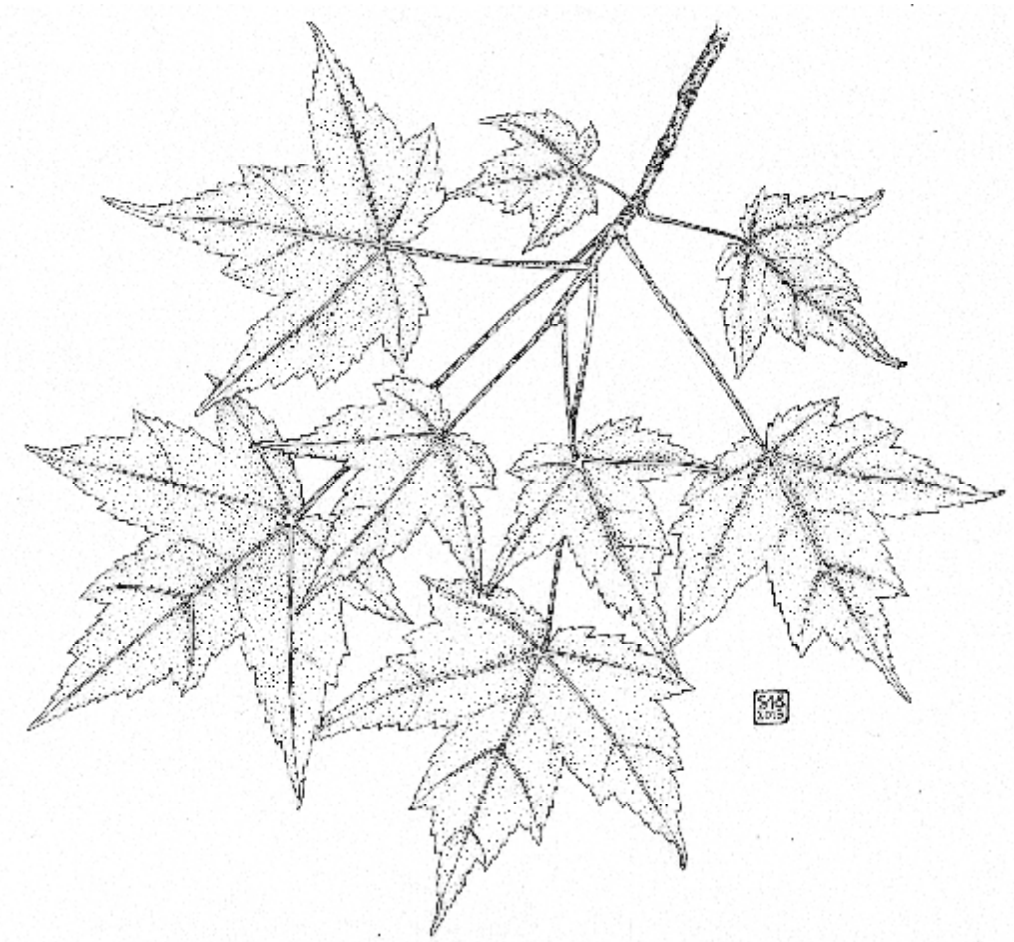
The Nature Program

Patterns in Nature

Looking for Similarities and Differences



"Nature uses only the longest threads to weave her patterns, so that each small piece of her fabric reveals the organization of the whole tapestry."
Richard P. Feynman

FOUR WINDS
NATURE INSTITUTE

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For more information about bringing The Nature Program to your school, please contact Four Winds Nature Institute at the address above, or visit our website.

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Four Winds Nature Institute
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Patterns in Nature

Looking for Similarities and Differences

Patterns exist everywhere in nature. Early on we learn to recognize them, and they help us make sense of the world. It starts simply – noticing that night follows day, plants have leaves, animals move, and winter snows change to spring rains.

This recognition of repeating events and reoccurring structures and shapes naturally leads to organizing and grouping things together and inspires us to look more closely. We recognize that insects are animals with six legs, the seeds of evergreen trees are contained in cones, and birds build nests every spring. Careful observation of similarities and differences within groups helps us further classify both living and non-living things. Snowflakes are all six-sided crystals, yet they can be sorted into categories by growth pattern and specific design. Insects, like butterflies, beetles and grasshoppers, can be separated into easily recognizable orders based on their shared traits. And, while all leaves share a similar function, they can be differentiated by shape and venation patterns.

With experience, sorting becomes more detailed, and the key features used in scientific classification systems help us identify and name the life around us. As a result, this information is organized into a framework that helps us communicate ideas and retrieve and share facts, aiding further scientific study.

Often our discoveries prompt questions about how and why these patterns form. We observe that body shape relates to track pattern, varying weather conditions affect the type of snowflake formed, and animals with the best disguise have a better chance of survival. Recognizing patterns, from simple to complex, helps us to understand, appreciate and make sense of the natural world.

This year we'll take a look at the many patterns found in nature. We'll practice sorting and classifying as well as describing and recording why objects or organisms belong in a certain group. By looking for similarities and differences within these groups, we'll identify patterns that can help us understand how things are related.

We'll learn what makes an insect an insect in **All Sorts of Insects,** and through outdoor observations of common insects, learn to recognize patterns that help us classify them into groups.

In **Leaves: Nature's Suncatchers,** we'll compare and contrast leaves in a variety of shapes and sizes while noting they all share a common function: making food for plants.

We'll note differences in size, shape, and arrangement of leaves and cones in **Conifer Clues: Cones, Needles and Spirals**, and use key characteristics to identify the evergreen trees that make up our forest.

A snowflake's story is one of constant change, from its trip through the sky to its resting place in the snow bank. In **Snowflakes** we'll learn how varying temperature and humidity affects their shape, size, and design, making each six-sided snow crystal unique. We'll view and sort snow crystals, compare winter weather patterns and their resulting precipitation, and make our own one-of-a-kind snowflake models, both indoors and out.

We'll focus on the clues that animals leave behind in **Track Detectives** and learn to read pattern, print and sign to tell a story of animal activity. We'll imitate track patterns, note how different body shapes affect movement, interpret stories in the snow and create our own on paper.

We'll further investigate the relationship between form and function in **Feathering the Nest.** For although they all contain and conceal the eggs, each nest reflects its maker and is characteristic for each species. We'll build our own distinctive model nests and learn to identify real nests using dichotomous keys and flow charts.

All around us animals are hidden in plain sight. Some are concealed by camouflage, while others warn off predators with bright colors. In **Animal Disguise and Surprise**, through hands-on activities and model building, we'll see how these adaptations contribute to an animal's survival, determining who lives to pass on their traits to the next generation.

In spring we'll study **Frogs and Toads** as they serenade us with their chorus of voices. We'll learn to distinguish who's who in the pond by studying different patterns of development, observing field marks, and listening closely to the sound patterns of the songs coming from the pond.

In **Fiddleheads to Ferns** we'll sort ferns by leaf design, create leaf prints, and see how patterns help us recognize and classify our common ferns.

