, shapes or textures. Use flowers with the word "dragon" in their name. Pictures of these are included on pages 14–15.
- Students can make their own book about the dragon and his/her favorite flower or place to fly.
- Have students create their own dragon and identify a way in which it was helpful or protected a person.
- Have students create their own flower with all its major parts, but include the word, "dragon" in its name—it may look or act like a dragon!
- Students may want to parade with their dragon through the hallway. Have students turn over the storyboard and color in the dragon on the other side. Remind them how the dragons move in Chinese parades!

TEACHER BACKGROUND INFORMATION

Dragons in Western Tradition

In Western cultures, dragons were often described as having small wings, breathing fire, being greedy and living in caves. Seen often in stories during the 1000–1700 CE time frame, they were often killed by knights.

Dragons in Eastern Tradition

Eastern dragons were revered as gods and

bringers of good fortune to people of Asia. They were docile and gentle creatures with long bodies, soft cow ears, four soft-padded big feet, fish-like scales, two horns, and no wings.

Confucian beliefs in China support the respect and traditions of listening to the wisdom of elders. Dragons that lived forever were often depicted with beards and considered to be wise. Long snake-like bodies usually meant that they were luckier. Dragons did not roar, but made gong and bell sounds. They ate sparrows. They were kind, friendly, helpful, and wise friends of human beings, which is perhaps why they were so colorful and depicted in combinations of red, green, blue, and gold. Instead of scaring people, they scared away evil, disease and other feared things. They were connected to important life-giving factors, especially rain and storm clouds. Their soft breath formed clouds. They slithered, swam, walked, and flew. Chinese dragons lived in the sky or in the ocean.

Some Chinese emperors called themselves dragons and sons of heaven. Thus the emperor's chair was called a dragon throne. Many palaces were decorated with dragons.

The Dragon Dance

A dance typically performed at the Lunar New Year (Spring Festival) celebration, it dates back to the first king of China, who was believed to bring medicine and agriculture to the Chinese. In the Chinese dragon dance, a few people carry the head. The dance team carrying the dragon's body synchronizes their movements in a grand, graceful, and powerful manner.

The Chinese Zodiac's Fifth Sign: the Dragon

It is believed that the Chinese Zodiac was developed sometime during the Han Dynasty using the astronomical rotation of Jupiter around the sun every 12 years. Actually, the zodiac's signs are connected to both the year in which a person was born and to the seasons. It is mathematical in that each year has 12 months. Someone born under the sign of the dragon, for example, is reputed to be helpful and generous, enjoy alone time, like to live by his or her own rules, and is noble and dignified.

Chinese dragon parade

Plants

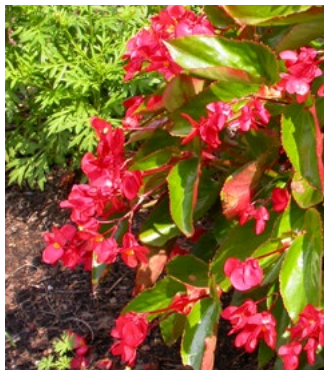
Flowers with Dragon Names

Dragon heart ➤ geranium (*Geranium* 'Dragon Heart'): spring bloom; prefers moist area.

Red dragon rice (*Oryza sativa* 'Red Dragon'): red foliage.

Silver dragon ➤ liriope (*Liriope spicata* "Gin-ryu' SILVER DRAGON): summer bloom; purple.

Jeweled dragon *(Polygonatum odoratum*): variegated perennial with red petioles.



Dragon red wing ➤ begonia (*Begonia* 'Bepared' DRAGON WING RED): shade-loving; waxy leaves.

Flying dragon/ Japanese bitter orange (*Poncirus trifoliate*)

Dragon root ➤ (*Arisaema dracontium*): spring bloom; found in woods.

Black dragon/ Japanese cedar (*Cryptomeria japonica*): coniferous tree, prefers rich, deep well drained soil; grows to 60' tall and has small cones.

Red dragon (*Persicaria* sp.): bright red fleshy stems, 3′ × 6′ leaves of dark purple, burgundy, and mint green with silver slivers running down the center of each; white baby's breath type of flowers; adapts well to many soils.

Flowers from China
All of these grow in the St. Louis region:

Autumn blooms:

- **Aster**: bluish-purple flowers, prefers sun.
- **Astilbe**: pink to purple shades.
- **Chrysanthemum**: member of the aster family; annual; available in many colors; prefers sun; easy to grow.

Summer blooms:

- **Daylily**: yellow, orange, and red; tolerates a wide range of soils.
- **Peony**: prefers rich soils and sun; red, pink, white.
- **Geranium**: blue-purple blooms.

Spring blooms:

- **Campanula**: low growing; blue-purple blooms.
- **Columbine**: prefers shade; blue-purple blooms.

Flowering Shrubs:

- **Butterfly bush**: blue-purple blossoms; blooms in summer
- **Cotoneaster**: red berries, white blossoms.
- **Hydrangea**: blue and purple blossoms; blooms in summer.
- **Rhododendron**: prefers shade; red, white, or orange blossoms; blooms in spring.

Rose of Sharon/hibiscus

- **Rose of Sharon/hibiscus**: red, pink, or white blossoms; blooms in summer.

Chinese Cultural Symbols

The Chinese Garden at the Missouri Botanical Garden mimics a garden found in China.

The garden has a water feature, rock formations and lotus beds. Many gardens throughout the world have water because it is symbolic of life. In the Chinese garden, water and stone are viewed as interconnected opposites; stones represent mountains and strength, while water represents oceans and passivity.

Lotus flowers are native to China. The sacred lotus grows not by seeds, but by rhizomes under the soil in shallow ponds in both China and the Midwest U.S. From under the mucky soil, a beautiful elegant-leaved plant and blossom emerge. The flowers can be one foot in diameter! The seed pods that follow are musical and unique. Many are used in floral arrangements. The lotus leaves are waxy and water beads on their surface, making a breathtaking site on cool foggy mornings. You can find the lotus at the Missouri Botanical Garden in the lake in the Japanese Garden.

Taoism and the Concept of Order in Chinese Beliefs

In the fifth century BCE, Lau Zhu supposedly lived and espoused the Taoist belief that natural phenomena can come together in a harmonious order, including in a person. Peace and health were the equivalent of harmony and order within one's body. Consider the idea of the entire world as an organic whole in which each person works to balance the energies of her own self, body and mind, and bring these into harmony with the greater universe, the greater natural world; this is what a Taoist believes.

Vocabulary

- **Author**—writer of poetry, stories, books
- **Dragon**—a pretend creature, often with bird or reptilian traits that is common to many cultures.
- **Editor**—advisor to a writer and illustrator to help their writings make more sense, have correct spelling and grammar
- **Illustrate**—to draw pictures; an illustrator is a person that creates the pictures that match a book or story
- **Rowdy**—active, sometimes without caution
- **Singed**—lightly burned
- **Smouldering**—when a fire's flames die down, or the fire becomes wet and smoky
- **Title**—name of a written text, poem, etc.

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Sacred lotus flower (Photo by Ashley DeRousse)

Student Objectives

Students will:

- learn that many insects need plants to survive.
- learn how plant and insect parts differ.
- make observations and ask questions about their local environment.
- use one of their questions to investigate insects and plant interactions in their schoolyard.
- understand that many insects are beneficial to plants.

Materials

- T-chart
- Posterboard chart
- Laminated pictures and names of insects
- Rotting log, chewed leaves, and roasting pan container
- Q-tips, plastic tweezers, straws, pinchers
- Fruit juice in plastic cups with straws, one per student
- Leaves, stems, roots, and flowers of plants for children to eat: spinach, lettuce, celery, cauliflower, broccoli, carrot
- Birthday party blower, one per student
- Books about insects and plants
- Unbreakable mirrors
- Napkins
- Cups
- *The Empress and the Silkworm* book, sample(s) of silk
- Salad for all children to eat at the end of the lesson

Lesson 2: Insects: From Silkworms to Crickets

Grades K–2

LESSON SUMMARY/PURPOSE

Students will learn that many organisms besides themselves rely on plants for food. Just like people have teeth designed for tearing, biting, and chewing, insects also have mouthparts suited to the types of food that they eat. Students will look at the insects' mouth parts.

Students will learn how insects use plants not just for food, but also for shelter and liquids. Students will explore their local environment, observe carefully over time, ask wondering questions and make an investigation. The students will collect data and notice patterns. Students will learn about insects like the silkworm and cricket in China that can have a positive contribution to people's lives.

Essential Questions

- How do plants interact[1] with insects?
- How do insects interact with plants?
- In what ways are insects beneficial to people?

Connections to China

The students will learn about how some insects can be pests by hurting plants or people, but that

1 Although you may want to use the term, "help" instead of "interact with;" it may be best to use the more difficult words because the insects and trees do not have the human characteristic of empathy in order to "help" each other. Assigning a human emotion or emotive behavior to a plant or an animal is called "anthropomorphism." You can rephrase the question: How do insects use plants? How do plants use insects?

many insects' actions are beneficial to people and plants:

- For example, without bees and butterflies, many plants could not reproduce.
- Without carpet beetles and bark beetles, dead leaves and rotting logs would pile up over our heads.
- People in many countries eat insects.
- In China, some people historically kept crickets as pets.
- In China, the silkworm is a valuable insect. The silkworm eats the leaves of the white mulberry (native to China) and the Osage orange tree (native to Missouri).
- In Missouri, honeybee species provide honey.

PRE-LESSON PREPARATION

Insects are different than we are! Create a T-chart to identify some ways that the insects are the same or different as people. Use a lifelike insect puppet.

Have children visit science stations you have created that show how insects eat. After students share findings, discuss how insects are important for breaking apart dead/dying natural materials and how they use different mouthpieces depending on the food they eat.

Station one: A rotting log or piece of bark with holes. Have Q-tips and plastic tweezers available for exploration. Have pictures of insects with different mouthparts, such as drills.

Station two: Salad tongs and leaves, blocks, etc. Children imagine that they have mandibles (teeth) like an insect. Try to pick up the leaf and tear it with the salad tongs.

Station three: Have soft plastic grapes floating in water in a tall container with a small opening. Make tongs, bamboo skewers, long tweezers, and tools for opening nuts available.

PROCEDURE

Activity One

Give younger children a snack that includes a variety of vegetables, such as carrots, lettuce, berries, etc. They will especially have fun with mirrors and looking at themselves chewing. Ask them to take the time to chew the things you give them; to eat very slowly. While they are chewing slowly, you want them to look in the mirror and observe how their hands, mouth, and teeth are working. You can talk about the parts of the body they are using (hands, mouth, teeth). Once they have had time with the mirrors, then focus them toward the questions:

- How are your teeth helping you eat this food?
- Where could we find these things that we are eating?
- What if we did not have teeth? How could we eat?

Children should grasp that the foods they are eating are plants. Add to the T-chart "We are similar to insects because we both eat plants!".

- Ask students what they discovered at their stations. Many insects love to eat plants. They have special mouth parts that hold, tear, chew, crush, or suck the plants to eat. Sometimes when insects munch on plants, they can hurt

or kill them. Those insects are often called pests.

- Provide students with straws and juice and ask them to sip their juice. Some insects (aphids, caterpillars, bees) suck the juices out of plants. Ask them to pretend to be a butterfly sipping nectar from a plant. Bees also have straw-like structures.
- As a visual you can use a party blower to show the children how the butterfly can roll out its long straw-like structure to drink from the plant. Or perhaps you will want to drill a small hole in a piece of wood to show how weevils use their "drill." You can also use salad or tool pinchers to show how insects (like beetles) can tear the leaves. Many insects chew like we do. Their teeth are called mandibles, and often they have pinchers to grab the food.

Activity Two

Ask students to observe insects outside and at the science stations. What do they look like? What are they doing? How are they using the plant (for food, as a home)? Keep a chart of the student observations and questions. Turn students' wondering questions into investigations such as described below.

- Decide with the class on a question to study. Choose from their questions, but make sure the question is do-able, has variables (things that can change), a control (stays the same) and can be measured.
- Collect your observation data on the insects/plants question. Use pictures on data charts (Velcro works well for attaching pictures on a data chart). Look for patterns. Make a conclusion from your findings.
- Assess students using the essential questions.

Activity Three

Have students gather to read the story, *The Empress and the Silkworm*. This book is designed for PreK through third grade. On its inside cover, the book provides the traditional story of silk, its discovery, use, and trade. The students can see how the insect and tree together make something special for people. Bring in samples of silk for the students.

Silk is a wonderful fabric for dyeing. Highlight that the silkworm (a moth larvae, not a worm), by eating the leaves of the mulberry tree, creates its cocoon and it is the silk that made the cocoon that is valuable for making thread and then the thread is spun into silk cloth.

*Silkworms can also survive by eating the leaves of the Osage Orange (*Maclura pomifera*), a tree native to Missouri.*

Share how other insects can contribute to people's lives: in China, crickets were sometimes kept as pets for their pleasant songs; honeybees make honey that people can eat.

Concluding Ideas

Play "Pass the Insect." Students can pass a plastic oversized insect, and as they do, answer one of the essential questions:

- How do insects use plants?
- How can insects and plants be beneficial to people? (Possible answers include: clothing from the silkworm, break down leaves to make good soil, pets, honey, etc.)

EXTENSIONS

- When they come in from recess, ask students what insects they saw and record the number of antennae, number of legs, and number of body parts. Create a data collection chart. Ask students to look at the body parts of insects. What is the same? Which insects can they name? How are they different?
- Ask students: What are the parts of a plant? List plant parts on one side of a T-chart. Make conclusions and comparisons between the plant parts and the insect parts.
- Create a chart with Velcro numbers. Put common insects as headings, leaving a few blank headings. Along the side, put behaviors: sleeping, hiding, eating, flying, etc. Students should explore what the insects are doing and where they are.
- Allow the children to pretend to fly as bees or other insects to collect pollen from plants. Insects can be helpful to plants and people.
- Have students dye white silk cloth. The dye is easily made. Procedure:

    1. Put the silk in alum (available at spice stores) to a boil, and then let cool overnight. Rinse.
    2. Take cranberries, blackberries, pokeweed berries, yarrow, or prairie dock stems and leaves (all Midwest natives) and boil for five minutes in small containers with half as much distilled water as berries or plant parts. Let cool overnight. Strain the plant parts and discard. Keep the dye.
    3. The next day, have students use rubber gloves to dip their silk into the dye. Hang up on string with paper clips to dry.

    Once dry, you can make sachets out of the dyed silk cloth. Use these Chinese spices and herbs for the sachet: dried perilla (can be invasive in this region), cassia, or cinnamon, peppermint, star anise, dried ginger, etc.

Perilla frutescens *(top) and* Mentha *sp. (bottom)*

TEACHER BACKGROUND INFORMATION

Harmful Insects

Aphid ➤

Aphids are often found on bushes, looking like a line of minute yellow cotton balls lined up on the stem of a plant, just under the sepals and flower itself. Quite often, a trail of ants may be nearby. You can find aphids at the start of the growing season. They do come in many colors. The aphids suck the plant sap, and then they eliminate a honeydew substance that ants love. The honeydew substance may leave fine black mold on the leaves. After the aphids suck out the plant sap, the blossoms become puckered and misshapen.

Stink Bug ➤

Stink bugs are easily hidden on the plants they eat. They may be ¼″ to 1″ long and often are green or brown, but may have yellow and red markings. The green and brown varieties keep seed growth in check in soybean fields. Stinkbugs like fruit trees, columbines, snapdragons, and sunflowers. They insert their mouth part into leaves and suck the plant sap. The plants may show pale yellow spots or become misshapen. Stink bugs overwinter as adults in leaf litter or under tree bark. The eggs look like black and white barrels, which hatch into wingless nymphs and then change color and use wings.

Japanese Beetle ➤

Japanese beetles are shiny metallic insects that do not taste good; many predators—except toads, moles, and skunks—leave them alone. The children may have found a grub in the soil; the larval grub eats grass roots. They use their pinchers to tear leaves and eat them.

Beneficial Insects

Beneficial insects help in many ways in gardens. Many pollinate trees and shrubs so that the fruit may develop. Some eat dead and decaying leaves and logs in the garden, helping release nutrients back into the soil for plant growth. Others kill insects that are pests and can destroy crops or gardens.

Some of the more common beneficial insects that students may see in a garden are:

Bee Fly ➤
Bee fly adults are interested in pollinating, not people.

Lacewing Larva ➤
Lacewing larva are small white organisms that feed on leaf scale.

Honeybee ➤
Only nine species of honeybees exist among the thousands of bee species. They are important pollinators.

Wheel Bug ➤
Wheel bugs eat other insects and their larva. The big proboscis is used for stabbing victims.

Chinese Praying Mantis ➤
Chinese praying mantises are not particular about the insects they eat, whether harmful or beneficial. They were brought to America in the 1890s to fight pests. They are quite large and cannot bite humans, but can kill small reptiles as well as insects.

European Paper Wasp ➤
European paper wasps are often mistaken for yellow jackets. These helpful insects feed on nectar; they collect caterpillars and other insects for their larvae. Identify them by their bright orange antennae.

Beneficial Black Scavenger ➤
Beneficial black scavengers do not bite! They are interested in eating dead wood and compost.

Cricket ➤

Crickets were kept as pets in China for good luck, for their singing or for watching their fighting. The singing of crickets in the home was considered lucky. See if you can find a cricket for your experiments. Crickets are helpful in eating fungi and other insects, but can also be a pest when they eat ornamental plants and human foods, fabric, or plastics. Crickets will need a closed terrarium. See if your students like or dislike their singing.

The Silkworm and the Mulberry Tree

Most moth and butterfly larvae make silk, but only one silkworm larvae (*Bombyx mori*) makes a silk that is of commercial worth. When the silkworm makes its **cocoon**, it is spun from one thread almost a mile long. If the silkworm was allowed to live, the silk would be worthless, so people kill the silkworm by boiling it. They then put the end of the silk on a spindle and make it into thread.

Silkmoth and cocoon

Silkworms grow quickly, emerging from their cocoons as creamy white moths.

A dwarf white mulberry

In China, the white mulberry (*Morus alba*) grows in rich soils and part to full sun. It is a strong, fast growing tree that can grow as high and wide as 30–50 feet. Beginning about 2500 BCE, it was used as the main diet for silkworms, which then created silk. With hopes of doing the same, the U.S. imported these white mulberry trees during the colonial time period. The silk trade did not take off, but the trees did, competing with the edible native red mulberry.