Patterns in nature occur at all different scales, from the spots on ladybugs to the changing phases of the moon. Studying such patterns and their variations enriches our understanding and appreciation of the natural world.

Vermont Standards: Inquiry *7.1*, The Living World *7.13*, Universe, Earth and the Environment *7.15*, Natural Resources and Agriculture *7.16*, Listening *1.13*, Questioning *2.1*, Sustainability *3.9*, Understanding Place *4.6*

New Hampshire Standards: Science Process Skills *SPS1*, *SPS3*, *SPS4*, Life Science *LS1*, *LS2*, *LS3*

New York Standards: Standard *4*: The Physical Setting; The Living Environment. Standard *1*: Analysis, Inquiry and Design. Standard *6*: Interconnectedness: Common Themes. Science Process Skills based on Standards *1, 4, 6 and 7*.

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Patterns – ALL SORTS OF INSECTS – Background

The world is full of all sorts of insects. You can find them everywhere you go, whether swimming in a pond, weeding your garden, playing on the playground or enjoying a picnic lunch. It is said that there are 200,000,000 insects for every person on earth. Scientists have identified more than a million different kinds of insects. And they think there are millions of species still waiting to be discovered.

Insects belong to a group called **arthropods**. Unlike you and me, with our bony internal skeletons, an arthropod's body is covered with a tough outer shell, or **exoskeleton**. This exoskeleton is divided into segments that allow the critter to move. In fact, the word arthropod means "jointed legs." Arthropods include not only insects, but also centipedes, crustaceans, and **arachnids** like spiders, ticks and mites.

So what makes an insect, an insect? Despite their great diversity, they all share certain common features. They all have three main body parts: **head**, **thorax** and **abdomen**, six legs, and **antennae**. Most adult insects have two pairs of wings.

Many sensory organs are located on an insect's head. Depending on the insect, antennae can detect motion, "hear" sounds, determine orientation, recognize changes in humidity, or identify odors, tastes and a variety of other chemical clues. Insects have two kinds of eyes. They typically have one to three **simple eyes**, each consisting of a single light-sensing unit that can detect changes in light intensity. Their two **compound eyes** can have anywhere from 4000 - 30,000 facets. These facets provide them with multiple images of their surroundings. This allows them to quickly detect the slightest movement, helping them escape from predators or catch their own lunch. Speaking of lunch, mouthparts vary greatly depending on an insect's diet. There are two basic types of jaws – those designed for biting and chewing and those that can only sip or mop up liquid food. The latter can range from a mosquito's piercing-sucking beak, reminiscent of a hypodermic needle, to a butterfly's coiled drinking straw or even a fly's absorbent sponge.

The thorax is composed of three segments, and attached to each segment is a pair of legs. Each leg has six joints, allowing for a wide range of mobility. The five leg segments are variously shaped and modified depending on their primary function and form of locomotion. They can range from thickened forelegs for digging or grasping prey, to legs fringed with hairs for swimming, to elongated hind legs for jumping. Legs can even function as sense organs: hearing, smelling and even tasting. Attached to the last two segments of the thorax are usually two pairs of wings, making insects the only invertebrates that can fly. A closer look at wings reveals their complex **venation** pattern. The veins bring not only the blood supply to the wings, but offer structural support and are an important characteristic used to classify insects into groups. And just as there are many kinds of insects, there are many different wings, ranging from clear and flexible, to scaly and colorful. They may hook together or swivel individually in flight, be hardened or leathery for protection, act as thermal collectors, give the insect balance and stability, or even be rubbed together to produce sounds!

The last body segment, the abdomen, contains the main organs and systems in the insect's body. Insects have an open circulatory system and blood flows freely throughout the body cavities, pumped forward and back by a simple heart. Their respiratory systems consist of **spiracles** or pairs of holes along each section of the abdomen and thorax. Gas exchange is achieved as air from outside flows into internal tubes and moves throughout the body by passive diffusion and muscle movement. They have a complete digestive system, which processes and digests food, absorbs nutrients and excretes waste. Reproductive structures are also located here, the most visible being **ovipositors,** the egg-laying devices in some females.

While all insects share these same body parts, scientists sort them into groups based on certain characteristic features. You will be surprised at how many insect groups you already know. First, meet the **beetles**. There are more beetles than any other animal in the world. They have tough, solid bodies covered by hard over-wings called **elytra**. These meet in a straight line down the center of their backs and protect the delicate, clear, flexible wings underneath. While not used in flight, elytra can be raised, providing additional lift, while the flexible under-wings help beetles take flight.

Butterflies and moths are easy to recognize by their large and often colorful or patterned wings. Modified hairs or scales cover their wings. Butterflies and moths can be distinguished from one another. Butterflies have thin smooth bodies, are active in day, have slender antennae with knobs at the ends, are brightly colored, and hold wings vertically or folded over their backs. Most moths are active at night, have feathery antennae and thick fuzzy bodies, are often dull colored, and hold wings flat over their bodies when at rest.

Dragonflies and damselflies are winged hunters, with large eyes, long, thin bodies, and outstretched wings, often seen flitting about in search of lunch. They can flap their front and hind wings independently, allowing them to change directions in a flash, hover, and even fly backwards. Dragonflies are more robust and when at rest, hold their wings horizontal to their bodies, while delicate damselflies hold their wings above their bodies, or only partly extended.

Crickets and grasshoppers are recognized by their large, strong back legs, used for jumping and hopping. They have thin, strong, leathery forewings covering clear, flexible hind wings that fold up like fans. These are the musicians of the insect world, and they can use their legs to both make and detect sounds.

Bees, wasps, and hornets are characterized by their four clear, flexible wings. These wings can be hooked together to create a larger wing surface, allowing them to fly for extended periods. Many insects in this group are important pollinators and live in social groups.

Flies have only two functional wings. The second set is reduced to small knobs called **halteres**, which are thought to aid in stability and balance. Insects in this group typically have short antennae, often can hover, taste with their feet, and only eat liquid food, which they lap up with their sponge-like mouths.

True bugs have forewings that are half leathery and half clear, while their hind wings are clear and flexible. When at rest, these overlap and create a distinctive X pattern on their back. This pattern and a beak-like mouth are key diagnostic features.

Plant hoppers and cicadas, hold their wings tent-like over their backs, are relatives, but more distantly related. They also have piercing-sucking mouthparts and only eat liquid food.

So the next time you are outside, see what you can find hiding under rocks, flying from flower to flower, hopping in the grass, or crawling in the sand. Take a closer look at wings, legs, shape and colors for clues to its identity. The best thing about looking for insects is that you're always sure to find them -- all sorts of insects are just waiting to be discovered.

Suggested Reading

Mound, L. *Eyewitness Books: Insects*, New York: Dorling Kindersley, 1990.
Wilsdon, C. *National Audubon Society First Field Guide Insects* New York: Scholastic Inc. 1998.
University of Michigan website: www.biokids.umich.edu/critters/Insecta/

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Patterns in Nature – ALL SORTS OF INSECTS – Activities

FOCUS: Honeybees, grasshoppers and butterflies are all insects, yet they look and behave very differently from each other. So what makes an insect an insect, and how is it different from other animals? Insects all share the same basic design of three body parts, six legs, wings, antennae, and compound eyes. Variations in the size and shape of these parts account for their great diversity. We'll learn to recognize common groups of insects by their characteristic features and watch them outside as they go about their daily lives.

PUPPET SHOW "Toad Gets Bugged"
Objective: To meet some different kinds of insects, learn basic insect anatomy and observe the variations that distinguish one insect from another.

Perform the puppet show. Afterward, ask the children to list the key characteristics that make insects different from other animals (3 body parts, 6 legs, wings, antennae). Discuss differences in the size, shape and color among the three kinds of insects in the puppet show.
Materials: puppets, script, props.

BUILD AN INSECT
Objective: to construct a felt model of an insect and note the variation and diversity in insect anatomy

Ahead of time, create bags of insect parts using the five *Build an Insect* templates and a variety of craft materials. In every bag use the same material to represent the same body part. (For example: use pipe cleaners to represent insect legs in every bag, make all insect bodies with the same color of felt, etc.). Each packet will contain the same number of body parts but these parts will vary in the size and shape for the different insects. Divide the children in groups of three or four and give each small group a bag of insect body parts. Have the children put the parts together to form an insect. Afterward, as a whole group, review the anatomy of an insect, naming the body parts, and making sure students understand the correct placement of legs and wings (all attach to the thorax), antennae and eyes. Note how all share the same basic body plan, and yet differ in size and shape of body parts.
Materials: felt or foam in 2 colors: one color used for the insect body, the other for wings; pipe cleaners for legs; various sized pom-poms for eyes; toothpicks for antennae; clear plastic sheets for membranous wings; *Build an Insect Templates*, *Insect Anatomy chart.*
For each group: bag of insect parts to create one insect.

SORTING OUT INSECTS
Objective: To notice similarities and differences in insect anatomy and to sort insects into groups based on similar features.

Begin by showing children stylized silhouettes of 8 different insect groups and point out identifying features. Place these on a table in a central location. Have children work in pairs and give each team 1-2 insect photos. Ask them to look for distinguishing features and compare their insects to the 8 silhouettes. Then, have students place each photo next to the silhouette of the

insect group to which it belongs. With the whole group together, look at the silhouettes and photos by each. Use the *Key to Insect Photos* to check students' choices and make any corrections needed. How many of these insect orders are already familiar to the children?
Materials: set of 8 *Insect Group Silhouettes*, *Insect photo set* - 24 cards, *Key to Insect Photos*.

INSECT SAFARI
Objective: To explore different habitats and observe evidence of insects and other arthropods living in the schoolyard.

Before going outside, divide the class into small groups and supply each team with an *Insect Safari Card*, clipboard, pencil and collecting kit. Take the children outside to look for insects and evidence of insect activity. Ask each group to use surveyor's tape to mark their most exciting insect discovery. Take the whole group on a tour of the groups' findings.
Materials: For each small group: *Insect Safari Card*; clipboard; pencil; collecting kit including bug jars, hand lenses, surveyor's tape, small piece of white sheet or pillowcase.

INSECT SAFARI CARD

Gently collect one of the insects you discover while on this search to inspect more closely later on. Avoid collecting any moths or butterflies as they can be injured fluttering inside the bug jars. Do not collect anything that looks like a bee, wasp or hornet!!

Listen for different insect noises. How many can you hear? Can you find the insect making the noise?

Follow a flying insect. How many times does it land? What does it land on?

Look for an insect on a flower. What is it doing? Check for pollen on its legs.

Look under rocks for hidden insects. Did you find any creatures that are not insects? How can you tell? Remember to gently replace the cover as you found it.

Find and watch a grasshopper. Does it have wings? Can you hop as far as it hops?

Find a cricket. Count the tail appendages to determine whether it's a boy or girl. (2=male; 3=female - the middle one is its egg-depositing tube)

Look for ants. Are they carrying anything? Where are they going? Can you find the anthill?

Spread a white cloth under some tall plants. Shake the plants and observe any critters that fall onto the sheet.

JOURNAL ACTIVITY
Objective: To record observations about an insect.

Prompt: Study and draw one of the insects caught in the Insect Safari.
Before drawing, display the insect silhouettes as reference. Ask children to determine the overall shape of their insect, noting where wings and legs come from. Then have them draw a simple outline of their insect. Next ask them to focus on details, such as where eyes are located, shape and length of antenna, wing shape and colors. Have them use colored pencils to fill in the details. Older students can label and date their drawing and add notes about their insect's behavior. Does this insect belong to one of the insect groups that were introduced earlier?
Materials: Clipboards, paper, colored pencils, hand lenses, insects in bug jars from the *Insect Safari*.

GO WILD
Objective: To demonstrate respect for other living things by carefully releasing study insects outdoors and to observe different patterns of insect movement.

Place the sheet on the ground and ask children to predict how their insect will leave when released from the jar. Will it fly? Hop? Crawl? Have children group their insects based on their predicted pattern of movement. Chant the release poem together. Now have the adults open the jars in small groups based on these guesses. Have children watch and note how and when each insect leaves. Try imitating their movements together. When all the insects have been released, talk about how insects get around.
Materials: Old sheet or shower curtain liner with concentric circles drawn in the center with permanent marker, insects in bug jars collected during *Insect Safari*, copy of *Goodbye Poem.*

Goodbye Poem

Thanks for spending time with me
Away you go, you're free
Hop or crawl, jump or fly
It's time to say goodbye!

CREEPY-CRAWLY CIRCLE DRAWINGS
Objective: To review basic insect anatomy while creating new and unusual insects.

In circles of 6-8 children, give each child a piece of letter-sized paper and guide them through folding their paper in quarters horizontally. Ask them to draw the outline of an insect head on the top 1/4 of their paper. Have them pass their paper to the child on their right, who will draw in a thorax beneath the head, using approximately the next ¼ of the paper. The next child will add an abdomen to complete the body in the remaining space. The drawing will continue to be passed around the circle, with each successive child adding a new body part in the following order: wings, legs, eyes and antennae. (Be sure to point out the correct location for these parts, i.e. wings and legs attach to thorax, eyes and antennae located on head.) Pass the completed insect one last time and have this child add additional features (mouthparts, stinger, ovipositor, veins on wings, etc.), color/decorate the insect and name it. Have children take turns introducing their funny insects and sharing a special feature with the rest of the group.
Materials: letter-sized drawing paper, colored pencils, markers or crayons, clipboards if doing this outside.

UPPER GRADES CHALLENGE (Grades 5-6) – INSECT CENSUS
Objective: To survey insects in your schoolyard using either pitfall or funnel traps to collect insects.