The U.S. has a native red mulberry with dark green glossy leaves. When fertilized by insects, it

produces a sweet berry for eating. In the spring the red mulberry has small yellow-green flowers that hang in catkins. In early summer these are followed by edible fruits which turn pink as they ripen.

Pollination

Pollination is the process in which a plant becomes fertilized. Insects—and sometimes other organisms, like bats (not North American, but tropical/subtropical) or hummingbirds—visit plants in order to sip the nectar. An insect picks up the pollen on its body and then carries the pollen to another plant of the same species, and as it is sipping more nectar, the pollen rubs off its body onto the pistil (female part) and begins the fertilization process.

Weather conditions are important for successful plant pollination. Wet sticky pollen does not transfer well. Plants in the squash family have flowers that are open for a short period of time and to be fertilized, at least 15 bee visits are needed. When pollination is incomplete, the fruit may begin to form and then become misshapen and die.

Young children may understand that insects need the liquid from the plants to survive and that plants need pollen to make new plants.

Nature of Science

Two scientists that demonstrated wonder about insects and turned this interest into amazing investigations and findings were Charles Henry Turner, who lived in St. Louis, Missouri and Chicago, Illinois and Ann Haven Morgan. Morgan studied in creeks and was best known for her study of mayflies. Turner made significant discoveries about ants, bees, and roaches. The children's books about them, by Michael Elsohn Ross, are best read at third grade level. Excellent content can be found on websites, such as the Oklahoma State biography of Turner. It is fun to tell Turner's story outside in the grass for, as a child and as an adult, he would lie in the grass observing the insects and asking questions that led to investigations, just what you want the students to do!

Send the students out at recess and ask them each day if they saw insects and what were they doing.

Use a chart at the recess door, inside the classroom door, where the students can mark their data. Collect and write down their questions, and then choose an investigatable one. For example:

- Which insects like the roses?
- Do the insects go to the purple or yellow flowers?
- Do [which] insects touch the flowers when they get nectar?
- What happens when we block the path of ants?
- How long does it take an insect to figure out how to go around [the blockade]?

The questions above are from preK–2nd graders, and these nonreaders can use pictures of the insects on a data chart to count insect visits to plants, measure time on a stopwatch, and sometimes just record what the insects were doing (flying, eating, sleeping, etc.) using a set of laminated insects.

Vocabulary

- **Cocoon**—a silky case spun by certain insects for use as a protective covering in which it passes the pupal stage
- **Pollination**—the transfer of pollen from a stamen to a pistil; pollination starts the production of seeds.

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Student Objectives

Students will:

- write riddles.
- create an imaginary organism that could live in a specific biome.
- design an experiment to test the interaction between two living organisms.
- use appropriate lab procedures and care of organisms.

Materials

Activity One:

- Paper for lanterns in light-color shades
- Glue for beasts (no bigger than 8" x 12") placed on the lanterns
- Paper for drawing and making beasts
- Cardstock, in 2" wide sentence strips for riddles
- String for lanterns
- 11" x 17" construction paper for lanterns (red)

Activity Two:

- A collection of known plant leaves and spices grown in Missouri and China as annuals or perennials (basil, gingers, mustard, garlic, onion, mints, cassia cinnamon, etc.). Lemon balm or lemons and tansy may be used.
- A set experimental area—a part of the playground where ants live, a terrarium with crickets, a plastic container or observation chamber with high edges
- Water
- Paper towels or cotton balls
- Insect observation chambers

Lesson 3: Plant Adaptations: From Chinese Lights to Plant Scents

Grades 3–5

LESSON SUMMARY/PURPOSE

People and insects co-exist, but not always happily. People have tried multiple methods of controlling insects and keeping them away from foods or themselves. In China, torchlight was once used to keep insects and grazing animals away from crops. One story in China indicates that this use of torches was the impetus for the lantern festival. In China and in the U.S., some plants have traits that **repel** insects. When you grow these near other plants, they are like a buddy or "companion" and keep insects away. In this interdisciplinary lesson set, students will create lanterns and make beasts and riddles to put on their lanterns for decoration, just as children in China decorated their lanterns. Students will also design their own experiment with insects and plants to see what kind of plants or plant extracts repel insects.

Connections to China

Origin of the Light Festival

The origin of the Lantern, or Light Festival, is wholly unknown; however, it is considered more than 2,000 years old. One theory is that **Buddhist** monks lit their temple lanterns to show respect to Buddha on the fifteenth day of the first **lunar** month. Another belief is that during the Han dynasty, rural residents in Hangzhou used torches to scare animals and insects away from crops and would pray for a good harvest during a torch

festival. Even today people in parts of Southwest China may light up torches during the Lantern Festival and dance in the fields and grain-sunning grounds. Plants farmed in Hangzhou include: soybeans, barley, wheat, and rice. Tea is grown in the nearby mountains. The Lantern Festival today is generally a five to fifteen day celebration.

Lantern Festival Legends

A long time ago, people would kill fierce birds and ferocious beasts that threatened them. One day, by accident, a hunter became afraid of a big bird soaring in the sky and killed it. However, the bird was a sacred crane from heaven. The Jade Emperor, who lived in heaven, was so mad that, on the fifteenth day of the first lunar month, he sent his soldiers to burn the village where the hunter lived. However, the heavenly emperor's daughter, who was merciful and kind, snuck away from home and came to Earth to warn the Earthly people about the plans for the fire. The villagers were scared, but quickly came together to decide on a solution. A very wise old person told the families to light up [red] lanterns and set off fireworks each night for three nights during the first lunar month to trick the heavenly emperor into thinking that Earth had burned away. The villagers continued to light the lanterns at the same time each year in celebration.

In a similar story, an ugly ferocious monster called Nian came out of the mountains on the first and fifteenth of the month to eat people. Everyone stayed indoors. A wise old person asked villagers to gather together, beat drums, burn bamboo, and make large noises to scare the monster. The monster appeared once more on a cold moonless night, but the noises and fire made the monster run away until it was so tired that the villagers caught and killed it. The people, joining together, brought the end of the monster. Thus, the noise-making, fireworks, and lanterns occur on one of the coldest days of the year. Nian refers to New Year's Day or the Spring Festival. The Lantern Festival is a part of the New Year celebration in China.

PROCEDURE

Activity One: Making a Chinese lantern

- Describe with students the varied subdivided **biomes** found in China. The biomes of China include: alpine, desert, deciduous forests, temperate forests, temperate grasslands, and tropical forests. Locate Hangzhou on the map and determine its temperature, rainfall, and soils compared to the Midwestern U.S. Create a fierce wild beast that could live in the southern part of China and be especially adapted to eat crops grown in that region near Hangzhou.
- Review the term, "**adaptation**."
- Students create a fantasy beast for their lantern. Students must use at least 10 descriptive words that identify how their fierce beast eats, moves, breathes, and looks as well as where it finds shelter and water. Then create a picture of the beast that can easily be copied and placed on a student-created lantern. Students need 2–4 beast copies for their lantern, OR they can trace their beast and cut out that part of their lantern.
- Make lanterns with folded paper and hangers or string.

Language Arts

Create a riddle. A riddle is a written puzzle that is

formed in a question or rhyme and provides clues to its answer. The answer should not be obvious to everyone.

- The Chinese people, like Midwesterners, have often played with homonyms in their language. Homonyms are words that are spelled differently but sound the same. One old riddle you may have heard is "What is black and white and red/read all over? When someone asks the riddle, most people assume "red" not "read" and then they miss the answer: a newspaper.
- In some parts of the St. Louis area, children must provide a riddle when they go out trick or treating on Halloween before they get their candy treat.

Young children in China put riddles on their lanterns. Give students a listing of homonyms that fit well with this Chinese Lantern Festival. Students should try to write a riddle that contains a plant, tree, crop, flower, or their beast.

Activity Two: Experiment

People's observations of insects and plants led them to discover that some plants repelled insects. So, people used these plants to keep insects away in order to reduce certain diseases (cedar oil keeps mosquitoes off the skin), protect foods (bay leaves in flour), stop bugs from eating clothes (lavender sachets in closets), etc. Essential oils from the mint and pine family are commonly used to deter bugs around the world. People have experimented with plant oils. One oil made from turmeric, basil, and vanilla repelled three types of mosquitoes for six hours, while most oils, like that of China's lemon eucalyptus, better known as citronella, work only for one to two hours. Thyme, cedar, patchouli, turmeric, and clove oils are used to repel a mosquito-borne disease called malaria in Asian countries. People today and throughout history in the U.S. have hung bouquets of herbs and spices by their doors, filled their beds or bathed in herbs to keep bugs away. [1]

When a person uses a plant-based oil or water-based plant material they should be careful to test it on their skin in case they may be allergic to it.

Students Design Their Own Experiment

To create a fair test, the teacher and students need to choose insect or insect larvae which they can find safely in the schoolyard or at home. Students must practice insect care, providing food and water to the organism and respecting its life. Thus, students may put a mint leaf and an insect larvae in an observation chamber, but should not put the citronella oil or leaf on top of an organism.

Students who have had practice with experiments and question writing may find they need little assistance. In some cases, teachers may want to do a group demonstration. Students unfamiliar with this process may need to work as a class to develop a template to use for this experiment.

- Students need to create a question that is do-able, has two variables, is measure-able, and can be repeated by someone else in the class: "What effect does the _____plant have on the_____insect/ organism?"

1 The teacher may not want to mention those plants which she/he may use for testing. Mints, thymes, turmeric, and cloves are readily found at nurseries or grocery stores. Fennel, mustard seeds, garlic cloves, shallots are found at grocery stores.

- Review the experiment above. What are the variables? [The plant or plant oil extract and the insect.] What will they measure? [The amount of time the insect interacted with plant/plant oil extract.]
- Ask students what the possibilities are for their results [the insect being attracted to the plant, being repelled by the plant, not noticing the plant, eating the plant, etc.]

The teacher may sort student experiment predictions into categories: Repel, Attract, and No Effect.

- How will we measure the plant's effect on the organism? Remind students that once the insect is in its "observation chamber," it may need some time to just get used to its surroundings, just as people do when we are in a new place.
- Before beginning, ask students, "How will we record and share our findings?"

When students are finished, they will want to share their findings. Make sure they talk about what worked or did not work, and what may need to be repeated. Ask students about what questions their experiments raised. Return students to the idea of plant and insect interaction, and how individual plants or animals respond to their environment, based on the results of their experiments. What part of the plant repelled the insects? Was it always the smell?

Finish by comparing plant adaptations. Let students understand that many of these scents evolved with insects—to either be pleasant (roses, lilacs) and attract the pollinators, or to be unpleasant and repel insect attacks (*Allium*–onions, *Artemisia*–wormwoods, *Mentha*–mints).

TEACHER BACKGROUND INFORMATION

Hangzhou

Hangzhou is one of seven ancient capitals of China, and is found near the Yangtze River Delta. The soil is mostly red clay. The area has hills and mountains. It also has low-lying rice paddy fields. Hangzhou has four seasons, but the winters are mild and mostly frost-free. The rain is excessive during the monsoon season. The average temperatures are 16 degrees C in winter and 28 degrees C in summer. The humidity is usually 75 percent. The warm four-season climate creates dense foliage and many flowering plants.

It has a 1,400-acre lake (your school and playground may take up the space of one acre) that is only five feet deep and shaped by silt that once settled here. Mountains rise in the distance. People on one of the human-created islands in the lake light lanterns at night similar to the Lantern Festival. When walking by the lake, the sweet aroma of tea comes down from the mountain. A Grand Canal, larger than the Suez Canal, was built to connect Hangzhou to Beijing, making it the longest human-created waterway in the world. Hangzhou is known for its fish, fruits,

West Lake in Hanzhou

and flowers. Hangzhou is also known for its two traditional exports, Longjing (Dragon Well) tea and silk. Silk is created by silkworms that eat the leaves of the mulberry tree.

Insect Sprays in History

One of the first pesticides ever used was sulfur, an element not a plant, by the Chinese in the 1800s. Although the use of pesticides is not new, the types of substances people have used as pesticides have changed. The earliest pesticides were inorganic substances such as sulfur, mercury, lead, arsenic, and ash. Lead and arsenic were used as insecticides until World War II. Even though many of these substances are effective pesticides, the use of some of these materials has been banned because of health and environmental problems associated with them.

In the U.S., lead and arsenic are no longer used as insecticides, the use of mercury as a fungicide has been restricted, and the U.S. Environmental Protection Agency (EPA) is phasing out the use of arsenic as a wood preservative. Rachel Carson, a U.S. scientist, spoke out against the use of synthetic sprays on plants and people, and wrote the book, *Silent Spring*, to bring attention to issues with synthetic pesticides. Her book helped bring about the formation of the U.S. Environmental Protection Agency (EPA).

Until the last century, most people did not have access to synthetic (human-created) insect sprays. The Chinese used their torches to literally shoo away the insects. Midwesterners today use bat boxes to bring bats near their houses since they will eat 600–1,000 mosquitoes per hour.

Observations of insect behavior when around particular plants probably led to the use of certain plants to keep insects away from food crops outside or to control insects inside homes. Plant-based pesticides can be effective, but production of large quantities is time-consuming and inefficient and the plant extracts are often difficult to purify.

Flowers as insect sprays

Pyrethrum is made from a Chinese flower, the chrysanthemum. The crushed flowers and oils were used during wars through the 1800s to keep bugs, like fleas and head lice, off of the soldiers. However, the insecticide did not last long in the sun. Today, because it is often mixed with other substances, it may not be as safe to use.

Chrysanthemums come in many varieties today.

Spices and herbs

Spices were one of the first items to be traded in ancient civilizations, most from the Mediterranean and Asian countries. Spices are not only used to improve the flavor of food, but also to prevent spoilage. Plants such as ginger and lemon (origin: China) and cranberries (origin: U.S.) have historically been used to prevent food spoilage. Spices and herbs are primarily used in foods, medicines, cosmetics, perfumes, and home scents. Spices and herbal plants can also be used for repelling insects. Since 1999, organic farmers

in the U.S. have experimented with spices to control pests such as aphids and mites on strawberries, spinach, and tomatoes. Spices such as mint, clove, citronella oil, lavender, thyme, and rosemary are not toxic to people or insects, so the oils from these plants chase away bugs, but do not kill them. Farmers have also found that they need to spray spice oils more frequently than synthetic sprays because the oils deteriorate in the hot sun.

Popular Chinese spices used for natural insect repellants:

- **Cassia (Chinese Cinnamon)** has been used since 2500 BCE. Cassia is an evergreen tree from Burma that has yellow flowers and a hanging fruit. It grows well on southern China's terraced hillsides. The trees are not harvested until they are about 60 years old. The bark is stripped and broken in small pieces and often sold that way to stores. It has a fantastic smell, but its flavor is more potent than and not as sweet as the typical cinnamons. It contains tannin, sugar, and starch for dyeing and oils that are distilled and used in medicine and flavoring. Ants do not like cinnamon.
- **Cloves** are the flower buds of an evergreen tree that was first cultivated in China in the third century BCE. It is slow-growing and flowers are not plentiful until the tree is over 20 years old. Clove buds are used for baking, medicines, sachets, gum, and cigarettes.
- **Peppermint (*Mentha piperita*)** is a perennial herb that grows in the U.S. and in China. It prefers moist ground. It is used for food and candy flavorings, antiseptics, perfumes, and soap. Most insects do not care for it.

Additional plants that repel insects

Many of these plants may be used whole or crushed for closet or home sachets. Some originated in China; many have been in China for thousands of years. Some of these plants are used in gardens to keep insects away from vegetables and fruits. Some plants, like basil and parsley, have strong smells and deter insects. Other plants keep insects away because they have sticky juices that make it difficult for insects to chew the leaves: dandelions, sedum, and apples. Some plants are difficult to eat, such as hard melons, celery, and raspberry (hairy). However, many flowers have attractive foliage and scents to attract pollinators. Plants are listed with their place of origin:

- **Allium** (China and U.S.) is found throughout the world; it keeps insects away, actually it would keep people away, too.

Allium (onion)

- **Bay leaves** (U.S.) will keep insects out of kitchen cabinets. In the U.S. northern bay is grown, which is a less potent flavoring than the Mediterranean bay.
- **Ginger** (China) and Bee Balm, Horsemint, and Mountain mint (U.S.) keep insects, such as mosquitoes, away. However, a plant sitting

on a back patio will not keep bugs away from the entire patio, just the area immediately next to the plant, and oftentimes only if the plant is rubbed on the person!

- **Cayenne peppers** (China) can be made into a juice that is sprayed in the garden to keep insects away, however, it can severely burn plant leaves and stems on a hot sunny day.
- **Tangerines** (China) and most citrus scents repel insects.
- **Lemongrass** (China) is used in soups and salads and is the source for citrol used in citronella oil.
- **Lemon basil** (India) is a self-sowing annual in the Midwest. In a garden, it keeps insects, like whiteflies, away from other plants.
- **Tansy** (Europe) deters ants, squash bugs, Japanese beetles, and striped cucumber ants. It helps roses and raspberries grow. Tansy is native to Europe and was brought to the U.S. before the American Revolution.
- **Marigolds** (U.S.) repel some beetles, tomato hornworm, and cabbage pests. Marigolds are one of fruits and vegetables' best buddies, or **companion plants** in the garden,

Marigolds

Care of Insects

- Establish a plan for addressing allergies and fear of animals.
- Develop and implement a plan for future care of the animals at the conclusion of the study as well as during school breaks and summer vacations.
- Espouse the importance of not conducting experimental procedures on animals if such procedures are likely to cause pain, induce nutritional deficiencies, or expose animals to parasites or hazardous/toxic chemicals.
- Shelter animals when the classroom is being cleaned with chemical cleaners, sprayed with pesticides, and during other times when potentially harmful chemicals are being used.
- Feed and water them or release them.