For pitfall traps: Gather a few small plastic cups or containers to use as traps. Dig holes at different locations in the schoolyard and set the containers in the holes so that the top of the container is even with the soil surface. Place a spoonful of jam, a piece of ripe banana or other fruit as bait in the bottom of each container. Place 3 stones around the edge of the container and set a board on top of these. The raised board will make it more difficult for flying insects to escape, shade the container and keep rain out, while still providing easy access for insects to enter. Leave your container out for several hours or overnight. You might want to set out markers or cones, so the traps are easy to find.
For funnel traps: Twist a half sheet of poster board into a funnel shape and secure shape with packaging tape. Insert the small end of this large paper funnel into large collecting jar and attach the funnel securely to the jar by wrapping packaging tape around the rim of the jar and the outside of the paper funnel. Shake tall plants and shrubs over the funnel traps to collect hidden insects.
Using the *Insect Census Tally sheet*, record the numbers and types of insect collected. Be sure to release the insects. For pitfall traps, remove traps and fill in the holes when done.
Materials: For pitfall traps: trowels, plastic cups or containers, bait such as fruit, jam, very ripe bananas; For funnel traps: poster board, packaging tape, large collecting container; hand lenses, clipboards, pencils, paper, *Insect Census Tally sheet*.

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Patterns – ALL SORTS OF INSECTS – Puppet Show

Toad Gets Bugged

Characters: *Teddy Toad, Millie Millipede, Davy Dragonfly, Bombardier Beetle, Giant Water Bug.*

Teddy Toad I've worked up an appetite in the garden today and a nice insect would hit the spot. Why, what's that I hear? Sounds like the pitter patter of little buggy feet. Who's that walking down my garden path? (*millipede enters*)

Millie Millipede It's me, Millie Millipede. Let me pass!

Toad Afraid not! I'm ready for an insect snack and a crunchy bug like you would be perfect.

Millipede You don't want to eat me. I might be crunchy, because of my hard outer shell or exoskeleton - but I'm NOT an insect!

Toad You sure look like an insect to me. You've got jointed legs and two antennae.

Millipede Yes, but insects only have three body parts, and I have way more than that.

Toad You do have many sections.

Millipede And insects have only six legs, and I have even more of those! Just think how they'd tickle your throat going down.

Toad A few dozen more won't make any difference to me.

Millipede And I just have tiny simple eyes and no wings. Why, insects have big compound eyes. And don't forget about their wings.

Toad Wings, yum-yum. I do love wings.

Millipede So if you eat me, you won't have any appetite left for an insect with wings. And here comes one right now.

Toad Well, OK. You can pass. I'll wait for a bug to eat. (*Millipede exits; dragonfly enters*) Who's that flitting down my garden path?

Davy Dragonfly It is I, Davy Dragonfly. Let me pass!

Toad Never! You're just what I've been waiting for - a nice crunchy bug to fill my belly.

Dragonfly Bug! I certainly am not a bug.

Toad What do you mean, you're not a bug? You've got three body parts, six legs, nice big compound eyes, and wings! You can't tell me you're not an insect!

Dragonfly Of course I'm an insect. But I'm not a BUG.

Toad Huh? Aren't bugs the same as insects?

Dragonfly Certainly not. A true bug is a particular type of insect – not just any old insect. Why, you wouldn't call a butterfly a "bug"?

Toad Well…no. A butterfly's a butterfly.

Dragonfly Right. A butterfly is another type of insect - one with big colorful wings. And, you wouldn't you call a bumblebee a bug either, would you?

Toad No, I guess not - I'd just call it a bee.

Dragonfly Exactly. Bees are insect cousins of wasps and ants. And you probably wouldn't call any of them bugs either.

Toad No- but to tell the truth, I'm confused. What's all this talk about bugs and true bugs.

Dragonfly Well, unfortunately many things get called bugs, but TRUE BUGS are a special group of insects. They have wings that close tightly over their backs, and beaks for sucking juices.

Toad Sounds like a juicy meal to me!

Dragonfly Right. You don't want a buzzy dragonfly when you could eat a juicy bug instead!

Toad Yeah, you can pass. I want a true bug – yum!

Dragonfly So long, Toad. (*exits*)

Toad Bug, bug, I want a true bug! (*tapping noise*) Ah ha! Something's coming. Who's that coming down my garden path?

Bombardier Beetle Hey toady, how's it going? You're gonna let me pass, right?

Toad No sir-ee! I think you're a true bug, and I'm gonna eat you!

Beetle True bug? No way - can't you see I'm a beetle?

Toad Beetle, bug, what's the difference?

Beetle Well, for one thing, when a true bug's wings are closed they make an X-shape on its back. Now check out my wings.

Toad Hum. I see that your wings close in a straight line down the middle of your back.

Beetle That's right. My front wings are hard and protect my delicate under-wings.

Toad Well, that's fine with me. I like hard, crunchy wings! So, here you go, down the hatch! (*lunges at beetle*)

Beetle Guess you don't know anything about Bombardier Beetles.

Toad Bombardier Beetles? What's to know?

Beetle Well, think of us as the skunks of the insect world. I take aim, like this..…

Toad OH! Now I remember about bombardier beetles. You can squirt an awful chemical. Go on – go away! You can pass! I don't want you for dinner! I'll wait for a juicy bug after all!

Beetle I toad you so! Bye, Teddy. (*exits*)

Toad That was a close call. But here comes something now! Maybe it's a true bug. Who's that walking down my garden path?

Giant Water B**ug** (deep *voice*) It is I. A Giant Water Bug. Let me pass!

Toad No way! I want a bug for dinner, and I can see that your wings make an X on your back. You're a true bug for sure.

Water Bug Yeah, I am a true bug all right, but you don't want to mess with me.

Toad You are pretty big- but I have a big appetite.

Water B**ug** Me too--see my long front legs? They're good for grabbing my prey. Why, I eat tadpoles for snacks!

Toad Ttttt- tadpoles, you say?

Water B**ug** Yeah, and when I catch them, I poke my piercing, sucking mouth tube right through their skin and suck out the juices!

Toad (*to audience*) True or not, this bug is making me nervous.

Water B**ug** We water bugs can pierce some pretty tough skin. People often call us toe-biters!

Toad (*to audience*) If I don't let it pass, it might become a toad-biter! (*to bug*) Turns out I'm not very hungry after all. On your way, Water Bug.

Water Bug Smart decision. Now I'm off to the pond for a dip and a quick snack. (*exits*)

Toad Phew, that was a close call. It's a good thing I had my wits about me or that bug might have made me his dinner. Dinner? Doggone it! I let all those juicy, crunchy, leggy critters get away. Now I'm toad-ally famished! I'd better hop to it and find a bite to eat. Bye now.

THE END

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Patterns – LEAVES: NATURE'S SUNCATCHERS – Background

Leaves are all around us. They are the first signs of spring, brightening the landscape with fresh green. They give us shade in summer and color fields and hillsides emerald. Every fall they dazzle us with their fiery display of color. Leaves come in a variety of shapes and sizes, yet a close-up look reveals patterns that help us identify them. Despite differences in form, all leaves perform the same vital function- capturing sunlight and turning it into food for the plant.

At its most fundamental, a leaf is a flattened green surface or **blade**, supported by a slender stalk or **petiole**. It is made up of layers of cells sandwiched between outer waxy coverings that help keep water in and harmful bacteria and fungi out. These surface layers are dotted with tiny pores called **stomata**, which can open and close to regulate gas exchange, moisture and temperature within the leaf. A network of veins carries water and nutrients into and out of the leaf and provides a supportive framework for these delicate tissues. A **simple leaf** has a single blade while a **compound leaf**, like clover, is made of several smaller blades, called **leaflets**, attached to the petiole. Leaves are arranged on the stem to maximize their exposure to sunlight.

Just as we can recognize people by small facial differences, we can identify plants by studying their leaf shapes and arrangement. Each leaf has a unique set of features, and there are many variations in leaf designs. Leaves can be broad like maple leaves, narrow like blades of grass or even needle-shaped like the leaves of evergreens. Leaf edges, also called **leaf margins**, can vary, too. Lilac leaves have smooth margins; elm leaves are toothed, like a saw blade; while dandelions are jagged and oak leaves are divided into lobes. Some leaves, like those of carrot, are so finely dissected they look like lace.

Another distinctive identifying feature of leaves is the pattern of veins that run throughout the blade. These act as the leaf's plumbing system carrying water and nutrients in and food, in the form of sugars, out of the leaf. There are three main types of **leaf venation--pinnate, palmate** and **parallel**. Pinnate venation consists of one main vein, called a **midrib**, running through the middle of the leaf with side veins extending to the leaf margins, similar to the structure of a feather. In palmate leaves, such as maple leaves, the main veins radiate from the petiole attachment and fan out through the leaf blade. In the grass, lily and related families, parallel veins are the rule, running side-by-side down the length of the leaf blade.

Environmental conditions influence leaf features in many ways. Shaded leaves tend to be larger, thinner and darker green than those in full sunlight. Quaking Aspen grows in open sunny places and has many small leaves with flattened petioles that let each leaf tremble in the slightest breeze, allowing sun to filter to the leaves below and keeping the leaf from overheating. Leaves of tropical plants often have "drip tips" that allow water to drain from leaf surfaces thus preventing mold growth that could damage the leaf. Common Mullein grows in sunny open places and their fuzzy leaves are thought to trap moisture, reflect sunlight, and reduce water loss.

Leaves come in all shapes and sizes, yet they all have the same function--to produce food for the plant. For unlike animals, plants don't raid the cookie jar or go hunting for food when they are hungry; they make their own food. And their green color is key to this function. The green comes

from the pigment, **chlorophyll**, which is contained in the upper surface of the leaf. To understand this food-making process, think of it as a recipe-- the plant's version of making a batch of brownies. Along with chlorophyll, the main ingredients are: solar energy, from the sun; water, absorbed by plant roots; and **carbon dioxide**, a gas absorbed from air through the leaves. Chlorophyll absorbs sunlight and acts as a **catalyst**, transforming solar energy into chemical energy used to make plant food. This energy is then used to split water into its component parts, hydrogen and oxygen. The hydrogen joins with carbon dioxide to form a simple sugar called **glucose**. This sugar is carried in the veins to other parts of the plant and used to help the plant grow, making new leaves, flowers, fruits and seeds. As a by-product, plants give off oxygen, an essential element needed by living things. This chemical reaction, called **photosynthesis**, is thought to be one of the most important processes on Earth, for it provides food, not only for plants, but ultimately, for most animals who depend on plants for energy to live and grow.

All summer, leaves are busy making and storing food. But the shortening days of fall signal a change in the seasons. Tree leaves have to cope with less light, cold temperatures and frozen water. Tough waxy evergreen needles are resistant to the cold and drought-like conditions of winter and remain on the tree. But broad-leaved trees seal off and shed their leaves. Special cork cells grow over the veins into the leaves, cutting off their water supply. Without water, chlorophyll production starts to dwindle. Now the other pigments that have been there all along start to show through. The orange colors come from **carotene** and yellow from **xanthophylls**, two pigments common in familiar fruits and vegetables, like carrots, corn and bananas. While yellow and orange colors are simply unmasked, red and purple colors are produced in response to bright light and sugar in leaves. As veins get sealed off, sugars get trapped in the leaves. On cool nights, a chemical reaction converts sugars in the sap to a new pigment, **anthocyanin**, tinting leaves red to purple.

Although not completely understood, temperature, light and water supply are thought to influence the degree and duration of fall color. An early frost weakens the leaf, turning it brown before the best color is developed. Drought tends to delay or halt color, causing pigments to fade, leaves to dry out and turn brown. A series of rainy or overcast days limits light, hence photosynthesis, resulting in less sugar production and fewer red leaves. The best colors are produced when a warm, wet spring is followed by a summer that is not too hot or dry. These combined with sunny fall days and cool nights above freezing produce the best display of colors. Fall leaf color can also be used to identify trees, as each type of tree has it own special range of color.

Leaves make up our natural world and without them there would be no forests, no grassy meadows, no gardens of leafy greens. Through the amazing process of photosynthesis, they provide the oxygen we breathe and the food we eat. We couldn't live without them!

Suggested Reading

Bang, Molly and Chisholm, Penny. *Living Sunlight—How Plants Bring the Earth to Life.* New York: Blue Sky Press, 2009.
Maestro, Betsy. *Why Do Leaves Change Color?* New York: Harper Collins, 1994.
Silverstein, A. et al. *Photosynthesis.* Minneapolis, MN: Twenty-First Century Books, 2008.

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Patterns – LEAVES: NATURE'S SUNCATCHERS – Activities

FOCUS: Leaves come in a variety of shapes and sizes but they are all designed to make food for the plant, using sunlight, water, air and their green pigment, chlorophyll. With close observation, leaf features such as shape and venation can provide important clues to the identity of plants.

PUPPET SHOW "Leaf It to Leaves"
Objective: To meet a variety of leaf types and learn about their common function- making food for plants and animals through the process of photosynthesis.

Perform the puppet show, or have a group of children perform it for the class. Afterward, review the photosynthesis process and stress its importance for both plants and animals.
Materials: puppets, props, script, *Photosynthesis diagram and explanation*.

LEAF LOOK SORT AND FIND
Objective: To become familiar with the different physical features of leaves and associated vocabulary.