Vocabulary

- **Adaptation**—a function or structure that enables an organism to survive and/or thrive in a habitat or ecosystem; an adaptation is affected by the evolutionary history of the species
- **Biome**—a major living community, one of a few in the world, that is determined by its vegetation and the organisms that rely on that vegetation over an extended time frame; typically divided into grassland, desert, forest, and aquatic; land biomes may be subdivided into temperate and tropical forests, temperate deciduous forests, etc.
- **Buddhist**—practitioner of a religion and philosophy that has no god, but practices equality, enlightenment for all, giving up

worldly possessions and meditating, with these beliefs leading to a person becoming mindful and practicing an end to ignorance, cravings and suffering

- **Companion plant**—one plant grown near a second plant to discourage insects or encourage growth in the second plant
- **Lunar**—moon
- **Repel**—opposite of attract; to make an organism turn away

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Student Objectives

Students will:

- identify and count plants in their schoolyard.
- compare their schoolyard plot to a diverse native plot. They will identify the benefits of native plantings.
- use measurement to accurately create their schoolyard plot, graph, and share data.
- learn about a useful plant that is grown in the U.S. and China.

Materials

Activity One: Making Maps Meaningful

- Sketchpad, one per student
- Colored pencils
- Paper bags

Activity Two: The Schoolyard Plot

- Hula hoops OR a measured grid of plots for study in the schoolyard area
- Scissors for taking leaf cuttings
- Cut cardboard squares, tape, contact paper, and permanent markers for mounting plant specimens
- White paper
- Clipboards
- Field Guides
- Measuring tape or rulers
- Graph/charts
- Thermometers for soil and air (optional)
- Rain gauges (optional)
- Laminated sit-upons or a tarp for the grass
- String, measuring tapes, stakes

Lesson 4: Mapping, Money and Ecosystems: Protecting China's Plants—Protecting the Plants in My Schoolyard

Grades 3–5 and 6–8

LESSON SUMMARY/PURPOSE

China has more plant species than almost any country in the world and has contributed beautiful, economically useful and nutritious plants to the U.S. Fruits such as peaches, herbs such as ginseng, spices such as cassia cinnamon, staples such as soybeans—all originated in China. Many ornamental flowering shrubs and trees in the U.S. were first grown in China. Some of the oldest species of trees, like the ginkgo, originated in China. Plants and their medicinal combinations have been recorded for centuries in the practice of traditional and formal medicine in China. China can be divided into these **biomes**: tropical forest, temperate forest, temperate grassland, alpine, and desert.

Botanists from the Missouri Botanical Garden have travelled through China with a team of Chinese botanists to collect and catalogue plants. Some interviewed local people about their uses of plants. The Missouri Botanical Garden's botanists used many tools in the field, including waterproof notebooks, magnifying loupes, compasses, maps, GPS with satellite coordinates, drying ovens, scales, light meters, soil sampling kits, surveying equipment, computers, and reference books. Field botanists' findings helped conservation officials and the public protect and preserve plants for the future through seed banking and care of public

and private lands. Botanists may also work in environmental, pharmaceutical, and biotechnology labs, herbarium libraries, zoos, and gardens. Botanical research improves our lives by helping us understand and effectively use plants and care for our planet.

This lesson introduces students to mapping via a familiar place: the schoolyard. Through a schoolyard activity, students create maps and learn about the importance of keyed and standardized maps. Combining nature of science, ecology, and math, this lesson engages students in observation skills and data collection. Students may find both beneficial and **invasive plants** introduced to the U.S. from China. The lesson invites students to learn about the usefulness of plants, and of the purpose in planting and preserving **native species**.

Connections to China

China has rainforests, frozen tundra, alpine mountain regions, low-lying river plains and desert.

This vast country, most of which lies in the temperate zones, has 32,000 species of native plants. That means that there are many more than 32,000 plants. A plant species is a group of plants that have similar structures, history, and DNA and can successfully reproduce within the group. Thus, China has 10 percent of the world's plant species and has more plant diversity than almost any other country in the world. The U.S. and Canada together have 19,000 species. More than 50 percent of the plant species in China are found *only* in China.

China is trying to protect its unique and diverse plant species. To protect its plants, China has established 2,500 nature reserves, most in the last forty years. The Chinese government has created a seed bank to conserve important crop seeds, such as rice and soybeans.

The most diverse area needing plant protection in Missouri is the Ozark region, where many rare plants are found. The Missouri Botanical Garden has established native seed banks and one of the largest herbarium collections in the world to preserve many plant species.

PRE-LESSON PREPARATION

Walk around the schoolyard and choose an area for study. Select an area representative of your schoolyard.

- Make sure it has the most diversity for the schoolyard. The site should contain vegetation, such as shrubs, trees, and weeds. Select fairly small areas so that temperature, wind, light, and/or moisture conditions are not likely to vary much within the area. Consider if and where you would want students to set up a simple weather station.
- Take a field guide and time yourself identifying some of the plants in order to give you an idea of how long students will need to identify, collect specimens, and use field guides.
- Contact administration and district/school facilities to post a "NO Mow" sign where you are setting up the study plot. If an area is staked out, it provides more opportunity to revisit the site to study it like a scientific study in which measurements allow for consistent evaluation and mathematical calculations over time. Hula hoops are suggested for

sample plots if your schoolyard does not have an area that can remain undisturbed.

- Use a garden volunteer (call the local Master Gardener or older boy scouts) and ask them to create a mini-field guide of trees, shrubs, and flowers for the schoolyard. You can then copy these and allow students to use them for their study plots if they do not have time to create their own guides.

Nature is often simply a backdrop to play for elementary aged students. Try these outdoor experiences for acclimating students to simply being outside before learning outside:

- Students can be amazing observers of nature, but this skill takes more than one visit outside. Students are not exposed to a wide range of temperatures; they may be uncomfortable outside in the weather. They may be frightened, frustrated, or fascinated by living organisms around them, such as insects, and will not be able to focus on the lesson. This first visit outside is a time for them to learn the rules, and two rules are listed below:
    1. Stay within teacher-identified area so he/she can see you and you can hear him/her.
    2. All living things are to be respected.
- Have students take an afternoon snack outside to eat. While snacking, each pair of students must find and describe an item, not human-made, found outside. You can tally what they found on a chart or graph, identifying characteristics of the plants or the locations of other organisms.
- Have students take their pencils and create a picture of an object they found outside that can be no larger than their fist. What, if anything, did they see that surprised them?
- Students are given a small bag and asked to select 10 items; they are asked to sort. Discuss how observers all have different perspectives on how to sort objects, that everyone has observations that can add depth to a description or a finding. Students may have considered shape, color, memorable or unique aspects, and use. Explain how scientists, specifically botanists, use a standardized system for identifying plants called a dichotomous key, which takes into account the trees, the leaf edges, the buds, the number of leaves and how they are arranged on a branch, etc. Their language for identifying plants is also consistent: Latin. However, many plants have common names for how they look: shagbark hickory.
- In small groups, give students three leaves and branches or stems from three shrubs, flowers or trees. Have them identify characteristics of each group and what makes them unique. Have students find the matching plants outside. The teacher can then show how a dichotomous key is created. Share a field guide with each team.
- Do a four sense map. Make a quick outline of the area marked by wooden stakes:
    - Listen. Draw the object you think made a sound on your map (without looking at what is truly at that location).
    - Look. Draw one item on the map.
    - Walk around and draw something that catches your sense of smell (not another person or item off the map).

- Feel a natural item in the area and draw it on the map.
- **Do not taste anything.**

PROCEDURE

Activity One: Making Maps Meaningful

As a pre-assessment, before going outside for the lesson, ask students to create a map of the class' study plot in the schoolyard.

- Ask what features would help them find their way on the map.
- Collect pencils. Use colored pencils to draw additional features on their maps. Save the maps. Make copies.

Follow Up on the Mapping Activity

In the mapped area, have students take an object (a paper, small block, etc. with their initial on it and no bigger than their fist). Hide it. Return to the circle and draw on their own map where the object is hidden. Trade maps. The students then need to try to find the objects. Return to the circle.

Discussion points:

- What made this an easy task? Difficult?
- What else could we add to our maps to make them useable for others?
- Talk about how mapmakers had to consider all of these items: gridlines, directional signals, landmarks, keys, measurement, and standardization. What should they do in their sample plot to make it easy for them to return in another season and remember where they first collected data?
- Discuss how to improve their own maps. Give students a colored pencil to improve their maps. Ask, "Why would a botanist need an accurate map of plants?"

Homework

Put the map into words.

- Describe the schoolyard using the map. Describe actual items on your map. Avoid common adjectives such as "nice, awesome, boring"; instead use specifics: "thorny shrub with pink flowers" or "muddy hole with lacy looking weeds in it" so someone else could find the plant you are talking about.
- Answer the questions:
  - Why do you think these things are growing in the schoolyard?
  - What do you think makes it possible for those items to grow?
- Improve the map so someone else can use it. Make copies of their maps for comparison to the pre-assessment. Do this one more time at the end of the entire lesson.

Activity Two: the Schoolyard Plot

Introduce students to their plot area. Put a circle of rope (or you may choose squared off plots or transects) on the ground, enough so students can sit around it.

Explain:

- Scientists, called ecologists, make observations and collect data on **ecosystems**. In science, you will be studying ecosystems. An ecosystem exists when a group of species (cats, rabbits, mice, raccoons) share a common location, interacting with each other and with the nonliving parts of that place. A

forest or a terrarium can be an ecosystem. Our schoolyard is an ecosystem. Tell students that scientists could never study every single organism in every habitat at the same time, so they study one organism or one sample of the ecosystem. This area inside the rope is a sample.

- Ask students if they see anything today that is new or different than last time they were out. Scientists do not make just one observation, but keep data and repeat observations or investigations in order to make sure that their data is accurate.
- Tell students that today they will be scientists searching for and studying the plants that live in the schoolyard. They will NOT be counting grass. They will map the plants, collect, identify, and count the plants. They will fill in the *Sample Plot* data sheet.
    - They need to take leaf samples and draw a plant. They will collect, press, and label their leaf /flower sample (contact paper on cardboard). They will then count all other plants that are the same as this leaf sample. Then they will repeat the process with another plant in their plot. Have them map the location of each plant species and calculate the percentage of coverage for each plant.
    - Encourage students to use adjectives to describe the plants and their location.
    - Make sure students comment on the area's moisture levels (wet/dry), light levels (shady/sunny), temperature (cold, cool, hot), and open area versus protected area. Knowing the soil conditions and moisture/temperature and sun/shade of the plot will help them identify the plant. Teachers may provide instruments for measuring abiotic factors, such as light meters and soil and air thermometers.
    - Students will share field guides to identify the plants in the schoolyard.
    - Assign students a rope/measured transect and area for their plot

Have students return inside:

- Students sort the samples by characteristics, and develop their own listing of plants. They may use cameras, but be sure to take a picture of the differentiating characteristics of the plant. Compare their pictures to see if they have similarly labeled identical plants. Group the data from the students' sample plots into a chart. Count the species.
- Put all the vegetation maps together. Discuss plant density and dominance. Relate to field studies over time—**edge effects**, **succession**, species distribution, and changing climate, etc.

Discussion: Plant Density and Plant Dominance
Plant density is the number of plant species in each plot.

- Have students look at their plots. Ask "How many total plants were in your count?"
- Put all the vegetation maps together. When the maps are combined, ask students: "What areas had the most plant density? The least? What might be the reasons for this? What evidence supports your answers?"

A measurement of density helps us define areas

and biomes—is it a prairie or a forest? Schoolyards are often manicured with grass, but the density can tell us about the soil, light, areas of foot traffic, etc.

Plant dominance examines one species compared to others in the plot(s). A species may be dominant because it has more influence on all the plants and wildlife than any other species in the ecosystem. Or a species may be dominant because of its height or because it uses the most nutrients, water, and light in the ecosystem compared to the other plants.

- Talk to each group of students about one or two dominant plants in their plot. Have them provide evidence for why they think the plant(s) chosen are dominant.
- When students return to the larger group, discuss their choices compared to the definition of dominance. Students may study the one or two dominant plant(s) in depth to find out why they are thriving. This may lead to further study of the abiotic conditions.

Using density and dominance results across large ranges of land over time helps botanists and ecologists determine which plants or animals may be endangered, or show how the typical location or range of a species is changing due to climatic conditions. Some botanists examine historical records to make these judgments and may predict the future range of a species or interventions needed to protect or reintroduce species.

Older students may discuss edge effects or succession (see Vocabulary section).

Summary

Focus the students' attention on plant diversity, or the lack thereof, and invasive plants. Define *native* and ***non-native***. What may happen when one type of plant is predominantly growing in the schoolyard? *[less food sources, therefore less animal diversity; disease could kill all of them]*

Upon introduction to a new area, non-native plants usually do not affect the ecosystem; however some become invasive because there are no natural predators or diseases to keep them in check.

Sometimes, plants are **native** to the area but are aggressive, like the Eastern red cedar that takes over dry rocky hillsides so smaller plants for wildlife cannot survive. *[A healthy ecosystem is most often considered by scientists as one in which the number and size of species is balanced by the nutrient resource availability. Competition between species and predator-prey relations are a part of that balance. Space and shelter for an organism is as necessary as food and water. Invasive species can disrupt the balance of an ecosystem by crowding out other plants, robbing them of nutrients.]*

An *ecosystem* is a group of species in a common location, with plant and animal species interacting with each other and with the nonliving (abiotic) factors.

Sometimes businesses, scientists, or the government decides how to define a healthy ecosystem. Decide as a class what is a balanced or healthy ecosystem.

Some people believe that the healthiest ecosystem is the one most productive for the animals or people living nearby. Have the students recall how they counted species in their plots. When farmers and scientists work together, they use similar plots. For example, a farmer may plant two

different types of corn seed. Before the harvest, college students will come to the field and count the ears of corn and even the numbers of kernels on each piece. The fields will be covered with these students, each in their own plots, counting. They will also be descriptive. As in these schoolyard studies they will notice the number and types of bugs eating the plants. They notice the conditions, too. What will they learn from all this counting? This is an example of productivity. The farmer wants to know how much food can be gained from one type of seed versus another.

That may be a different view on the health of the ecosystem compared to an ecologist studying a plot of land. An ecologist will look at the balance within the system, between species and between the species and the resources.

There is no perfect answer to the question of what makes a healthy ecosystem. Hopefully students will talk about the number of plant types, evidence of individually healthy plants, animals eating the plants, and whether or not there is the right type of soil for the plants to survive or **thrive**.

Once students decide on their criteria for a healthy ecosystem, their data can be used to help them decide whether or not their schoolyard qualifies as a healthy ecosystem. You may then give examples of healthy ecosystems as defined by the different groups.

Have students share their ideas about the health of the schoolyard ecosystem based on their data collection:

- What additional information do we need to make a decision about whether it is a surviving or thriving schoolyard?
- What is the value of counting species in the schoolyard?
- What should be our next steps?
- What questions do we have now about the schoolyard?
- We focused on plants; what do plants have to do with animals in the neighborhood?

Conclude this lesson by connecting the activities to the concept of ecosystem, and how field data is used to study species distribution, succession, and edge effects, etc. (see Teacher Background section).

Activity Three: Research on Plants in China and Those Native to Our Region

Since China has so many plants to choose from, we can look at some of their plants and determine how useful they are to people or animals. How much do they contribute to the productivity of China? The productivity of the U.S.? Then we will revisit our plots and see if and how those plants are useful to organisms and people. We can evaluate our plot based on its available productivity.

Assign students one of the plants in their schoolyard and a plant that is native to China and introduced to the United States (see table on page 42). They can begin by looking up their plants on the Missouri Botanical

The peony is an example of a plant species native to China and introduced into the U.S.

Garden *Plant Finder* website for information. They will report on the economic use of the plant in the U.S. or in China, and the plant's characteristics, such as a description of which part is used for production.

Plants from China (introduced to the U.S.)	Plants native to Missouri/Midwest
Asarum (woodland ginger) *	American basswood tree +
Camellia #	Black cherry tree +
Chicory	Black cohash *
Chinese privet	Black walnut tree + #
Chrysanthemum *	Cranberry # *
Common plantain #	Curly dock
Epimedium *	Currant +
Ginseng +	*Lindera* #
Magnolia tree*	Pale purple coneflower *
Oilseed rape #	Persimmon tree #
Peony	Rattlesnake master *
Peppermint *	Vernal witch hazel *
Rhubarb # +	
Soybean #	

*Key: * medicine + wood # food*

Discussion/Concluding Ideas

Students will discuss the value of the plants, whether the plants could, would, or should be grown in their schoolyard, based on their criteria for a healthy ecosystem.

Tell students about how China and the U.S. study and/or protect plants. Ask for their opinions.

EXTENSIONS

- Older students can use math to calculate a density count. In this way, they can identify native versus the non-native plants, plants that are thriving, or just the number of different types of plants in the schoolyard.
- Students can take the abiotic measurements of their marked plots or area over time. They can make observations of the activity of living organisms in the schoolyard—both plants and animals—over time.
- Students may decide to pull the invasives and create a native schoolyard planting.
- Students may want to study water and soil erosion in the schoolyard.
- Consider applications with handheld devices, such as GIS.

Pale purple coneflower (top); persimmon tree (bottom)

TEACHER BACKGROUND INFORMATION

Ecology

Ecology is the study of ecosystems or systems of organisms that interact with each other and with their environment. An ecosystem is a group of species existing in a common location that functions as a unit with the surrounding environment, interacting with that environment and other species. Each organism has particular functions in this schoolyard, called niches.

What Ecologists Study

Ecologists study everything that affects an organism's ability to grow and reproduce. Since the entire ecosystem cannot be studied at once, ecologists usually study one aspect of the ecosystem:

- An ecologist may study the interaction between an organism and one of its nonliving or abiotic needs. An ecologist may study the food that an organism eats and how it acquires that food.
- An ecologist may study how a group of different kinds of organisms that have similar feeding patterns transform food into energy and discard the waste.
- An ecologist may study a single plant that invades an area and its effect on that ecosystem.

Ecologists put the results of their studies together to form a complete understanding of the effect that the environment has on organisms and the effect that organisms have on the environment. Ecologists often study simple interactions and then put them together to try to understand an entire system—a skill necessary for the responsible caretaking of our planet and the health of humans. The health of an ecosystem may be evaluated by its living organism diversity, its balance between the natural resources and uses by living organisms, or by its economic worth.

Plants from China

Many plants brought to the U.S. from China have successfully thrived with natives and are important to our lifestyle. Species like ginkgos and dawn redwoods are some of the oldest known plant species still surviving—these species lived at the time of dinosaurs 65 million years ago. Lilac and rose of Sharon shrubs add beauty to American landscapes. Peonies and chrysanthemums are large attractive flowers.

The camellia species are native of southern China and highly prized for its dried leaves. Different types are used in traditional medicine to relieve fatigue and are reported to have a delicate taste. In China, species of camellia were first used as medicines and then became popular as a drink we know as "tea." Camellias grow in warmer climates and can be found in the Linnean House at the Missouri Botanical Garden.