Bring in an assortment of different types of leaves and give one to each child. Using the *Leaf Anatomy* and *A Variety of Leaves diagrams,* have them note the various features on their leaf. Explain that you will now be asking them to split into 2 groups based on particular leaf features. Possible leaf features to sort by include:

- Compound versus simple leaves
- Smooth leaf edges versus toothed edges
- Entire leaf versus leaves divided into lobes
- Short versus long petiole
- Big versus small leaves
- Smooth surface texture versus rough texture

Once they are in their groups, ask them to compare their leaves, noting variations among that particular feature. Then sort again, using another leaf feature. Have older children keep track of features that make their leaf unique. Continue to sort by a few more features into 2 groups. After the final sort, have the children sit in circle with this group and collect their leaves. Spread their leaves in the center and have each child pick out their leaf, noting the features that helped them identify it.
Materials: Assortment of leaves; *Leaf Anatomy diagram, A Variety of Leaves diagram.*

LEAF PRINTS
Objective: To learn about venation patterns in leaves while making prints using ink, paint or crayons.
Give children leaves and have them inspect the underside, noting the patterns of veins that run from petiole to leaf tip. Explain that these veins are like the plumbing system of the leaf, and transport water and minerals into the leaf and carry food out. Use the *Three Leaf Venation Types diagram* to show the three main venation patterns: pinnate, palmate or parallel.
Pass out paper and have the children make a leaf print using one of the following methods:

Simple crayon rubbing- fold a piece of white paper in half. Place leaf, vein side up, in between. Using the broad side of the crayon, rub it over the enclosed leaf and an impression of the leaf and its vein pattern will appear.
Printing with paint and roller/brayer- Begin by applying paint or ink to a flat surface. Use the brayer to spread the paint/ink in a thin film and ask the children to use this supply to re-ink the brayer after each leaf. Direct each child to place their leaf, vein-side up on a piece of paper and using the brayer, spread a thin layer of paint all over the leaf surface. Have them carefully remove their leaf, place it, paint-side down, on another sheet of white paper and cover it with a clean paper towel or a piece of scrap paper. Roll a second clean brayer over the leaf, remove the scrap paper and gently lift off the leaf to reveal the vein impression.
Set out the *Three Leaf Venation Types diagram* depicting the 3 types of leaf venation - palmate, parallel and pinnate. Ask children to place their leaf prints in line next to the matching venation type to create a bar graph, noting which type is most and least common among the leaves collected.
Materials: Assortment of leaves, paper, crayons, ink or paint, brayers/rollers, *Three Leaf Venation Types diagram.*

LEAF GRAB BAG (Grades K-2)
Objective: To discover a variety of leaves outdoors and examine their characteristics looking for patterns.

WARNING: Before collecting leaves, be sure to check your school grounds for any poisonous plants, such as Poison Ivy and Poison Parsnip.
Have young children work in small groups with a leader to look for different types of leaves. Provide paper lunch bags to collect samples. Ask them to collect leaves from different types of plants, such as grasses, weeds, trees, shrubs, even garden plants. Have each small group sort their leaves into 2 piles and see if the other groups can guess the feature used to sort them.
Have the children save their leaves for future activities.
Materials: paper lunch bags, *Poison Ivy Information* sheet.

UPPER GRADES CHALLENGE (Grades 3-6) – FALL TREE LEAF COLLECTIONS
Objective: *To identify tree leaves by shape, color and vein patterns*.

Ahead of time, survey the school grounds to be sure there is a good selection of trees and leaves. If not, bring in leaves to supplement those on the school grounds. Take students outside to areas where different kinds of trees are growing. In small groups, have students collect leaves, choosing a variety of shapes and colors. Challenge them to collect one sample of as many different kinds of leaves as they can find and different color variants of each leaf type.
First ask students to sort their leaf collections into groups based on color only. Then have them further divide these larger color groups into smaller groups based on leaf shape and vein patterns. Note which leaves come in only one color and which come in a wider range of colors.
Using the *Fall Tree Leaf Identification Guide*, have students try to identify the leaves.
As a closing activity, have small groups line up 10 leaves of each tree species identified, highlighting either their uniformity of fall color or variation of hues.
As a learning extension, students may press leaves between sheets of newsprint weighted down under a stack of books. Later, have them pick their favorite pressed specimens; glue them onto paper, cardboard or into a journal; and label them to make a personal reference book.
Materials: *Fall Tree Leaf Identification Guide*; (Optional for learning extension activity - newspaper and heavy books for pressing leaves, glue, white paper or journal in which to mount collection).

LEAF EYE SPY (Grades K-2)
Objective: To accurately describe and identify key physical characteristics of leaves.

Working in groups of 3 or 4, have the children sit in a circle with leaves from their *Leaf Grab Bag* activity spread in the center. Explain that, one at a time, each child will visually choose one leaf to describe to the other children, to see if they can guess his or her leaf. The child describing the leaf should focus on one feature at a time. For example, "I spy with my little eye a leaf that has smooth edges". After each feature is described, the children guessing remove all the leaves that don't match that description. This is a good strategy to help narrow down the leaf choices. Continue until the children correctly guess the "eye spy" leaf. Return all the leaves to the center of the circle and play again with a new child choosing and describing their secret leaf.
Materials: Leaves from *Leaf Grab Bag* activity.

PICTURE A LEAF (Grades 3-6)
Objective: To make detailed observations and describe a leaf so that someone else can accurately draw it without seeing it.

Divide the children into pairs and have them sit back to back. Provide one with a clipboard, pencil, paper while the other secretly picks out a leaf from their *Fall Tree Leaf Collections*. With both children using the *Leaf Anatomy* and *A Variety of Leaves diagrams* as a guide, have one child describe their selected leaf, while the other tries to draw it based on the description. Compare the finished drawing to the chosen leaf. Switch roles and repeat the activity with a new leaf.
Materials: Leaves from the *Fall Tree Leaf Collections*; paper, pencil, clipboard, one per pair; *Leaf Anatomy* and *A Variety of Leaves diagrams,* one per child.

LEAF CRITTERS (Grades K-2)
Objective: To create collage animals using different shaped leaves.

Explain to the children that they will be using leaves of different shapes and colors to create animals. Show examples and ask questions to guide them in their leaf selection process.
What leaf shape reminds you of wings? Ears? Fins? Legs? A tail?
What shape leaf could be the body of a fish? A turtle? A bird?
How could you give an animal spots using leaves? What about stripes?
Give them each a piece of cardstock and glue sticks to assemble their leaf collage animal.
If you press an assortment of leaves beforehand, they will retain their shape, color and last longer. You can also try pressing the final creations.
Materials: *Leaf Critter* examples, leaves, both newly collected and from *Leaf Grab Bag* activity; cardstock and glue sticks.

ENVIRONMENTAL ART/SCULPTURE (Grades 3-6)
Objective: To use leaves in a range of colors along with other natural materials to create art assemblages outdoors.

Show the children examples of environmental artwork by artists, such as Andy Goldsworthy and Vermont artist Sally J. Smith. Using gathered leaves and other natural materials have children work together in small groups to create environmental art assemblages around their schoolyard. Take a tour of the finished artwork and photograph each piece. If possible, leave the artwork in place for others to enjoy.

Materials: Environmental art examples, leaves and other natural materials, camera to photograph artwork.

JOURNAL ACTIVITY AND CLOSING THOUGHTS
Objective: To record observations about leaves.

There are several options for journal activities: For children in grades K-2, consider *Leaf Prints* and *Leaf Critters.* For children in grades 3-6, *Leaf Prints*, *Upper Grades Challenge- Fall Tree Leaf Collections*, and *Picture a Leaf* would be good choices.
Afterwards, in small groups, have children share their work and one thing they learned about leaves.
Materials: Paper or science journals; clipboards and drawing materials

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Patterns – LEAVES: NATURE'S SUNCATCHERS – Puppet Show

Leaf It to Leaves!

Characters: Woody Woodchuck, Freda Fern, Pine Needles, Gertie Grass, Chlorophyll, Maple Leaf
Props: carbon dioxide, water drop, sun, leaf cut-outs (clover, jagged, smooth) or real leaves.

Woody Woodchuck (*singing while holding clover*) I'm looking over a four-leaf clover that I overlooked before. Mmm - I certainly do love leaves. They make such wonderful meals for a woodchuck. And they come in all shapes and sizes. Take this clover - four tiny leaflets joined in the middle to make one compound leaf. Yum-yum. And there are simple leaves with smooth edges (*hold up smooth leaf*) and leaves with jagged teeth (*hold up jagged leaf*). And (*Fern enters*) here comes a lacey one. Hi there, Freda Fern. I was just thinking about you.

Freda Fern You were? Why's that? I'm all ears – well, actually I'm all leaves.

Woodchuck Why, that's what I was thinking about – leaves. Yours are so pretty – delicate, lacey and such a lovely shade of green.

Fern Yes, I think my leaves are just fern-tastic. They're so long and graceful they even have a special name.

Woodchuck Yes, I remember, they're called "fronds" aren't they?

Fern That's right, and I'm very frond of them. In fact, I'd be nothing without them. Well, see you later, Woody. *(fern exits)*

Woodchuck Bye, Freda. (*pine needles enter*). Wow, who are you? You look dangerous with all those sharp points!

Pine Needles They're called needles, pine needles, that is. And I think they make me look pretty sharp.

Woodchuck Gee, I wonder why pine trees have needles but other kinds of trees have leaves.

Pine Needles Hey, needles <u>are</u> leaves – they're the leaves on pines and other evergreen trees.

Woodchuck Really? But they're so skinny and hard.

Pine Needles Needles have a hard waxy coating to keep them from drying out. That's why they can stay on the tree all year long.

Woodchuck But it's so cold in winter! Don't they just turn blue?

Pine Needles No, silly! If they did we'd be called "everblues" instead of evergreens! (*exits, grass enters*)

Woodchuck Oh, hi there, Gertie Grass. I was just thinking about you grasses.

Gertie Grass I was afraid of that.

Woodchuck I mean, a grass leaf sure is long and narrow compared to other leaves.

Grass That's why it's called a "blade" of grass. It's narrow and has sharp edges like a knife. But be-<u>leaf</u> me, it's still a leaf.

Woodchuck You know, Gertie, all this talk about leaves is making me hungry. Are you getting hungry, too?

Grass Me? No, plants don't ever get hungry.

Woodchuck What do you mean? Everybody gets hungry! We all need to eat to get energy to live and grow.

Grass Well, plants just don't get hungry.

Woodchuck OK, if that's true, then how do you get energy to make leaves, fruits, seeds and all the other good things that I like to eat? You can't just conjure them up out of thin air.

Grass Actually, that's just what we do.

Woodchuck Come on, you're joking – how can you make leaves out of air?

Grass Well, not just air. We need water from the soil, too.

Woodchuck Sounds like magic. So where does the energy come from to turn air and water into leaves, fruits and seeds?

Grass Why, from the sun, of course. Our leaves are like solar panels. They catch the sunlight and use the energy to make our food.

Woodchuck Amazing! But how can leaves do that?

Grass The secret is chlorophyll. It's what makes our leaves green.

Woodchuck Well, I'm green with envy! But I still don't completely understand how it works.

Grass Then, you'd better talk to my plant manager. Why, here he comes now. (*exits*)

Chlorophyll Hi, Phil's the name – Chlorophyll, that is, and I'm the green stuff in leaves. I help turn sunshine into food. It's called photosynthesis and it's very fulfilling work.

Woodchuck I bet! So how do you do it?

Chlorophyll It's easy to understand if you learn this simple song (*sung to the tune of "Frere Jacques"*):

Plants begin with
Carbon dioxide (*hold up CO2 prop*)
From the air
From the air
Water from the soil (*hold up water drop*)
Add a dose of sunshine (*hold up sun*)
Makes our food
Enough to share!

Woodchuck Hey, that's a catchy tune. But, I'm kind of shy when it comes to singing.

Chlorophyll Then let's get everyone to sing along. All together now. (*repeat song*) Hey, that was pretty good. Now, I'd better get back to work – catching sunshine and making food – not just for plants but for everyone. See you around! (*exits*)

Woodchuck Goodbye, Chlorophyll. Thanks for sharing your song - and your food with us. (*maple leaf enters*). Hello! Where did you come from?

Maple Leaf I just blew off that tree over there. I'm a maple leaf. Just call me Sugar.

Woodchuck Gee, you're so colorful – all yellow and orange. Hey wait a minute, you're not green! Where's your chlorophyll?

Maple Leaf I <u>used</u> to have chlorophyll when I was younger. But now that it's fall, leaves like me stop making food and our chlorophyll fades away. Now you can see all the other colors in me that were hidden by the green.

Woodchuck Well, you sure look jazzy!

Maple Leaf Hey, thanks! You should check out some other fall leaves. Red Maples turn bright red. Ash leaves turn yellow or purple. And Beech leaves change to golden brown.

Woodchuck Wow! Leaves come in all different shapes, sizes and colors – from big to small, lacy to smooth, fronds, blades, needles…

Maple Leaf We might all look different, but we all do the same job – making food for plants.

Woodchuck And for animals, too. Photosynthesis is really important work! Why, we couldn't live without you.

Maple Leaf Yeah, I know. It's a big job but we can handle it, Woody. Just <u>leaf</u> it to us!

The End

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Patterns – CONIFER CLUES: CONES, NEEDLES AND SPIRALS – Background

Follow a shaded trail through a northern forest on a warm summer's day and the warm rich scent of fragrant conifer needles fills the air. Though we tend to refer to all conifers as pine trees, a closer look reveals a wide variety of cone-bearing species in our woods. Plants are classified by how they grow and reproduce, the type of flower they produce, how the seeds are formed and the structure in which they are contained. **Conifer** is the scientific term for trees with seeds in cones and, generally, needle-like leaves. Conifer trees are part of a larger group, called **gymnosperm**s, which includes plants with seeds considered naked, not enclosed in a fruit.

For most of our conifers, these seeds rest atop woody **scales** that **spiral** around a central stalk, making up the **seed cones** with which we are so familiar. However, there are two types of cones in each species of conifer. One is the pollen, or male, cone. These are quite small and not very substantial in structure, falling apart easily after releasing their pollen. The **pollen cone**s do their job well, though, as anyone who has ever seen their car or a puddle or pond coated in yellow **pollen** dust can attest. Each pollen cone releases a mass of pollen grains which the wind transports, often great distances, to where some may encounter and stick to developing female seed cones of other trees of the same species. You'll need to look up high in the tree to see these young cones located near the tips of branches.