Observation of a local schoolyard

Creek

The quality of a creek is related to the land that is on its banks and on the banks of the smaller streams leading into it. In St. Louis, water in schoolyards usually empties into storm drains and small, then larger creeks, which eventually empty into the Mississippi River, since all land in Missouri is a part of the Mississippi River watershed. A watershed is a drainage basin where surface water runs off to a common site.

The schoolyard watershed is influenced by

the buildings and the shape of the land. The compacted soil near the edges of the paved sidewalks and parking lot increase the schoolyard runoff because the soil cannot absorb water. One reason why native and diverse plants are important to the schoolyard is to reduce water run-off into the storm drains and instead recoup that water for the health of the plants and the creeks/rivers.

Seasonal Changes

Trees and plants respond to seasonal changes. Most Missouri native deciduous trees' seeds mature and drop in autumn. If leaves remained on the tree during the winter, water inside the leaf cells would freeze and expand, bursting the leaf cells and damaging the leaf. Autumn-dispersing seeds include locust pods, sweet gum balls, acorns, and hickory nuts. Trees with spring-dispersing seeds include elms, cottonwoods, willows, sycamores, and red maples.

In the temperate deciduous forest and in the eastern Missouri schoolyard, the evenly distributed annual precipitation varies between 75–125 centimeters (20–60 inches). The average air temperature varies between -12 to 15 degrees C in winter and 21 to 27 degrees C in spring/summer. The humid growing season lasts from four to six months. In the schoolyard, without a thick canopy overhead, the moisture quickly evaporates.

Tallgrass Prairie

A tallgrass prairie is characterized by an abundance of grasses that typically grow more than three feet tall (Short grass prairie grasses, in comparison, reach an average height of less than 2 feet or .61 meters.). Tallgrass prairies usually contain many native Missouri flowers. Having no particular form or shape, the prairie is dependent on the soil type, climate, terrain, rainfall, and seeds in the soil.

Tallgrass prairies have these characteristics:

- Precipitation averages 25 to 39 inches (63.5 to 99 centimeters) annually—enough for moisture to be available in the subsoil all year.
- Grasses grow to an average height of over 5 feet (1.5 meters), with some varieties such as big bluestem or turkey foot reaching heights of 12 feet (3.6 meters).
- Shorter grasses and many species of flowering plants also grow on tallgrass prairies. Most have large taproots that may travel for a long distance in order to still survive when fires burn across the prairie
- Trees grow primarily along streams, creeks, and rivers, or riparian corridors.
- Topsoil is very dark due to moisture, which promotes plant growth with the large amount of organic material it contains.

If you wanted to grow a schoolyard prairie, it will take three years to form. Exotic or non-native species, such as honeysuckle, lespedeza, or fescue will try to invade new prairie. Larger prairies can be burned with a hot fire that will kill most exotic plants and trees. Smaller prairies can only be maintained by frequent weeding because fires cannot be made intense enough to kill the invasive prairie species.

Two hundred years ago, many schoolyards in St. Louis may have been part of a savannah. Savannahs in this area would be identified by large oak trees separated by open grassy spaces

and some flowers. A savannah is a series of meadows and grasslands interspersed with few trees.

Plants in the Schoolyard
These additional plants may be found along the edges of a schoolyard:

Native Missouri prairie plants:

- Indian grass
- Sawtooth sunflower
- Goldenrod
- Black raspberry

Native Missouri plants:

- Shingle oak
- Wild black cherry
- Grape vine

Non-native grasses:

- Tall fescue
- Johnson's grass

Non-native shrubs:

- Bush honeysuckle
- Honeysuckle vine
- Spirea

Non-native vines:

- Bindweed
- Morning glory

Invasive Species

Invasive plants can be U.S. native plants in the wrong U.S. region or non-natives. Invasive plants species are efficient adapters to different soil and weather conditions. They have structures that enable them to spread easily, like seeds that can float, fly on the breeze, and stick to organisms. They grow fast. If invasives are non-native, then they may not be eaten by organisms or get diseases like the native plants in the area, so they can spread faster. Many invasive plants were brought to the U.S. to take care of another problem. Plants such as shrub roses or Chinese privet were used as natural fences, for example. Others were brought to the U.S. because they were disease resistant, fast-growing, easy to maintain, or for their beauty, such as honeysuckles and plum trees.

An invasive species does well in its native country where the plant is controlled by grazing animals, climate, etc. However, when introduced to a new area, the conditions for the plant's growth improve and it often crowds out native species. The plants listed in the table on page 47 have survival behaviors and structures that give them an advantage over native plants: many seeds, the seeds can live in the soil without deteriorating for many years, the plants give off chemicals that disrupt natives or they may form dense thickets or groups that crowd or over-shade new native growth. Many invasive species in the Midwest were introduced from Asia or Europe.

Vocabulary

- **Biome**—a major living community, one of a few in the world, that is determined by its vegetation and the organisms that rely on that vegetation over an extended time frame; typically divided into grassland, desert, forest, and aquatic; land biomes may be subdivided into temperate and tropical forests, temperate deciduous forests, etc.
- **Ecosystem**—a specific environment and the interaction of abiotic/nonliving and biotic/living organisms within that environment

- **Edge effects**—the effects of open corridors or fragmentation of an ecosystem on its plant and animal species, often but not always harmful.
- **Invasive plants**—a species of plant that is not native to the ecosystem being observed and whose introduction may, or has, caused harm, to either the environment, productivity, or organisms' health
- **Key (legend)**—a consistent set of words, colors and phrases that explain map symbols and help with finding your way on a map, usually found in the left-hand corner
- **Native species**—a species that occurs naturally within a particular ecosystem, as opposed to a species that has been purposely or accidentally introduced
- **Non-native**—a species moved from one geographical region to one where it had not previously lived
- **Succession**—the orderly and predictable change that occurs over time to the initial development of an ecosystem (There are different levels of succession: The succession that occurs in a new habitat, as following a massive strip mining operation, is called *primary* succession. When abandoned farmland in the Midwest is overtaken by particular species of small brush and trees, like the sassafras, this is called *secondary* succession.)
- **Thrive**—grow and develop with success and vigor

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Invasive Species Found in Midwest U.S. Schoolyards

Plant Name	Type of Plant	Identifying Characteristics	Measured Characteristics	Country of Origin	Why does it thrive?
* **Tree-of-heaven** *(Ailanthus altissima)*	Small tree	Slim smooth-barked trunk with 11–40 leaves per twig; strong odor; white-green delicate late spring flower		China Brought to U.S. in 1820 because they were pollution-tolerant	Up to 350,000 seeds per plant each year; forms a tight clique
Autumn olive *(Elaegnus umbellata)*	Shrub can grow to 20'	Silver-gray thin long leaves shaped like wavy swords; pink-red fruits with silver spots (look closely) in fall			Over-planted by people because it is easy-growing and attractive
Japanese honeysuckle *(Lonicera japonica)*	Shrub can grow into a small tree	Vine; often keeps leaves year-round; older stems are hollow with bark that can peel in strips; shiny soft hairy leaves; purple-black berries; nectar can be sipped from flowers		China	Spreads easily underground and winds tightly around native plants
* **Garlic mustard** *(Alliaria petiolata)*	Perennial Flower	Strong odor; attractive serrated-edged leaves with pretty four-petal white flowers in spring bloom; tolerates shade or sun		China	3,000 seeds per plant; crowds out wildflowers
Nodding thistle *(Carduus nutans)*	Biennial flower	Purple flower; long, deeply serrated leaves that flatten out on the ground; prickly to the touch		China	Not eaten by wildlife so it is able to set seeds easily
Sweetclover *(Meiloltus alba & M. officinalis)*	Perennial flower	Stems can curl out and up; longer and thinner leaves than the usual clover in groups of three; flowers yellow or white		Europe and Asia	Crowds out natives; some farmers still use them; 350,000 seeds per plant

* Both of these plants disrupt the ability of nearby plants to succeed due to alleolopathy, because of chemicals it exudes into the soil. Garlic mustard seeps antifungal chemicals into the soil which upsets the balance of the fungi and native plants so that native are less likely to grow.

Non-Native Species Found in Midwest U.S. Schoolyards (continued)

Plant Name	Type of Plant	Identifying Characteristics	Measured Characteristics	Country of Origin	Why does it thrive?
Dandelion	Perennial flower	Spear-shaped leaves with deep serrated lobes; sticky white sap; fluffy seedhead; yellow flower; flat set of ground hugging leaves; edible with lots of vitamin A, B, C, D and potassium	2–18" tall	Europe and Asia; brought to U.S. from Europe as food for honeybees	Deep taproot
Indian mock strawberry	Flower	Round serrated leaves like a strawberry; five petals on each yellow flower		India	Spreads by ground-hugging vines
Purslane	Perennial herb	Fleshy, small, fat leaves that hold moisture; thick flat mat; was a cultivated vegetable with more beta carotene than spinach, also vitamins A, B, C, E, omega 3 fatty acids	½ to 1" high	Believed to be the Himalayas, Middle East deserts, India	Survives dry unfertile soil; roots along the ground
Common plantain		Leaves flat to ground; stem with seeds at top	3–18" high depending on the type	Europe, Asia	Forms a dense mat of plants; crowds out other plants
Wild garlic/ onions (*Allium vineale*)		Difficult to distinguish between the two—look for the small bulbs when you pull one out; grassy; strong smelling; good for circulation and immunity; repels insects (and people?!)	10–12" high	Central Asia	Self-fertilizes
Butterfly bush (*Buddleia davidii*)		Twigs arch downward; flowers are long and colorful	4–6'	China	Invasive in West because of climate
Common daylily (*Hemerocallis fulvar*)		Yellow or orange flowers; big stems; straight, green leaves	2–3'	China	Grows quickly through spreading tubers; sprouts in any condition

Names: _____

Reporting: Our Team
Sample Plot

Conditions: dry/wet sun/shade	Leaf shape/ feel/veins	Flower color # petals	Height	Drawing	# of identical plants	Field Guide Match? Name?
Wet, some sun, low ground	Tall grass, thin and rough	No flower, flat seeds in triangle shape,	4 feet		6 in row	Northern Sea oats

Names: _____

Self-evaluation: Collecting Data

When collecting data, it is important that your tests are accurate and can be repeated by someone else on your team in the future.

Directions

Examine your findings. Put a question mark (?) by something that your team is unsure about; it may cancel out (negate) or skew the results of the investigation.

Put a plus symbol (+) by the things that were carefully done so the observation could be repeated by someone else.

Materials. Our team:

___used proper materials

___used proper procedure

Observations. Our team:

_____stayed focused

_____used the tools carefully

_____asked for the teacher's help when needed

_____recorded numbers and used measurements

_____measured in a place that was typical of our entire space

_____wrote down only what we saw (not what we thought)

_____recorded the observations and data

Reporting. Our team:

_____used background information such as field guides and internet (Missouri Botanical Garden *Plant Finder*)

_____reported in a way that others can easily repeat

Names: _____

The Temperate Deciduous (Oak-Hickory) Forest Biome

Directions:
Parts of Missouri and China are within the temperate forest biome. How do the characteristics of this biome compare to our schoolyard? Use information from historical societies, the library, community agencies, examination of the schoolyard, or other sources to support your experiences.

Characteristic	Temperate Forest Biome	Our Schoolyard
Growing season	6 months / 4 seasons	
Precipitation	20–60 inches (75–120 cm.) per year	
Temperature Average	50° C	
Temperature Range	Yearly: -30° to 30° C Winter: -12° to 15° C Spring: 21° to 27° C	
Trees	Oak, hickory, dogwood, serviceberry, elm, basswood, black walnut, persimmon	
Shrubs	Lindera (creekside), fragrant sumac, viburnum	
Herbaceous	Mostly early spring: boneset, sensitive ferns, mayapples, Jack-in-the pulpits, sedge grasses, spring beauties, toad lilies, violets, Virginia waterleaves; Fall: goldenrod	
Latitude	23° north to 38° south	
Soil	fertile, enriched with decaying litter	
Canopy	moderately dense, allows light to penetrate	
Flora	3–4 tree species per square kilometer; Trees are mostly deciduous	
Fauna	Squirrels, rabbits, skunks, birds, deer, mountain lions, bobcats, mice, coyotes, turkeys	

Student Objectives

Students will:

- conduct an interview using a set of student-designed questions.
- share the results of the interview in a summary.
- complete and present a presentation using a wide range of interactive computer tools.
- identify the scientific characteristics of a plant and its uses.
- identify the career of ethnobotany.

Materials

- Access to internet/books about trees
- Software/media tools for presentations

Lesson 5: Worth All the Trees in China: Public Speaking and Botany

Grades 3–5 and 6–8

LESSON SUMMARY/PURPOSE

Writing in 1913, a naturalist visiting China was shocked at how little timber existed in populated areas except around Chinese temples. With an even larger population today that continues to heavily rely on timber products, what would be the most important tree in China? What would make it so important?

How do the Chinese protect it? China has created thousands of nature preserves to save its trees. Likewise, in another large country, the U.S., it seems that we may have an endless supply of trees to use and enjoy, but how do we use them, which are most important to use and how do we conserve them?

Students will conduct interviews or surveys about trees, and together, the class will use the categories or themes from the interviews as the base for their own research about a tree native to the U.S. or China. Students will research many aspects of a tree, from **taxonomy** to products, and create their own multimedia presentation to share their information with the class. They will use digital devices to record interviews and take pictures of their tree. The presentation will contain a graph showing information about the tree and survey results. Students will understand how trees are identified.

Ethnobotanists collect plant specimens,

interview people about how they use plants and may work with people to conserve plants. Ethnobotanists who work for the Missouri Botanical Garden may be found in St. Louis, in another state, or in one of 36 countries around the world. In this lesson, students will be asked to interview someone about trees and how they use them. Students will learn interviewing skills. They will share their findings in presentations. After the presentations, students will be asked what tree they believe to be most important to China, the U.S., or even the world.

PROCEDURE

Activity One

Students will learn about the aspects of interviewing, such as eye contact, body posture, and clarity in delivery of questions. The students will learn about the use of a warm-up question and the use of open-ended questions that will provide the most information from a person being interviewed. Students will practice together, so that they may develop a few probing questions for follow-up. Students will develop questions that garner descriptive rather than yes/no answers.

Leaves of the ginkgo tree (origin: China)

They will learn the value of accurate interview notes and how to write a quote.

Students will then be assigned to interview an adult about their understanding of how trees are used, why trees are important to them personally and what, if anything, they think about trees and their value. They will be asking a person about a tree memory.

Students will be asked to categorize their interview answers using the categories in the above paragraph. Students may have additional categories from interview answers; the class will review these for relevance. The class will combine their data for each category. They will review the class data and make conclusions about how people value trees. The class will review interviewing skills.

Activity Two

Students will begin research on their trees and their value, keeping in mind the categories of value that evolved from the interviews. A storyboard sketch of slides—graphics, hyperlinks, narration and audio files, with basic information is due before the presentation. They will prepare their presentation using the identified trees and provide evidence of:

- research from a variety of reliable sources appropriately dated.
- a logical sequenced presentation.
- engaging graphics, audio, narration, video and photos that align carefully with the text and presentation and fit well together.
- accurate descriptive and scientific information about the tree and its uses.

Students will contemplate the worth of the trees, once all presentations are given. The discussion will center on these items:

- the composition of the presentations and their use of tools to enhance and engage the audience.
- the effort and skill of the presenter in using the tools as an engaging aid to the presentation.
- the results of the presentations compared to the results of the interviews: What is the value of a tree? How are trees valued by people?

TEACHER BACKGROUND INFORMATION

The information below provides the teachers with some background information about the economically viable trees in China so that she/he can converse with students about their projects.

China is one of the world's five largest wood-producing countries. It uses two-thirds of its wood for fuel.

China must import a great amount of wood. It imports from the U.S., Indonesia, and Russia.

The main wood products produced in China are plywood, particleboard, and fiberboard.

Bamboo (*Bambusa* spp) is easy to work with because it is lightweight and thin; however, it is a very tough tree. Bamboo is so tough that it was historically used for bridge building in remote areas. It is used extensively in construction of furniture, flooring, and fences, pillars, in the building of boats, instruments, and boxes. People can wear it and ages ago, people wrote on it.

Bamboo
(origin: China)

Bamboo can grow in all but one of the regions of China, where it is too cold. Bamboo is resistant to disease, grows quickly, and is hardy in many soils. People can eat young bamboo shoots and drink its fermented sap.

The Chinese fir (*Cunninghamia lancelota*), truly a cypress tree, was one of the first trees cultivated in China and is widely spread across China. In sub-tropical areas, it grows straight and tall. When cut down, it sends new shoots quickly. The bark is easy to work with and fragrant. It grows very quickly so that it is highly productive when grown on tree farms. Chinese people use it for coffins and building windows, doors, panels, furniture, and garden products. It is resistant to insect pests.

In its native habitat from the equator to the 45th parallel, the Chinese *Camellia sinensis* or tea tree is a hardy 30 foot evergreen. It grows on hills up to 4,000 square feet in limestone or basic soils that are loamy or silty. Camellias prefer dry soils. White, black, green, and oolong teas are all harvested from this species, but the processing of the leaves is different. To prepare tea, the leaves

are rolled, then after they are dry they are smoked over a stove, stirred, and put into baskets. There are many stories about how tea was discovered, but the time frame is about the same—tea got its start as a drink about 3000 BCE. Some say the leaves fell into an Emperor's teacup and others say that his servant gave him water heated with dried leaves. China carefully guarded its tea trees and its tea making process for 4,700 years. In European trading through the 16th century, the Chinese only accepted silver bars for the purchase of tea. The British East India Company smuggled some tea into India and India became the world's largest producer of the drink. Once India began growing tea, it was cheap enough for people of all socio-economic levels to drink. China, India, and Japan grow, process, and export tea today.

Mangrove forests are found in silty, salty habitats, usually along riverbanks, deltas, and coastal areas. Red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and white mangrove (*Laguncularia racemosa*) are crucial to protecting the coastlines of southern China and also would help stave off a tsunami. Since mangrove forests are near coastlines, many have been destroyed to make room for resort areas. They are extremely productive fishing areas. Such forests can also be a holding place for pollution before it is released into the ocean. The forests can hold sediments before they negatively affect the coral reefs. In Florida, the red mangrove with its red roots, is the best known and it grows on the edge of the water. The tannin from the bark can be used to make a red dye. One third of all mangrove forests in the world have disappeared since 1960.

The leaves of the white mulberry tree (*Morus alba*) are eaten by silkworms (*Bombyx mori*). Once the silkworms begin to weave their cocoon, they release a cocoon-making thread that is important to the silk trade. At that point, the silkworms are killed and their silk is gathered for spinning into fabric.

The weeping willow (*Salix babylonica*) is a beautiful tree with a history tied to both religion and mythology. They are fast growers and provide extensive shade in the temperate climates of the U.S. and China. Weeping willows like standing water. They will grow in almost any kind of soil; however, they do love water so they can be problematic near pipes. They are not very resistant to pests and often do not live longer than 30–40 years.

The wood can be used to make instruments, furniture, and whistles, but is best known for making great baseball bats.

More important is the medicinal value of the willow. The bark has a compound called salicylic acid which is used to make aspirin. It is also used to make medicines that act as anti-inflammatory agents. Salicylic acid is used to reduce heartburn and treat bleeding in the arteries.

Weeping willow (origin: China)

A tree that grows in the southwestern U.S. as well as in China, but is a Chinese native, is the Jujube tree (*Ziziphus jujuba*). The candy does not come from the tree, but small edible fruits can be eaten fresh or baked in cakes, etc. The trees like dry environments and are not bothered by pests.

Additional Trees

Native to China

- Loquat (*Eriobotrya japonica*), Lychee (*Litchi chinensis*) and Peach (*Prunus* sp.)
- Iron walnut (*Juglans sigillata*)
- Chinese bayberry/strawberry tree (*Myrica rubra*)
- Chinese quince (*Cydonia sinensis*)
- Maidenhair (*Ginkgo biloba*)

Native to the U.S. Midwest

- Hickory (*Carya* spp.)
- White oak (*Quercus alba*)
- Ironwood/Hornbeam (*Carpinus caroliniana*)
- Sugar maple (*Acer saccharum*)
- American filbert (*Corylus americana*)

White oak
(origin: U.S.)

- Balsam fir (*Abies balsamea*)
- Slippery Elm (*Ulmus rubra*)
- Pecan (*Carya illinoensis*)

Vocabulary

- **Ethnobotanist**—a botanist who studies the use of plants within a culture
- **Taxonomy**—the classification of organisms into groups based on similarities

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Student Objectives

Students will:

- differentiate between limestone and other sedimentary rocks.
- provide an example of how soil types affect plants.
- recognize the difference between weathering and erosion.
- demonstrate chemical weathering in sedimentary rock.
- demonstrate the effects of wind and water erosion on soil, and identify causes.
- identify preventive measures, using plants, that anyone can do to avoid eroding soil.

Materials

Per each team of students:

Activity One: Rock Identification

- *Rock and Mineral ID Dichotomous Key* handout
- Nail
- HCl (adult supervision only) or high strength vinegar
- Three different sedimentary rocks, plus rocks that students bring to class from home
- Paper towels to dry hands or clean rocks

Activities Two & Three: Wind and Water Erosion

- Sturdy plastic or metal painter's tray and roasting pan large enough to hold two trays; optional: newspaper
- Small bag of silt, sand, gravel, topsoil, sod
- Rocks that each group brought in to share
- Small cut-up sponges (trees and plants)
- Measuring cup with ¾ cup of water as well as three paper cups
- *Effects of Wind on Soil* & *Effects of Moving Water on Soil and Rocks* handouts
- Pictures of loess soils (download from internet)

Lesson 6: Loess and Limestone of Missouri and China: Weathering and Erosion

Grades 3–5 and 6–8

LESSON SUMMARY/PURPOSE

Students will learn about the causes of weathering and erosion, especially on some of the soils of the Midwestern U.S. and China. Limestone is a prevalent **sedimentary** rock found in Missouri. It is mined in 80 percent of Missouri's counties. However, whereas Missouri has only sedimentary and a very small amount of **igneous** rocks found on its surface, China has a myriad of landforms with all types of rocks on its surface. Students will learn about **loess** (pronounced "luss"), a common windblown soil deposit, but rarely found as big hills in the world except along the Missouri, Yangtze and Rhine Rivers. Both China and Missouri and Iowa had glaciers that left behind this windblown soil. Loess soils are easily eroded and climate, fires, small animals, and prairie plants affect erosion rates. Topsoils that are easily eroded, like loess, especially benefit from soil and water conservation plans in order to productively use the land and protect it from desertification.

LESSON CONNECTIONS TO CHINA

Limestone Rocks

Many Chinese gardens make use of interestingly shaped rocks and stones in their gardens, not just as walls or seats, like often found in the U.S. Beginning in 700 CE, Chinese poets began using limestone rocks in their gardens, often as a focal

point. It wasn't until 600 years later that the use of rocks to create mountain or waterfall features in gardens became popular. Limestone rocks of a yellowish-brown tint or with many lines, showing the layering of the rock over many years, were most valued by Chinese gardeners.

Loess Soils

China is the only place in the world where loess, a silty soil, is 165 to over 260 feet thick. Two million years ago, the glaciers left wind-blown soil and glacial till behind. The windblown silt continues to be eroded by wind and re-deposited across plateaus and in gullies and ravines, about ½ of which erodes into rivers. Loess is a fertile soil often used for farming in China, but it can become quite mucky when wet. Loess is often the cause of dust storms in China—and recently in Texas. Loess soil is light and fine-grained and often has little deep-rooted vegetation to anchor it when it becomes extremely dry. Very few trees remain on the loess soils in China to prevent erosion. Western Missouri and Iowa also have one of the thickest deposits of loess in the world—but it is only 15 to 30 feet thick and only one-fifth as old as China's.

PRE-LESSON PREPARATION

Preparation for Activity One

If you are using vinegar rather than HCl, test it on clean rocks to see if it is strong enough to cause a chemical reaction.

Ask students to collect one or two rocks **NO BIGGER** THAN THEIR FIST. Have an additional selection of rocks to test for each group. Do not use box sets of rocks for testing. Use the rock identification chart to assist you in identifying St. Louis region rocks. Go to the Missouri Department of Natural Resources website for more information.

Ask students to look at the buildings around the schoolyard and in the neighborhood made of rock and even look at gravel roads. Look for cracks in buildings, rock tie walls, driveways, garages, etc. What is causing those cracks? [plants, water that freezes]

Preparation for Activity Two

Using a permanent marker draw a line on the deeper part of the painter's tray about two to three inches from the top—all materials must start above that line.

Have magnifying glasses or a microscope for students to examine particles of sand, silt, and clay that are in small containers. For this lesson, students will put a layer of soil or sod in the first tray. (The teacher may want just one sod tray for a demonstration.) In a second tray, place gravel then a 1-inch layer of silt and sand or topsoil on top. You may want students to both blow on the soil and use a low-level hand fan.

This is a great schoolyard activity because the materials are easy to take outside and you can use the landscapes around the school to talk about weathering and erosion.

Preparation for Activity Three

Use the same painter's tray in the roasting pan. Remember to draw a line in dark permanent marker near the top of the painter's tray. Each group will receive three paper cups. Prepare the cups by punching a small hole in the bottom of one, and punching a large hole in the bottom of each of the other two cups (these last two cups

should be identical to each other). The cup with the small hole will be used first in the experiment.

Make sure that some silt and sand is on top of the gravel.

Again, this is a great activity for outside on the playground—students can use a rock to hold their papers down. They can talk first about where the water goes on their playground and what the water takes with it. Make sure students look out the windows or even go out to the playground in the next rain to see where the water is going and what's moving with it!

PROCEDURE

Activity One: Rock Identification and Weathering

(about 40 minutes)

1. Ask students to meet in a group of four with their rocks and the rocks the teacher provided to each group. Have students talk about why each chose their particular rocks to bring in. Have them describe their rocks and talk about how to sort the rocks. Bring the students together in a discussion about their sorting methods. Collapse these on the board. For example, your sorting grid may be pie-shaped with five student-created categories: color, size, feel, or amount of holes. You can add some of the students' descriptive words to each category.

2. Let students know, using size or color, why it may be difficult for scientists to identify rock types unless they had a common key because what looks medium sized to us may be small to another person, or perhaps all of the rocks come in all the sizes or shapes we listed. So, scientists use special tools, like magnifying glasses, microscopes, hammers (to see how rocks break apart: in rounded, flat, thin, or wide breaks), nails, and chemicals to help them identify rocks.

3. Students will use the tools, rocks, and an identification sheet to determine which, if any, of their rocks is limestone. **Only the teacher handles the HCl.** The students may also identify other rocks they have in the collection.

4. Have groups share one or two rocks from their groups.

   - How did you identify the rock?
   - What are some special characteristics?
   - Were there any surprises?
   - How could you tell which rock was limestone?

5. Explain how rainwater can dissolve a rock. This is called chemical weathering. What do you think would happen if this rock sat outside in the sun and rain for 20 or even 100 years? Ask if students notice worn buildings, stone, or old gravestones made of limestone. Rocks are constantly weathering, or breaking down. Some are weathered by a chemical solution in water.

6. How else might a rock break apart or break into smaller pieces? Ask if students noticed cracks in sidewalks, driveways, walls, etc. What caused these cracks (plants growing or water freezing and thawing)? This is called physical weathering. Sometimes a big boulder could land on another rock and break it apart.

A stream or ocean wave over time could soften the edges of a rock. That is physical weathering. (See reference section for books with other activities that show weathering.)

Activity Two: Loess Soils and Erosion

Sedimentary rocks are made of sediments, like sands, clays, and silts (like fine dried mud) compacted together. Tell the students:

- All of you have two trays, one with clay and grass from outside on the schoolyard and the other with a layer of gravel, loess soil and sand or topsoil without grass. The one tray represents some of the soil layers—primarily rock, silt and clay, and topsoil.

Have the entire group stand on one side of the trays. Each person has one try to blow gently on the soils in the pan; the materials in the pan should not blow out onto the floor.

- What happened in the clay and grass-filled tray? Record your results.
- What happened in the sand and silt tray? Record answers on the handout.

Ask each team to talk together for a minute or two to compare and summarize what happened.

- What happened in the gravel, silt, and sand tray?
- What was different about the two trays?

Discussion Points

Compare this activity to chemical weathering of the rocks in activity one. How is this different? The key is in the word, "move" because when the soil or rocks get moving, it is called erosion.

- How is the clay and grass tray different from the soil and silt tray? What do you think made the soil stay in place (or move)? [type of soil; grass]
- What questions do we still have?
- Have students create their own tray to answer their questions or find out more (for example, they may choose to add vegetation to the gravel tray).

Concluding Ideas

When vegetation is present, especially if it is deep-rooted and native to the area, it can often hold the soil and prevent erosion. Prairie plants are well-suited to the flat plains of Nebraska and Kansas because their deep roots and tough stems can help them survive the winds on the prairie. Discuss the loess soils unique to Missouri and to China.

Activity Three: Soils, Rocks and Erosion

Put names on papers and put them aside to stay dry. The water should be contained in the big roaster pan at the end of the lesson.

Make sure the painter's pan is stable on the edge of the big pan for each group.

Push all of the tray materials back above the line you made on the tray: gravel with as much silt and sand on top as possible.

Have students:

1. Take turns with the three cups. The first person, with the smallest hole in the paper cup, will pour ¼ cup of water into the paper cup while holding it at the top of the painter's tray OVER the gravel, but above the line.

   Draw what is seen. Write a sentence about what happened.

2. The next person uses a ¼ cup of water in the

measuring cup and, placing the paper cup with the larger hole at the top of the painter's tray OVER the gravel, but above the line, pours the water through the paper cup.

Draw what is seen. What do you notice that is different? Write a sentence.

3. The third person adds the sponges and stands them up like flowers and trees. This person gets to add the rocks. All rocks and "plants" must be in the gravel or soil, not in the water at the bottom of the pan.

4. The fourth person uses a ¼ cup of water in the measuring cup and, placing a paper cup with a larger hole at the top of the painter's tray OVER the gravel, but above the line, pours the water through the paper cup.

5. Each team puts their materials down. They look at what happened this time, draw their picture, label it, and write a sentence. How is it different this time? Do not change anything in your tray because the other groups will be coming to visit!

6. Each team shares and decides on two important points to share with the whole class. The different teams gather around each tray and observe and listen to the important points.

Discussion Points

Students may notice the effect of the vegetation in creating channels, or that the sponges can hold the water—important because they can slow the flow and amount of water going into a creek, but the rocks do not absorb the water. Sponges represent trees and deep rooted plants that hold water after heavy rains and reduce the flow of the water into a stream, in turn slowing the soil erosion. Students should see that the silt and sand affect the water quality in the "river." A delta or new land is formed at the end of the river…or sand bars are created in the river. The water moved the soil just like the wind did, which is called erosion. Some students may notice that gravel tumbled down, too, so the rocks could get smoother or break up on their way down a river.

Students may notice how the sand or silt feels in the river.

Concluding Ideas

Weathering is a normal process. Provide information about the loss of topsoil and loess and ask students their ideas for what they think can slow or stop erosion. Rates of weathering and erosion can increase depending on the environment. People can reduce erosion through the use of native plantings, planting along areas easily eroded, like stream banks, planting deep rooted plants and using soil and water conservation methods identified by organizations such as the Natural Resources Conservation Services.

TEACHER BACKGROUND INFORMATION

Soil

Soil Definition

Soil is nonliving. Dead plant and animal(organic) material make up five percent (5 percent) of the soil. Small pieces of rock comprise forty-five percent (45 percent) of the soil. Air (25 percent) and water (25 percent) are also in the soil. The soil is made of humus, sand, and clay. Since soil can provide air, water, food, nutrients, and shelter, it may be a habitat for living organisms. These

organisms contribute to the breakdown of the organic materials in the soil. There are basically three layers, or horizons, of soil that are not static.

- A layer: the thinnest top layer is the rich **topsoil** that has minerals and nutrients for plants and living organisms, and the organic material, such as decaying leaves and dead insects.
- B layer: the next layer, or **subsoil**, contains some nutrients and a lot of clay. Some water and strong tree taproots can drive into the subsoil.
- C layer: a l**ayer of mostly rock-based soil** is between the subsoil and the bedrock.

Types of Soil

Sand is made of large grains that we can see without a microscope. Sometimes you can feel the grittiness of sand when you are sitting on a beach. Water moves quickly through sand. Sandstone is found on and near the bluffs of the Meramec and Mississippi Rivers. Clay is common in Missouri and is made up of very tiny grains seen through a microscope. These grains are so small and compact that they feel sticky, not gritty. Water does not easily flow through clay soils. Silt grains can be seen with magnifying glasses or a microscope. Silt is common in and along river banks.

Loess soil is a fine-grained silty soil found around the world, but rarely in large thick deposits as found in Missouri or on the Loess Plateau in China. Loess is a great agricultural soil. When wet, the loess silt turns into a toothpaste consistency, which gets top-heavy and then collapses into ditches or rivers.

The best kind of soil for plants is a mixture of fine organic material (**humus**), and a mixture of the three types of soils. Plants in sand often can't access the water because it moves through it too quickly and sometimes plants drown in clay soils that hold too much moisture for a long time.

A good soil for plants crumbles in your hands and can readily soak up water. Unless this mix of soils and organic material (humus) is very shallow, it will absorb rain and snowmelt, rather than move down the roads, storm sewers, or ditches into creeks and rivers.

Next to a **loamy** soil, silty soil is the most fertile, being rich in nutrients. Plants that like water often do well in silty soils, such as willow, river birch, and red twig dogwoods, aronia and elderberry bushes, and yellow iris flowers.

Aronia melanocarpa

Weathering

The rocks *on top of* and *in* the soil can be weathered and broken down into smaller segments, contributing to soil formation. Rocks deeper in the ground, in what is called the C layer, are broken down by solutions of water and naturally occurring chemicals from below the surface of the soil. When rocks are broken down in this layer, minerals are released into the soil and travel upward. When these minerals reach the topsoil or first few soil layers, then plant roots can use them for growth and health.

Sedimentary rocks usually break down faster than igneous or **metamorphic** rocks. Heat and pressure have solidified the grains in igneous and metamorphic rocks whereas sedimentary rocks are typically cemented together through pressure on organic or inorganic materials. Weathering occurs faster in damp humid climates than in dry desert climates.

Erosion

The *movement* of rocks or soil to other locations is called **erosion**. Any moving or running water, wind, gravity, and glaciers—as well as the force of gravity—can move soil and rocks. Soil erosion is usually measured by tons of soil moved per acre of land each year. A one inch layer of topsoil over one acre of land weighs about 150 tons. Now, why do these numbers matter? U.S. lands are losing soil faster than topsoil can be naturally created by the decomposition of plant and animal matter.

In the last hundred years, over half of the topsoil in Iowa and Missouri has been lost down the Missouri and Mississippi Rivers into the river bottom and also the delta of New Orleans. Soybean farming, with its small root systems, has increased the loss of topsoil. Government programs that encourage soil and water conservation such as no till and terraced farming, reduce soil erosion. Programs such as "edge-to-edge" farming increase soil loss. Fewer riparian zones result in more topsoil being lost, especially loess soils on the western side of Missouri. Some of the loess hills of Missouri are protected by nature preserves.

Conserving soil is not only important for better crop yields, but also for the cleanliness of water and soil. Water filled with silt is not as easy to clean for drinking use nor is it good for diversity in the fish population. The wind erosion in China on the Loess Plateau, similar to the dust storms in the southwestern U.S. in the 1930s and today, can cause air pollution and aggravate breathing.

Loess Soil

Loess soil is sculpted by erosion. Loess is considered the most erodible soil, usually by wind or water, in the world. In the Midwest, the loess, a silty soil, was caused by the movement of glacial deposits 11,000 years ago (when very few people lived in the area) that were dry, silty, and wind-blown. Loess continues to be sculpted by erosion, primarily by wind erosion. From the east, between Sioux City, Iowa and Kansas City, Missouri, the loess hills gradually rise until they are steeply pitched bluffs at the Missouri River. The loess in the Plains states—including Missouri—ranges from 15 to 30 feet thick.

In China, the loess is 165 to over 260 feet thick. Two million years ago, the glaciers left windblown soil and glacial soil/rock debris behind. The windblown silt continues to be re-deposited by wind storms on a massive plateau that covers three provinces, above and along the Yangtze River. The erosion of the loess has created pillars, gullies, and caves. China is more heavily populated than Missouri so the loess has been more heavily farmed and many of the human-terraced hills are without trees and shrubs.

Loess is a soil that was made fertile by the breakdown of the inorganic minerals in glacial rocks and soils. Many other soils in Missouri and China become fertile through the break-down of organic material, like rotting leaves.

Many potatoes, winter wheat, maize, and oil seed rape are grown on the hills, in terraces and rows

as far as the eye can see, with houses dotting even the steepest slopes. The few visible trees may include bamboo and pines—camphor, Australian gum, and funeral cypress.

Similar to the Missouri River, the Yangtze River in China is usually muddy and brown for most of its journey because of the eroded soils. Although it will take longer to lose 165 feet of topsoil compared to 30 feet, the loess soils are eroding quickly. With so little vegetation, the silty topsoil rushes down huge gullies into the Yangtze River creating large silty mud deposits. Eventually, the soil will not be farmable, but rather more like the clay-based subsoil. Both of these loess areas lie between 500 and 1,000 feet above sea level near rivers. Both countries have taken steps to try to reduce the erosion of the loess.

This aerial photo from a NASA satellite shows sediment from the Yellow River spilling into the ocean.

Another plateau of loess found in a 150,000 square mile area, wedged between desert and mountains, begins south of the Great Wall of China, 4,000 feet above sea level. Eroded silt in the ravines from these tall plateaus may reach 650 feet thick. Terracing on the hills is used to control water flow and erosion. Water collects on each tier and then flows more gently down steep slopes when terraced. Crops are planted along the terraces with grassy waterways or shallow ditches at the ends.

Limestone

Missouri was covered by an inland sea about 400 million years ago. The many shelled organisms that lived in the sea died and layer upon layer of their shells fell to the bottom. After the sea dried up, the shells began to harden into limestone. The mineral in the shells, called calcium carbonate (calcite), is similar to baking soda or sodium bicarbonate in that both are bases.

(To be described to students AFTER they do their testing.) The hollows in limestone are caused by rainwater. Although you and I can stand in the rain and our hair does not dissolve in the mildly acidic carbonic acid (CO_2 and rainwater mixed), limestone as a base does slowly dissolve, leaving holes and depressions in the rock. It is similar to combining diluted vinegar and baking soda: there is a chemical reaction, but not the visible fizz. The holes in limestone often get bigger, and under the ground can even create caverns and caves. St. Louis is known for its sinkholes and caves in the limestone rock found along highways 44 and 55. Limestone formed caves are also found south of the Yangtze River in China.

Limestone is a sedimentary rock, formed by the compaction or cementing of soils and seashells. Missouri has other sedimentary rocks on its surface, not just limestone. Two of them contain the tough mineral, quartz: sandstone and chert. Two other sedimentary rocks found near the Missouri Botanical Garden are coal, mined in small seams near the Garden over 100 years ago, and fireclay.

Terracotta Warriors

About 40 years ago, a set of life-sized clay terracotta warriors were discovered in China. The first emperor of the Qin dynasty had these warriors created around 200 BCE. The 8,000 warriors were painted and have individual facial features. Horses, chariots, and larger than life generals were found. Upon excavation, exposure to the oxygen in the air—after so many years of being covered and protected from wind, water, and fluctuating temperatures—caused the painted surface on the warriors to fade and flake off. After almost 2,200 years of being buried, the warriors began to weather. Today some of these warriors remain buried to protect them and others have been brought into museums that are climate-controlled to protect them. These warriors are one of the most popular tourist destinations in China.

Terracotta warrior and horse on display in a museum

Vocabulary

- **Erosion**—the wearing away of the land's surface materials, usually rocks or soil, by the action of water, wind, glaciers; also movement of eroded particles to other locations
- **Humus**—an organic substance made from the decay of plant and animal matter which improves fertility and water retention in soil
- **Igneous**—rock produced by the solidification of magma or molten lava
- **Loamy**—soil made up of about equal parts sand, silt, and clay in addition to organic matter
- **Loess**—a fine-grained silt or clay
- **Metamorphic**—rock produced by a transformation of the original igneous or sedimentary rock via heat or pressure
- **Sedimentary**—rock formed by the accumulation of particles

REFERENCES AND RESOURCES

Missouri Department of Natural Resources, Division of Geology and Land survey. Available on line at http://www.dnr.mo.gov/geology. [Use this website to find excellent descriptions of Missouri minerals and rock types, along with images. The site provides additional information about how rocks and minerals are used in the life of a student.]

Tenenbaum, David. (2002). Dust if You Must. *The Why Files*. Available online at http://whyfiles.org/shorties/100dust_china/.

Images of loess soils are available online by running a search for "loess" at http://bing.com/images or http://google.com/images.

Bureau of Economic Geology. *Impact of Soil Conservation Practices on Water Resources in the Loess Plateau, China*. Available online at http://www.beg.utexas.edu/cswr/loess.html.

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Environmental Education Media Project. (2007). Restoring China's Loess Plateau. *The World Bank*. Available online at *http://www.worldbank.org/en/news/2007/03/15/restoring-chinas-loess-plateau*.

Names: _____

Effects of Wind on Soil

1a. When you blew on the clay and grass filled tray, show what happened. Can you measure it? (If yes, ask the teacher for a measuring tool).

1b. Write a sentence about what happened to the grass filled tray.

2a. When you blew on the sand and silt tray, what happened?

2b. Write a sentence that compares what happened in the sand and silt tray to what happened in the clay and grass tray.

3. What question(s) do you have now?

4. What do we call it when the soil moves because of the wind's action?

Names: _____

Effects of Moving Water on Soil and Rocks

1a. Paper cup with a small hole: Draw what happened when the water poured out onto the gravel.

1b. Write a sentence about what happened.

1c. How is this similar to wind erosion?

2a. Paper cup with larger hole: Draw what happened when the water poured out onto the gravel.

2b. Write a sentence about changes to the silt, sand, gravel, and water.

3a. Paper cup with a larger hole and added sponges: Draw what you noticed when the water was poured onto the "land." What do you think the sponges represent?

3b. Write a sentence about what you saw with the sponges (plants) and/or other materials.

4. What have you learned about weathering compared to erosion?

Names: _____

Missouri Sedimentary Rock and Mineral Key

TOOLS NEEDED: Steel nail, dilute hydrochloric acid (HCl), paper towel.
DIRECTIONS: Using the tools provided, follow the steps below to identify your rock.

1. Scratch your rock with the steel nail. (You may have to scratch very hard and more than once.)

   If your rock is easily scratched by the nail (leaves a deep mark)..... go to 2

   If your rock is not easily scratched by the nail, but the nail leaves a silver mark like a pencil..... go to 6

2. Scratch your rock with your fingernail.

   If your rock is easily scratched or broken by your fingernail and is black and lightweight, your rock is..... COAL

   If your rock is not scratched by your fingernail..... go to 3

3. If your rock is wet, dry it off with a paper towel. Have your teacher put a small drop of hydrochloric acid on your rock and observe what happens.

   If your rock fizzes or bubbles..... go to 4

   If your rock does not fizz or bubble..... go to 5

4. Look closely at your rock.

   If your rock is opaque yellow-white and looks like a crystal, your rock is a mineral called..... CALCITE

   If your rock does not look like a crystal, your rock is..... LIMESTONE

5. Look closely at your rock and touch its surface.

   If your rock is white, reddish-brown, or golden-brown, and feels sandy and rough, your rock is..... SANDSTONE

6. Look closely at your rock and touch its surface.

   If your rock is white, tan, light gray, pink, or purple, and has sharp edges and points, your rock is..... CHERT

   If your rock is opaque white, does not have sharp edges and points, and may have crystals, your rock is a mineral called..... QUARTZ

Student Objectives

Students will:

- write a couplet, with or without rhyme.
- write statements that use antithetical, or opposite thoughts.

Materials

- Sample books of poetry
- Samples of Chinese language characters, specifically for "plant" and "tree"
- Samples of Chinese couplets
- Pictures of a Lunar Spring Festival: dragon parade, doorways with couplets
- Drawing paper
- Sentence strips for couplets
- Red paper for classroom door (optional)
- Black chalk drawing pencils (optional)
- Missouri Botanical Garden *Plant Finder* access on computers
- List of homonyms, synonyms

Lesson 7: Characters and Couplets: Poetry and Botany

Grades 6–8

LESSON SUMMARY/PURPOSE

In this lesson, students will learn of differences between the written language forms of Chinese and English. The primary goal is writing a **couplet**, similar to those written for a Lunar Spring Festival in China.

PRE-LESSON PREPARATION

- Download pictures of China's Lunar Spring Festival, with its dragon parades and couplets on red doorways. Use "Chinese couplets" as your search term.
- Download additional Chinese **characters**.
- Students will need access to computers for the Missouri Botanical Garden's *Plant Finder* (*http://www.missouribotanicalgarden.org/gardens-gardening/your-garden/plant-finder.aspx*), and to explore homonym and rhyming word use.
- Books about flower or plant folklore and uses will help students write their couplets. See reference section for information.
- Provide books of sample poems that rhyme, use homonyms, use antithetical (opposing) themes and contain humor. Find sample Chinese couplets online.
- Tape red paper outside the classroom door.

PROCEDURE

Activity One: Playing with the Language

Have students examine different plants from the U.S. or China online using the Missouri Botanical Garden's *Plant Finder.* Once students have their plant, have them use computer tools to enlarge the picture. See the plant list on pages 73–74.

- Draw a picture of a plant using just a pencil.
- Then use a thicker black crayon, chalk, or marker to outline ONLY the most identifiable and unique aspects of that plant.
- This Chinese calligraphy or brush painting technique demonstrates how the many (~3,000) Chinese symbols or characters were created in Chinese language.
- If students use their tool bar on the computer and go to "Insert_symbol," they will find the Latin and Greco-Roman symbols most closely related to English. Some computers provide access to Arabic, Chinese, and many other symbols or language characters used to write.
- Compare the English and the Chinese written language forms.

Ask students, as a whole class, to create a pictorial Chinese symbol to represent the category, "plant." On the board, provide them with samples of Chinese pictorial words. Have students share their characters.

- If you had to choose just a portion of your symbol to represent "woodland," "flower," or "tree," which part would it be? Add another mark to represent perennial or annual plant.
- Provide historical information about the Chinese written language. Conclude by talking about the use of symbols to communicate and how this has an impact on cultural progress.

Activity Two: Create a Poem

Shi is the general Chinese word for poetry.

Talk with students about Chinese poetry. Imagine that prior to becoming a teacher, police officer, or mayor, you would be required to write a poem. That was a requirement years ago in China. What could that tell you about someone? Today in the U.S., to become a teacher or police officer, a person must go through training and take a test demonstrating their knowledge. Reading and writing are skills required in most professions.

- Years ago in China, a person's **character** would be partly assessed through their ability to write poetry as a requirement for becoming a teacher, police officer, or mayor. Why do you think that outstanding character is demonstrated through the writing of poetry or **riddles**?
- What are the reasons you believe that you must write poetry in school?

Just as some of us like to make plays on words, so do the Chinese. They enjoy poetic riddles and comical verses, too. Provide examples of Jack Prelutsky's poems.

During the Chinese Lantern Festival, it is customary to write couplets and hang them on either side of the doorway leading into a house. Lanterns themselves are decorated with riddles. Many poems talk about wishes, but many are also humorous or joyful like Prelutsky's.

- Tell students: "We are going to create couplets about plants. We will need some words that

Poison ivy

Chinese fringe tree blossoms

relate to what plants look like, how they grow, or for what they are used."

- Review some of the couplets below with the students. What do they notice about couplet poems? [May or may not rhyme, have the same number of syllables in English in each line, may give advice or a blessing or say two opposite things about an event or object]
- Most students have heard the couplet, "Leaves of three, let it be." This couplet describes what plant? [poison ivy]

  Seeking solace with nature
  Amid insect symphonies.

  Memorable fragrant flower
  Terrific stings from thorny stems.
  [Rose]

  Delicate orange lantern of beauty
  Turns complexions green and insides out.
  [Chinese lantern flower]

  When in life's thunderstorms, may you be
  Under the fringe tree, not on the fringe.
  [Chinese fringe tree]

Poetry is about making observations. Have students make observations about the plant they chose from the Missouri Botanical Garden *Plant Finder* or choose one from the list on pages 73–74.

- Write down everything about that plant that comes to mind, use descriptive phrases or words instead of sentences.
- Homonyms and rhyming words are often used in Chinese word play. Use a rhyming dictionary to find rhyming words that go with *Plant Finder's* descriptive words. Are any of them homonyms? Think of opposing characteristics of the plant—what is a positive aspect of the plant? A negative aspect?

When finished, share the couplets. Younger students may want to hang the couplets on either side of the doorway, just as in China during the Lunar Spring Festival.

TEACHER BACKGROUND

Chinese Language

Characters

Students can build upon the basic characters below, or these may be shared with students *after*

they create their own characters.

Chinese (simplified Mandarin) characters:

Tree Flower Shrub (evergreen)

Chinese and English Language Comparisons
The English language contains many word parts built from simpler roots, such as suffixes, prefixes, and verb endings. The Chinese written language is similar in that larger words are created from the use of simpler pictorial representations. When you see characters like those above, you know they are words associated with plants because of the shared symbol. What symbol do you see in all three? English contains 26 basic alphabet letters; however, Chinese contains more than 3,000 characters.

Written Chinese has a number of forms for the differing language or dialects spoken in China, but these forms are extremely similar. Thus, no matter which Chinese language or dialect a person speaks, that person can probably read all of the written language forms. Older, more intricate characters are a part of the "traditional form."

One billion people speak the most common Chinese language or dialect: Mandarin. (Note: many Chinese who now live outside of China may speak a different dialect, such as Cantonese.) Speaking Mandarin requires that a person must understand the consonants, then attach the appropriate four **tones** for each syllable, each of which has a corresponding meaning. The verbs have one form so that complex words are made of shorter roots. Just as in English, roots and affixes are used to communicate time and word purpose.

Couplets and the Lunar Chinese New Year (Spring Festival)

When an English-speaking person reads a Chinese poem, it may look and sound different because English speakers do not often understand the play of tonal qualities within Chinese poetry nor does Chinese grammar, like other languages, use articles, plurals, or verb tenses to represent time as English speakers are familiar with from their language.

During the Spring Festival, which culminates in a Lantern Festival, Chinese families may hang couplets along their doorway. First, a string is hung over the doorway. Then, above the door, a theme would be identified—a title, a wish, something to celebrate, a summary of the couplets. Red, a celebratory color, may be found in the string, in the paper colors, or in the written words. This tradition began during the Tang dynasty (618–907 CE). Zhu Yuanzhang, an emperor during the Ming dynasty, about 700 years ago, ordered people to display couplets on their doors during the Lunar Spring Festival.

During the festival, many poetry contests are held in the decorative pavilions found in Chinese gardens.

Couplets are written and used at other times in China; most have a few characters, but some have more than 100 characters. Couplets are used to celebrate and bless marriages, share wisdom about life, or express friendship.

Plants Native to Missouri/Midwest

- Bird's foot violet (*Viola pedata*)
- Highbush blueberry (*Vaccinium corymbosum*)
- Dogwood (*Cornus florida*)
- Eastern redbud (*Cercis canadensis*)

- Eastern wahoo (*Euonymus atropupureus*)
- Jack-in-the-pulpit (*Arisaema tryphyllum*)
- Kentucky coffee tree (*Gymnocladus dioica*)
- Mayapple (*Podophyllum peltatum*)
- Northern sea oats (*Chasmanthium latifolium*)
- Sassafras tree (*Sassafras albidum*)
- Osage orange (*Maclura pomifera*)
- Pawpaw (*Asimina triloba*)
- Poison ivy (*Toxicodendron radicans*)
- Rattlesnake master (*Eryngium yuccifolium*)

Plants Native to China

- Bleeding heart (*Dicentra spectabilis*)
- Chinese lantern (*Physalis alkekengi*)
- Chinese plum (*Prunus glandulosa*)
- Chinese wisteria (*Wisteria sinensis*)
- Dragon's claw willow (*Salix matsudana tortuosa*)
- Fringe tree (*Chionanthus retusus*)
- Giant dogwood tree (*Cornus controversa*)
- Golden rain tree (*Koelreuteria paniculata*)
- Lotus (*Nelumbo nucifera*)
- Princess tree (*Paulownia tomentosa*)
- Smoketree (*Cotinus coggygria*)
- Witch hazel (*Hamamelis mollis*)

Flora of China Project

As the publication of the comprehensive catalog, *Flora of China,* nears completion, the Missouri Botanical Garden is celebrating this important milestone in plant discovery and knowledge.

The Missouri Botanical Garden reports:

"The 31,500 species of Chinese vascular plants represent about eight percent of the world's estimated total of ca. 400,000 species. This compares with some 19,500 in the U.S. and Canada combined and about 12,500 in Europe. Moreover, approximately 51 percent of the species in the Chinese flora are endemic (grow nowhere else on Earth as wild plants). This means that one in 25 of the world's plant species are found in China. Information about Chinese plants is essential to the study of the evolution of North American and European plants, because several groups that were widespread in the northern temperate zone in prehistoric times now survive only in China.

Golden rain tree (top); lotus (middle); smoketree (bottom)

"Chinese plants are also important to the world because of their medicinal value. For thousands of years, the Chinese have used plants very extensively for medicinal purposes. It is estimated that more than 5,000 Chinese species are actively traded and used medically. The properties of these plants as sources of drugs, waxes, oils, and other useful products are of considerable scientific

interest. The *Flora of China* will provide a ready means of locating, understanding, and utilizing these plants.

"During the course of working on the *Flora of China*, consistent efforts are made to identify rare, vulnerable, and endangered species of Chinese plants. This baseline taxonomic inventory will make it possible to locate and identify these species, evaluate threats to them and set in place the appropriate conservation measures. By making this information available, the *Flora* will help enlist the participation of the international community in China's effort to preserve its own botanical diversity.

"The *Flora of China* marks a new stage in the exchange of scientific information between China and the United States. The project was supported for almost two decades by the U.S. National Science Foundation and the National Natural Science Foundation of China, and is still supported by the Chinese Academy of Sciences, the highest political/scientific body in China. Other major funding has been received from the Starr Foundation, the Stanley Smith Horticultural Trust and Foundation Franklinia. The project involves the four most important botanical centers in China: the Institute of Botany, Beijing; the Kunming Institute of Botany; the South China Botanical Garden, Guangzhou; and the Jiangsu Institute of Botany, Nanjing."

— *Flora of China* Fact Page
Missouri Botanical Garden

Vocabulary

- **Character**—combination of traits that make up a person and uniquely separates that person from others;
- **Character**—a sign or symbol
- **Couplet**—A pair of lines of meter in poetry. A couplet usually has two lines that rhyme and have the same meter (the number of syllables in a line and how the syllables are stressed as spoken). Although most couplets rhyme, some do not. In China, couplets have two sentences that are related in theme, but really say the opposite. Couplets are more challenging to create because the first two lines have an equal number of characters and the words in the first and second lines match or fit together in length, sound, word types (verb, noun) and even in characters in order to achieve harmony. Each Chinese couplet has one syllable per character. Couplets for the Spring Festival have a special name, "Chunlian"
- **Riddle**—a question or statement made that has a double meaning, with a purpose of being solved. Two common examples are:

  What plant is found on every child's face?
  [Tu lips]

  What kind of flowers do you give King Tut?
  [Chysanthamummies]

- **Tone**—the inflection (a voice's pitch up or down) given in speech to differentiate meaning. In spoken English a higher pitch at the end of a sentence designates it as being a question. In Mandarin Chinese, inflection is given to specific words and syllables to differentiate them in meaning

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Student Objectives

Students will:

- clone a plant from plant tissue.
- consistently use sterile lab procedures.
- consider variables related to plants that involve feeding the future world population.
- debate that a particular plant is the best candidate for sustaining the future populations of China and the U.S.

Materials

- Cauliflower
- Sterile plastic gloves, one per student
- Detergent
- Ethanol, 70% concentration
- Sterilized small pots
- Potting soil
- Rinse water and rinse containers for each group
- 100 ml graduated container, sterilized
- Tissue culture kit for 30 students (Cauliflower) Multiplication and pretransplant medium (available from Carolina Biological Supply; see resources section)

Lesson 8: Feeding the Future: China and the U.S.

Grades 6–8

LESSON SUMMARY/PURPOSE

This lesson focuses on the need to efficiently reproduce plants as food sources for large amounts of the population. Students will consider issues of population growth, new sources of food, and how to **clone** a plant. Both China and the U.S. are working towards more **sustainable** practices in the growth and preparation of foods.

China is losing its farmland to encroaching desert and building projects for industry and housing. China and parts of the U.S. have already looked to the use of ocean plants for foods.

Tissue culture connects cell biology to genetics. Tissue culture is one method used in the cloning, or breeding of plants. A botanist or horticulturalist will start with a plant that contains a special positive trait, such as pest or disease resistance. A botanist, like Nyima Zhoima from Tibet, can take one plant cell and using sterile lab and specific growing conditions, can grow an entirely new plant. (From culture to plant takes about 8 weeks; Carolina Biological Supply has a variety of kits for use at a reasonable cost.) Future scientists are learning how to increase plant yields and how to improve upon plants in order to increase nutritional value while maintaining low stress on the land. The tissue culture experiment and the research into a plant will lead us to some valuable findings about the future of agriculture.

Essential questions:

- How could plant cloning be used to feed a growing population?
- What criteria should be used to determine if a plant is the best choice for cultivation to feed the largest amount of the population so they may survive/thrive?
- What other questions about feeding the future population have developed from your plant research?

PRE-LESSON PREPARATION

Determine a place in your classroom closet or storage space where there will be the least interruption to the work area as possible since a sterile work area is of utmost importance in tissue culture.

Clean all surfaces and materials and rinse well.

PROCEDURE

Activity One

Assign students to teams to study particular plants that may solve the world's food shortages in the future. Students are to identify the plusses and minuses of each plant and argue its viability. Check the Teacher Background Information section for additional details needed to lead this activity.

- Examine the population of China and the U.S. Using these numbers and the growth of the population in the last 50 years, estimate the amount of population increase within these two countries within the *next* 50 years.
- Choose one of the plants listed on pages 80–82. Read the assignment below and divide responsibilities. Each person will be responsible for turning in a write-up of their contribution. Student teams may speak with the teacher if they choose another plant than those identified in the Teacher Background Information section. Students must use reliable internet and text resources that make use of expert opinions in the fields of nutrition, sustainability, and agriculture.
- Identify the plant's benefit(s) to people as a food or in any other ways.
- Identify how much energy (labor input, sunlight, fertilizer, water) it takes to grow this plant. How is the plant a plus or minus for the soil? How much water is needed for its growth? What is the origin of the plant?
- In what types of soils and in what climates will this plant grow?
- How well will this plant transport or be refined for use?
- Identify any other special characteristics that make this plant a good candidate for future production.
- Identify the nutritional strengths, the ease of processing or transporting the plant, and how easily it may be adopted into the cuisine of China, the U.S., and other countries.
- Draw or create a likeness of the plant and identify its scientific name, its plant parts.
- Be prepared to return to class to argue how your plant is the best for the future.

- What other questions does your group now have about feeding the future?

We will use debate rules for sharing our content. We will vote on the most appropriate plant for feeding the world in the future. Students may consider other issues, such as transportation or plant viability over time (between the farm and the market).

Activity Two

Scientists are looking for ways to improve plants: to breed them more rapidly to keep up with food needs and to cultivate healthy and filling foods for the world. In a set of activities over time, as identified in the tissue culture kit, students will use proper lab procedures to set up the phases of cloning in the petri dishes, cut and place plantlets into planting medium, and move plantlets with roots into the potting mix soil.

EXTENSIONS

Students may bring up the role of genetically modified foods and use this topic as a second debate. They may be able to interview business people, farmers, and the general public about genetically modified foods, conduct surveys, and evaluate websites and information for misconceptions and scientific data. How is cloning plants different than genetically modifying plants? Which method holds the most promise for feeding the future population?

TEACHER BACKGROUND INFORMATION

World Food Needs and Plants

The population of the world has tripled in the last 50 years. It is estimated that it will nearly double again by 2035. Human stress on the Earth may lead to further deforestation, water and food shortages, and less usable fertile land.

China and U.S. Populations

The world's population is 6.7 billion. In 2012, one in five of the world's people lives in China, approximately 1.3 billion (1,330,700,100). China's population doubled from 1950 to 2000. Since it enforced the one child rule beginning in 1979, China's population growth from new births has maintained and if the rule is continued, then the birthrate will slightly decline in the next 50 years; however, more people will add to the population due to increased lifespan and immigration.

The population of the U.S. is 313,335,000 with a population increase that averages one percent yearly.

Plant Research

In 2010, Nyima Zhoima, was honored as one of China's top 10 scientists for breeding the first kind of oil-rich rapeseed. A rapeseed that provides more oil would be useful for cooking in China because each person would use a fewer number of plants, saving space and energy for other agricultural plants. Scientists are studying how particular plants can be bred to have greater benefit to humans. Some plants are bred to be more efficient for water uptake, for instance; others are bred to grow in a different way: bigger, thinner, have more seed, etc.

Climate Change and Plant Research

Dr. Jan Salick, Senior Curator of Ethnobotany at the Missouri Botanical Garden, has studied in the Himalayan **alpine** region for many years. The alpine regions are at very high elevations

and therefore are those most negatively affected by a changing climate, including increases in temperature. The snows on top of the Himalayan mountains are the source of fresh water for a large part of Asia. As climate changes and temperatures increase in the mountains, there is no longer as much snow on the mountains and glaciers are melting. Because of this, familiar crops may fail, and methods of food storage may no longer be successful. New varieties of food crops are urgently needed and are being developed by plant breeders to help the Tibetan people who live in the Himalayan mountains grow enough food to continue to survive in this alpine region.

Economics

Knowing how to improve upon plants to increase their yield and nutritional value while maintaining low stress on the land is important for the future. For example, corn is valuable in the U.S. as a food and food additive for humans and domesticated animals; it is also used in making **ethanol**. Yet, corn extracts significant amounts of nutrients from the soil, wearing out the land and making it necessary to replenish nutrients through the use of fertilizers. Likewise, Chinese cabbages, such as bok choy, are rich in vitamins, fiber, and minerals for people, but also extract many nutrients from the soil. The question is how to improve the efficiency of agricultural practices, maintain soil and water conservation, and still achieve a high plant yield. When planning for the future, it is important to grow plants that resist pests and disease.

Food Preparation

Some foods may be cooked in ways that are healthy and more energy-efficient other than eating just raw foods! The Chinese often boil foods just as Americans often bake foods in ovens for long periods of time. A more energy efficient and nutritious method would be to steam foods in a microwave or to stir-fry foods, popular with both countries.

Many people choose to become vegetarian not for the food choices, but rather because eating more plant products rather than meat products eliminates the calories wasted by feeding grain to animals and then having people eat the animals. Changing dietary practices on a large scale would make more food available over time to our own countries, although it may not succeed in feeding the world since many countries' peoples already rely on most of their calorie intake from plants.

Plants that Could Feed the World

This section includes brief facts about different foods as a starting point for the teacher to discuss the plants with students while they are preparing for the debate.

Seaweeds

Many countries have harvested types of algae called seaweeds for use as fertilizer, animal or human foodstuffs: France, Ireland, New Zealand, Chile, Japan, Indonesia, South Africa, and the U.S. Seaweed can be added to the grains fed to poultry and cattle, and has been found to reduce butterfat in cattle's milk and improve the thickness of hen's eggs. Seaweeds, by weight, typically contain 20–200 percent more minerals than land-based vegetables. Seaweed is high in protein and is reputedly good for the urinary and nervous systems.

The coast of California is one of the richest for kelp farming (kelp are a subset of seaweeds). However, the beds have been subject to attack by

sea urchins and bacteria. The south central Pacific Ocean has always been the site of Euchema (a tribe of red seaweeds) harvesting for carrageenan which is used in gum, foods, and agar. China primarily harvests those in the *Laminaria* genera.

Kelp and Nori are two of the best food choices for nutrient value. Nori is used in making sushi.

A list of seaweeds, their uses, and nutritional value are found in the table below.

Rice

Rice is so common in China that the Chinese word also means, "food." Rice can be used for animal fodder, straw, sandal making, and fuel in addition to feeding half of the world's peoples. Rice flour is used for baking and paper sizing. Rice production worldwide has doubled in 30 years, with China as the top producer. Even China had to import rice in 2004 to meet the needs of its population. The Chinese prefer a bland rice flavor because the rice is a mere backdrop to the "sung," or meat and vegetables in a typical meal. In China, rice is usually boiled. Rice is not the only grain produced in China. Winter wheat, barley, and

Rice

Name of Seaweed	Country used	Nutritional Highlights	Food type
Asparagopsis taxiformis (limu)	U.S.		Cooked
Caulerpa racemosa (sea grapes)	China	Potassium, Vitamins A, K, B12	Salad
Chaetomorpha crassa (sea spaghetti)	China		Salad
Chondrus crispus (Irish moss)	U.S.	Vitamin A	Cooked
Enteromorpha spp. (light green nori)	U.S., China	Calcium, Iron, Vitamins A, B	Salad
Fucus vesiculosus (rockweed)	U.S.	Vitamin A, Magnesium, Protein	Tea
Hijikia fusiforme (hijiki)	China	Protein	Raw or cooked
Laminaria longicruris (a type of kelp known as Atlantic kombu)	U.S.	Protein	Cooked, soup
Nostroc spp. [a cyanobacteria rather than an algae]	China	Protein	Raw or cooked soup
Porphyra spp. (nori)	China, U.S.	Protein	Baked goods, soups, salad
Ulva lactuca (sea lettuce)	China	Iron	Soups, salad, tea

buckwheat are grown in the north and maize is grown in the south.

Rice has a center of almost pure starch. The protein, vitamin B_1 is in the seed coat. With plant genetics improving, rice plants can mature in 110 days instead of 160, are shorter to increase grain loss, and more disease-resistant.

Rice needs much water. Rice grown in paddies can require many hours of labor. Rice does not deplete the soil. Evidence of rice was found in a site from 12,000 BCE.

Corn
Corn has been modified to provide more Vitamin A and protein; however, it is low in amino acids needed to make it an adequate source of protein. A new harder kernel brand of corn was developed that would withstand travel better. Corn is a heavy user of soil nutrients.

Wolfberry or Gou qi zi (*Lycium barbarum*)
This plant that has been collected for thousands of years in China is used in many recipes and traditional medicines. It has a nutty taste. The seeds, powdered pulp, dried berries, and juice have recently been exported to other countries. The wolfberry is over half carbohydrate, about 10 percent protein and 10 percent fiber and fat. The plant is related to the tomato, potato, and eggplant. Wolfberry contains calcium, potassium, iron, zinc, selenium, Vitamin B_2, Vitamin C, and Beta-carotene.


Wolfberry

Soybeans
China decided in the 1990s to focus more on other grain crops besides soybeans. It produced and used about 15 million tons of soybeans; today it still produces the same amount, but it imports over four times that amount. Soybeans have become a major export for the Americas. Soybeans contain protein, carbohydrates, and fat, as well as vitamins and minerals, including calcium, folic acid, and iron.

Fruit and Vegetable Giants: Sweet Potatoes, Eggplants, Bok Choy, and Tangerines
A combination of vegetable giants that provide unique vitamins, such as K, B, C, and P, as well as heart-healthy benefits.

Vocabulary

- **Alpine**—relating to high mountain regions
- **Clone**—a plant or other organism that is genetically identical to its parent having been created from a single cell through vegetative reproduction: a bulb, cutting, or other plant part under experimental conditions
- **Ethanol**—fuel source
- **Plant Morphology**—the study of the development of plant structure and form that considers the individual plant within the context of the species' evolutionary development
- **Sustainable**—not being harmful to the environment or depleting natural resources

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Student Objectives

Students will:

- model archeologist's scientific behaviors, unearth 'artifacts,' and understand the role of an archeologist.
- predict the functions of the artifacts and people who used them.
- compare the (organized) settlements in a particular time frame in the Mississippi/ Missouri/Ohio river valleys and compare those to settlements along the Yangtze in China.
- understand the primary aspects of civilization, such as economics, political structures, language/written communication, and reasons for our study of them.
- understand the significance of settlement location: rivers and useful plants.
- understand the role of natural resources in the rise, settlement, and decline of civilizations.

Materials

- Artifacts buried in or embedded in Plaster of Paris (garage sale items like old Tupperware giveaways are excellent for this activity as well as cold ashes/piece of trash like foil; it works well to use all items from a single room, such as a kitchen or bathroom)
- Tools for unearthing and cleaning artifacts like paintbrushes, tweezers, nut picks, toothpicks, plastic utensils
- Observation sheet

Lesson 9: Ancient Rivers and Their People: The Yangtze and Mississippi Rivers ca. 770 BCE–400 CE

Grades 6–8

LESSON SUMMARY/PURPOSE

When we study ancient civilizations, classes often focus on Asia, South America, and Italy/Greece. Rarely do we study the river **civilizations** in our own Midwest that existed along the Missouri and Mississippi Rivers.

The Yangtze and Mississippi Rivers were a resource and the lands nearby were rich with additional resources for ancient peoples. This lesson provides information about the **Zhou** and **Han** Dynasties in ancient China and the **Early** and **Middle Woodland** peoples along the ancient Mississippi/Missouri Rivers in the Midwest during the time period from 700 **BCE** to 400 **CE**. Our goal is for students to better understand the land and the two cultures during ancient times.

Additionally, students will determine what **archeology** is, and discover how archeologists come to understand ancient civilizations. Lastly, students will learn about plants and how they were used by ancient civilizations.

PRE-LESSON PREPARATION (OPTIONAL)

- Ask students to bring in an item that, in 50 years, someone could look back and say, "Wow, that [game, toothbrush] was something our families used to use. Provide

an example [someone who lived during the 1920s might have a baseball glove, a spittoon, a doll made of porcelain or straw. etc.].

- Find small garage sale items of obscure use, such as a Tupperware strawberry top remover, electric beater cleaner, etc,. to use in the Plaster of Paris mix. Do not use the items that students brought into class to share. Mix Plaster of Paris and pour over items to cover them; let dry 24 hours before class.

PROCEDURE

Activity One

Introduction (Optional)

Ask students to share the items they brought in to school in small groups of three. Ask them to provide a reason why they think their items might define the early second millennium CE (the 2000s) when someone examines the class' buried trash in the year 3000.

- If our classroom was unearthed by a future society, what items may survive after 1,000 years?
- Would those give an archeologist a clear idea of what our daily lives were like in this classroom?
- If not mentioned, ask students, "In what other ways could archeologists understand our daily lives 1,000 years from now?"

Have a few groups share their thoughts with the whole class.

Small Group Work

Explain to the students that they are going to try their hands at being archaeologists. At the end of the activity, they will define the career of an archeologist. Students will then consider the artifacts, possible uses and the people who used them. This in turn, will help us start defining "civilization."

The Dig

- Divide the students into groups. Give each group a chunk of plaster with an artifact embedded inside and a set of tools to use. Explain that the chunks came from a room in a settlement that is being excavated. They need to see if they can find any artifacts within the chunk.
- Give them time to dig into the plaster and recover the artifacts. Since they don't know what they're looking for, they have no idea if the artifact they are recovering is large or small, whether it can stand up to pounding on the plaster without breaking or not, etc. Therefore, they need to go slowly and break the plaster carefully.
- Each group should find one artifact in their plaster and then clean up their area.

Discussing the Artifact

- Each group should record observations about their artifact, including making a sketch of it and writing a description. Divide the tasks among the group members and take turns.
- As a group, the students should propose theories regarding how their artifact may have been used by the people of the culture from which it originates. Proposed theory notes should be written on the observation sheet.
- Each group should present their theories to the class.

Expedition Discussion

- Assemble the artifacts with the theories each group has come up with regarding their functions.
- More important than the use of the artifacts, is the story that they tell when gathered together. The teacher may reveal to each group the actual function of each of the artifacts.
    - What does this tell us about the room and of the house in which the items were found?
    - What value do you think the ashes/trash have?
    - How would we find out what people ate?

      Archeologists examine the ashes of trash pits; people do not often value what they throw away. Many times, it is only if a catastrophic landslide, fire, or volcanic eruption like in Pompeii occurs, that we discover the items of daily life intact.

Concluding Ideas: Defining Archeology

Discuss the role of an archeologist. What might be some of their hobbies and personality strengths that would help them succeed in their job?

Archeology, the study of the past, includes human beings from a point of 2.5 million years ago. In many cases, archeologists are best known for studying shipwrecks or ancient cities; however, an archeologist may be studying an area that is 50 or more years old.

Activity Two (Day Two)

Introduction

Ask students to share in pairs the most important ideas we learned yesterday.

- What do you believe is the purpose of an archeologist's study?
- What do you know of peoples who may have lived in ancient time periods *in the Midwest* just before or at the beginning of the Common Era (CE; beginning of our current calendar years 1–2012)?

Follow-up questions may include:

- How do you think people travelled?
- Do you think they had free time, and if so, what do you think they did?
- What kinds of jobs do you think they had?
- What do you think was important in their beliefs?
- What would they have eaten?
- Do you think life was similar in other cultures around the world? Does anyone have ideas of ancient groups of peoples that we will be studying in upcoming lessons?

A Story of the First Peoples of the Mississippi/ Missouri Rivers:

Ice sheets covered the land south to the current location of the Missouri River until 14,000 BCE. A warming period occurred between 12,000 and 10,000 BCE. A small band of humans, between 30 and 200 in number, appear to have been the first known to live in the area near the Mississippi and Missouri Rivers since10,000 to 12,000 BCE. They may have been lucky to have a warm day, maybe 50 degrees F. Imagine a group of people, lying on a small hill in Chesterfield, Missouri, spears at the ready, watching a giant mastodon lumbering toward a water-filled sinkhole next to where the Missouri Botanical Garden's Butterfly House now stands.

Paleo-Indian (9500 to 8500 BCE) points were discovered in the area, supporting existence of people in the region since this time. The peoples living in the Midwest were not a single tribe from this point forward. The Paleo-Indian, Early and Middle Woodland peoples constituted an ebb and flow of peoples inhabiting the Midwestern portion of the U.S. This ebb and flow was due to climactic conditions, available land, and resources. Likewise, many different native peoples built burial and non-burial mounds throughout the U.S. beginning in the Archaic period (ca. 3500 BCE) for thousands of years. These peoples had varying ideologies, cultural practices and ways of life and some were connected across water and land-based trading routes.

Exploration

Discuss the significance of agriculture as a part of the definition of a civilization. "What else might cause us to call _____(our city) a part of a civilization?"

Expand student ideas about the criteria for a civilization. Historians and archeologists do not have an agreed upon definition for civilization, although some consider it to be the same as a culture.

Divide into groups to do an online study of the time periods from 700 BCE to 400 CE. (BCE stands from "Before the Common Era," or the start of the world's commonly accepted calendar for world business.) Examine the characteristics of the Mississippi/Missouri/Ohio River settlements during this period and the settlements of the Yangtze River in China.

Assign groups to examine:

- Woodland Periods: Early and Middle will cover parts of the time frame from 700 BCE to 400 CE with a focus on the Midwest; includes Early/Middle Woodland and Adena/Hopewell cultures
- Han, **Qin** and Zhou dynasties in China during a similar time frame

Tell students: "In the discussion of artifacts and civilization, we mentioned important classroom items that would help people understand the process of schooling in our civilization."

Students will work in small groups (Early, Middle Woodland or Han, Qin and Zhou dynasties) to talk about the primary criteria for a civilization [trade and business, culture, language, food, and home, etc] and to determine if or when this group of settlements is a civilization. Put information on chart paper/a concluding paper for the Smartboard or Elmo.

Each small group will present primary aspects of the criteria for each period/dynasty.

- What could account for the differences in the establishment or continuation of civilizations? (climate, war, use/overuse of resources)

Concluding Ideas

- When finished, create a thorough definition of civilization.
- Ask students for comparisons and contributions of each set of ancient peoples to today's society.
- Highlight the uses of plants then and today as foods, medicines, art, clothing, or aids for living.
- Highlight the role of natural resources in the rise and decline of civilizations. Students

should be able to discuss the role of natural resources in building and sustaining a culture. They may consider significant resources—both then and today—in sustaining a culture, as well as the relationship between food, technology, and the building of an empire, and the primary resources that initiate conflict between peoples.

A Final Story on the Woodland Peoples

By 500 BCE, the climate was amenable to raising crops. Imagine waking up to make acorn tea and making a breakfast of dried hickory, chestnut or oak nuts, and fruits in water (like oatmeal), taking a hike through a savannah, nibbling on a sunflower or redbud seed pod, killing wild game or fish to eat. On the way home, a person walks over a sharp rock and cuts himself. He gingerly walks over to a tall white oak, and popping off some bark with his knife, he puts it on the cut to soothe it. As the wild game is skinned back at camp with flint scrapers, the person can soak the cut in an herbal bath of wild plants, such as yarrow. The wild game is taken to a deep somewhat narrow pit, where a hot flat rock sits on the bottom over a fire. Wrapped in grapevine leaves, the food is placed on the rock, and then the pit is covered with a slab of mud. This "Dutch oven" is opened four hours later and flavorful, moist meat is shared. How do we know all of this? Local archeologists identified the remains of charcoal found in the pits.

BACKGROUND INFORMATION FOR TEACHERS

Focus: ca. 770 BCE to 400 CE. This information is not exhaustive, but rather is a sampling for the time period.

Civilization

The term "civilization" is not standardized among historians and archeologists. Many believe that a civilization has an infrastructure which includes the following components (but the degree of organization, stratification, intellectual pursuits, or size, etc. are argued among scholars):

- a form of political structure
- social class distinctions
- center of control over the production of goods, trade, or wealth
- some control over the surrounding physical environment, such as organized food production and storage
- a consistent geographic settlement location for an extensive number of people
- shared or unifying cultural constructs, such as religion, rituals, language
- mental pursuits that contribute to cultural achievements, such as written language, art forms, philosophy

Midwestern U.S. including the Mississippi, Ohio and Missouri Rivers

Climate

Climatic change does not need to be great—an average of eight degrees cooler per year can create a mini-ice age. At around 1500 BCE, a more temperate climate emerged in Middle America, enough for maize to be successfully introduced into southern areas and begin a northward spread. A warmer, drier period occurred between 750 BCE through 150/250 CE, which approached today's averages. The forest-prairie landforms and vegetation were similar to this century.

The Ozark terrain just south of St. Louis provided warm, sunny, steep slopes and valleys for winter protection and for people digging and working the surface rock, chert on the hills and practicing horticulture in the valleys.

Geography—Mississippi River
The Mississippi River is the third largest drainage basin in the world, exceeded in size only by the Amazon and Congo watersheds of the Amazon and Congo Rivers. The Mississippi drains 41 percent of the United States. The basin includes all or parts of 31 states from New York to Montana and two Canadian provinces.

Pre-historical native peoples considered the Missouri, Ohio, and the Mississippi rivers as one great river.

Although both the Yangtze and the Mississippi lie in temperate zones, the Yangtze crosses additional climactic zones and a wider range of terrain including mountains.

Settlements
During the Early Woodland period, small bands of 50–60 people became more settled than their predecessors and their burial rituals became more elaborate. Some mounds, like those of the Adena, indicated the remains of distinguished groups: the elite and the commoners. The Adena had elaborate burial customs that included formal gift-giving. Burial goods included shell gorgets, beads, pipes, and stone tablets.

Settlements in both periods aligned river valleys, used for either part or full-time living. During the Woodland era, geometrically shaped burial mounds and enclosures may have covered one to over 100 acres. Neither the Hopewell nor Adena were a single culture, but covered a range of Woodland societies.

Wood cutting tools like axes and celts could help take down trees to create home building posts or canoes.

Paleobotanists recover and identify plant remains to help archeologists in dating settlements, such as from burned remains of a home or a structure atop a burial mound. Burial mounds contained people's personal items for afterlife, and many people were buried in single mounds.

Settlements in Missouri had houses built around a central group area on terraces above Mississippi tributaries.

Political Systems
Some suggest that the Adena had a class structure in which specific lineages or classes controlled geographic territories from Ohio west to Indiana south to Virginia and north to Pennsylvania. In the Middle Woodland era, the breadth of trade, stratification of burial rituals, and effigy pipes suggest that a class of social and religious leaders existed, with possible clans.

Food
The Early Woodland period was a period of transition from hunter-gatherer to a more sedentary lifestyle. **Midden** samples showed evidence of a wide diet of nuts, corn, seeds, fruits (paw paw, persimmon) goosefoot, knotweed, and maygrass. Remnants of fishing nets made from milkweed and hemp indicated a heavy reliance on fish. Seeds, berries, and nuts from familiar Missouri trees, such as hickories, black walnuts, and oaks, were collected and eaten. Plant seeds and nuts were mixed with water to create an oatmeal-like meal. Common plant seeds included ragweed, sunflower, smartweed, and jewelweed. Cultiva-

tion of squash, sunflower, or chenopodium varied based on the amount of nuts and seed available

Horticulture transitioned from single plant collection to full-blown gardening during the Middle Woodland period.

Bottle gourd

Bottle gourds, shells, and pottery were probably used as ladles, bowls, and cups. Mortar and pestles and stone rolling pins could crush hard nutshells.

The bulk of the diet throughout the Woodland period was still garnered through the hunting of deer, turkeys, and small birds and game. Spears propelled with atlatls were used to kill larger mammals. Storage pits, processing areas, and limestone-filled earthen ovens have been identified in some Midwestern sites.

Culture

The Early Woodland period was characterized by cord-decorated, geometrically designed pottery that could be heated at low temperatures. The use of pottery indicates a more sedentary lifestyle because it implies the need for material and food storage. Food storage also indicates a surplus of food, which in turn could mean an increase in population.

Economics/Trade

The hillsides in Missouri were covered with an unweathered sedimentary rock called chert that could be worked into extremely sharp and wonderfully curved tools. The quartz mineral content in the chert was resilient, tough, and created the concave faces perfect for tools; however, much sharpening had to be done. Tools included knives, hide scrapers, spears, arrowhead points, and multipurpose tools. Sharp tools could be used in medicine: knives were used for cutting, and basswood or vegetable fibers could be used for sewing up wounds.

The Adena Early Woodland peoples traded extensively on the Ohio River and its tributaries. Middle Woodland trade continued to flourish, with Hopewell-related populations across Iowa and Missouri trading with settlements further east.

Items used for ornamental purposes, such as shark and alligator teeth from the southeast, were found in burial mounds along with galena (Missouri) grizzly bear teeth and copper (upper Midwest), and obsidian from the Rocky Mountains. Shells were also used for cups. Galena from southeast Missouri was used after 200 BCE for beads and ground into a powder to use for white paint for ceremonial dye. Hematite, a mineral from southern Missouri, was thought to be used to rub on one's skin, perhaps to prevent sunburn or for decorative purposes and was also used in making fishing nets.

Trade over the rivers was conducted in canoe-type vessels created from various trees including the basswood and white oak; they were often covered with animal hides.

Weapons/Tools

The atlatl, often made of oak, was not a weapon, but a tool for providing more leverage for distance and accuracy for spears and darts.

A skilled bowman, living in North America between 770 BCE and 400 CE, could boost the speed and distance of a spear using an atlatl, with speeds up to 90 miles per hour for 300 feet.

China's Yangtze River Civilization, including the Huang He and Xia Rivers

Geography

The Yellow and Yangtze rivers in China are at the heart of Chinese civilization (China has one of the world's oldest known civilizations). The Yangtze River is the third longest river in the world. One-third of all of China's population today lives in the river valleys and basin of the Yangtze. The Yangtze River region and basin are believed to be the beginning hub of ancient Chinese civilization.

Political System

The **Eastern Zhou** dynasty established a flourishing arts culture and philosophical foundation for future dynasties. The feudal system of government lasted longer than any other in the world, from 1040 to 200 BCE. Towns were fortified in areas along the river valleys thus indicating that groups were fighting over territories.

The feudal system produced higher crop yields than other methods of government. Planting systems were efficient: squared plots of land were farmed, crops were rotated, irrigation systems developed, and fertilizer applied. Millet and soybeans were introduced.

Culture

Musical instruments created using bronze and copper were perfected; more elaborate jewelry, ceramics, and bronze vessels were created.

A 12-month, 360-day calendar was created before or during the Eastern Zhou and it contained additional months as needed for accuracy.

Papermaking is traced back to the Han dynasty. Mulberry tree and hemp were two ingredients used in papermaking. Paper was first used for wrapping and as padding material, not writing, until just a few years before the Common Era began. Paper was one of many achievements in the arts and sciences made during the Han dynasty. Poetry, creative writing, and accounts of history flourished during this time period.

During the Qin dynasty, the multiplication table was used. Ji Sheng, one of Confucius' followers, wrote a book on the cultivation of hemp in 220 BCE, describing mathematical yields when using particular methods of caring for the crop. Hemp was made into yarn fibers used for clothing and shoes. Many families raised Rhea, a rough grass, for weaving. Increased written and mathematical works along with the development of iron led to widespread improvement in agricultural practices that enabled people to rely less on hunting for survival and to hunt for sport. The *ErYa*, the first Chinese dictionary, was written during the Qin dynasty and contained agricultural, cultural, and social terms.

Confucius introduced his philosophy of virtue and morality during the Eastern Zhou. Buddhism was introduced to China during the Han dynasty.

Taoism emerged as a philosophy. Taoism was based on simplicity. Simple agricultural methods and a return to older ways were encouraged. Taoist philosophy espoused the ideas of harmony and balance, often associated with the symbols of yin and yang. Yin and yang are not competing, but rather just complementary opposites, like the ebb and flow of a tide. The concepts of yin

and yang were related to people's health. The use of plant herbals to maintain or restore a healthy balance was fundamental to Chinese medicine. Shen-nong's *Materia Medica*, a primary herbal medical text, was published in 100 BCE.

In burial rites, people were buried in long willow baskets.

Economics and Trade

Just before the Eastern Zhou dynasty began, bamboo pipes were used for transporting liquids, such as piping in homes, wells, etc.

The use of ruddered ships improved trade during the Eastern Zhou dynasty and continued into the Qin dynasty (ca. 220–206 BCE). Evidence indicates that lodestones were used as compasses—which would aid in navigation—around 400 BCE. Persimmon juice was used in making the varnish to seal the ships. T'ung tree oil was mixed with lime to repair the ships' hulls.

Roads, bridges, and canals were built to aid transportation. Boats and rafts made from bamboo traversed the waterways. The Silk Road—as the various trading routes between the east and west were called—connected China to Russia. Silks, bronze and porcelain objects, and carved jade were traded in the centuries before the Common Era. The cultivation of tea first appears in written records during the Han dynasty; evidence of trade in tea began around 9 CE. China continues to be one of the top producers of tea to this day.

During the Eastern Zhou, the Arabians and Chinese were trading along the Silk Road and sharing knowledge of astronomy. It is believed that the animals of the zodiac were brought to ancient China from Arabia, but some believe they came from Chinese astronomy. The zodiac may have been based on the 12-year orbit of Jupiter around the Sun. Still others believe the zodiac originated with the pre-Zhou dynasty nomadic tribes who created a calendar based on their hunted animals. Evidence is clear that zodiac animals were in use during the Eastern Zhou period from 475–220 BCE. A ruler needed to be adept in astronomy. The zodiac was used as a social tool in Chinese politics.

During the Qin dynasty weights, measures, and coinage were standardized, leading to improved commerce and taxation as well as the sharing of agricultural knowledge.

Food

For thousands of years sheep, cattle, and water buffalo were domesticated and grains such as rice, wheat, wild millet, and sorghum were eaten. Fish was carried in bamboo baskets while grains were weighed in standardized willow baskets.

During the Han dynasty, evidence indicates the use of seed saving to improve crops as well as grafting in fruit tree production. Plums and peaches had been introduced to China by 300 BCE. *Ginkgo biloba* and lotus lily seeds were roasted or fried as a dessert, perhaps with sugar—which was described in Chinese poetry by 2 CE.

Improved tools for agriculture during the Eastern Zhou dynasty led to deep plowing, which in turn led to an interest in the properties of soil and fertilization. During the Zhou dynasties, cereals were first grown in China as food crops. Astronomers brought attention to the effects on crops of changing seasons and local conditions. The control of pests and plant diseases began. Such improvements lead to increased crop yields and movement of people into the cities. During the

Qin dynasty engineers created narrow irrigation trenches that allowed the Yangtze River to irrigate crops—one of the first-known examples of the practice.

Vocabulary

- **Archeology**—the scientific study of human remains and artifacts at a point at least 50 years ago
- **BCE and CE**—"before common era" and "common era": These terms are aligned to the current calendar but remove the association of a time period with a single religion; they replace the previously used forms of BC and AD. Depending on the geographical location, archeologist, use of time frames, as well as lack of exact knowledge, time frames used in this text may vary somewhat from those found in other texts or websites; **BP** ("before present time") is another time frame used by archeologists that arbitrarily places 1950 as being the "beginning of present time"
- **Civilization**—the term used to describe a community at the point where it is large and then grows technologically, and begins using a system involving writing/language and written records are kept
- **Early Woodland Period (Midwest)**—(ca. 750/600 BCE to 150 BCE/150 CE) this period is not well documented; increased use of ceramic pots
- **Han dynasty**—(ca.206 BCE to 220 CE) dynasty can be separated into earlier (Western Han) and later (Eastern Han) periods; during these two reigns positive cultural strides were made in literature, arts, and technology
- **Midden**—in archeology, the name given to an ancient or historical trash heap, which may or may not have been burned; it could include shells, food remains, bones, etc.
- **Middle Woodland Period (Midwest)**—(ca. 150 BCE/150 CE to 300/400 CE) small communities had some cultivated crops; Hopewell Indians of Ohio built serpent mounds and intricate art; increasing use of settlements, decorative pottery, and burial mounds
- **Qin dynasty**—(ca. 221–206 BCE) considered the beginning of the Imperial civilizations as compared to the ancient civilizations of China; creation of terra cotta soldiers; beginning of a protective wall later finished as the Great Wall of China in the Ming dynasty; porcelain created
- **Zhou dynasties**—(1045–256 BCE) the longest ruling political system in China, had two sections, west and east, and later divided into two periods following the downfall of the Zhou families; **Eastern Zhou dynasty**—(ca. 770 to 256/221 BCE)

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Plant and insect photos courtesy of the Missouri Botanical Garden *Plant Finder*. Available online at *http://www.missouribotanicalgarden.org/gardens-gardening/your-garden/plant-finder.aspx*.

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