When a pollen grain lands on a sticky female cone, the process of **pollination** has begun. It can take a year or more for the pollen grain to grow and the male cells to fuse with the female cells inside. Depending on the species, it can be another year or more before the seeds ripen and mature. During this time, the female cone slowly swells, as the scales enlarge and become woody and the seeds develop between these scales. The spiral arrangement of the scales allows the greatest number of seeds to be packed into the cones, yet still be easily dispersed when mature. Usually two seeds rest on each scale, and most grow a tiny wing to aid in their **dispersal** by the wind.

The mature cones are specially designed so that they only open in dry weather, remaining closed when damp. Since most conifers are shade intolerant, it is important that the tree's seeds are able to travel away from the parent tree. With cones only opening on dry days, the winged seeds are more likely to catch the wind and be carried to an open sunny spot rather than end in a soggy heap at the base of their parent tree.

Though most conifer seeds are designed for wind dispersal, many attract birds and other animals that pry open or strip off the scales to enjoy a tasty meal of seeds. Any that inadvertently fall to the ground or are carried away by birds or squirrels or other hungry animals may germinate in a new, and hopefully sunny, spot. Some cones are designed to open only after exposed to fire. These serotinous cones are sealed shut, and heat breaks down their resinous "glue." After the fire, the cones open, the seeds fall out, and the fire-scorched barren landscape is perfect for these sun-loving species to germinate and grow.

Coniferous trees have needle- or scale-like leaves designed to conserve moisture. Their waxy coating keeps them from drying out in winter's drought-like conditions. They can range in size

from scales less than one-fifth of an inch long to needles 16 inches long. They can be variously arranged on the stem, either singly, encircling the branch, in **whorls**, or in bundles. Needles are replaced gradually, with new growth replacing the oldest every year. Most needles last from two to four years, but some can remain on the tree and photosynthesize as long as ten years.

Conifers can be recognized by their striking silhouettes in the landscape; a single main trunk with branches radiating off it. Each of the seven main types of conifer has its own distinctive growth habit and form that can be used to identify it from a distance.

Pines are thought to have existed before the dinosaurs and have continued virtually unchanged, thanks to their great adaptability. A pine tree's branches arise in very tight spirals, that appear as whorls encircling the tree. Pines usually add one whorl of branches per year. You can get a pretty accurate estimate of the tree's age, then, by counting the branch whorls, the remnants of lower branches that have died and broken off, and adding five (to account for the tiny scars of its earliest branches). Their waxy needles are grouped in bundles, or fascicles, with two, three, or five needles per bundles. Many animals use pines for nesting and cover as well as for food.

Spruce trees can be identified by their densely packed needles that attach individually and spiral around the branch. Their needles are four-sided, sharp, prickly and uniformly green. Thanks to their dense foliage, spruce branches can hold a lot of snow, providing great cover for animals seeking shelter. The tree's steeple shape helps it shed snow when the load is too great.

The boughs of Balsam Fir, with their rich resinous smell, are the fragrance of winter holidays. Thanks to their shade tolerance, firs keep many of their lower branches, creating perfectly-shaped symmetrical silhouettes. They have long-lived, flattened needles encircling their branches, with faint white lines (stomata) on the undersides. Unlike the prickly spruce, the softer fir needles are considered "friendly" – an easy mnemonic to distinguish between these two trees with similar growth forms. A fir's upright cones are purple when young, and, unlike other conifers, fall apart when the seeds ripen, leaving only spikes (called candles) to mark their former place on the branch. Fir seeds are winged, though birds or other animals often eat them before they get a chance to fly away.

Hemlocks are shade-loving trees that can create thick groves since only new hemlocks can germinate in such dense shade. Their needles are short with two prominent white lines underneath. They attach to just two sides of each branch by tiny stalks, creating a flattened surface. The branches, leaves and cones of hemlock provide food for wildlife.

Our only conifer to lose its needles each fall is the American Larch, or Tamarack. It looks like a typical "evergreen" until fall, when its needles turn a lovely yellow and drift to the ground along with the leaves of other deciduous trees. Tamarack needles grow in clusters out of stubby twigs that cover the branches. These give the tree a characteristic knobby look in winter when the needles are gone.

Instead of needles, short scale-like leaves form the spray-like branches of Northern White Cedar, or Arborvitae. Though in the wild it prefers damp areas, it is widely planted as a hedgerow, thanks to its characteristic spire shape. Deer often browse the foliage, and its tiny cones, which are produced in large numbers every three to five years, provide food for birds.

Found in fields, Red Cedar, also called Juniper, is a sun-loving tree with a columnar or pyramidal shape. It has two types of leaves. When young, it has sharp pointed needles that

become more flattened and scale-like with age. Its pollen and seed cones form on different trees. The seed cones start out with fleshy scales, but never dry out to form the typical woody conifer cones. Instead, Red Cedar cones stay fleshy, looking rather like a blue-grey berry covered with a powdery bloom. Unlike the primarily wind-dispersed seeds of other conifers, Red Cedar seeds attract animals that eat them and pass the seeds along in their droppings.

All these different types of conifers can be found growing in the fields, forests, and wetlands across New England. Though they share some common characteristics, a closer look at the branches, needles, and cones of individual trees provides an opportunity to better know our evergreen neighbors. From the pointed spire of spruce to the spreading branches of White Pine, the conifers of the northern woods grace the landscape with their varied shapes and many shades of green year ‘round.

Suggested Reading

Eastman, John. *The Book of Forest and Thicket: Trees, Shrubs, and Wildflowers of Eastern North America*. Harrisburg, PA: Stackpole Books, 1992.

Heinrich, Bernd. *The Trees in My Forest*. New York: HarperCollins, 1997.

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Patterns – CONIFER CLUES – Activities

FOCUS: A closer look at the many variations in conifer cones and their leaves makes each species unique and recognizable and distinguishes the common evergreen trees in our neighborhoods and nearby woods.

PUPPET SHOW "A Very Pine Day"
Objective: To meet some common conifer trees and learn how the design of their cones and needle-like leaves can help in identifying them.

Perform or have the children perform the puppet show. Afterward, hold up the conifer tree puppets and ask the children to name some ways in which they are alike. In what ways are they different from each other? Emphasize that all cones serve the same purpose: they hold and protect the growing seeds until they are ready to be dispersed. Show examples of cones in various stages of development.
Materials: puppets, script, *Cone Development* handout.

CONE CHOOSE AND MATCH (Grades K-2)
Objective: To use the sense of touch to examine and match cones of the same species.

Ahead of time, create several sets of bags of matching cones. In every set, place two or three distinctly different kinds of cones in a bag labeled "Choose." Place the same two or three types of cones in a second bag labeled "Match," along with one different cone. Decorate or label each pair of bags in a set with its own unique design. Vary the types of cones used in each set of bags, so no two sets are exactly alike. Divide children into pairs and give them a matching set of Cone Choose and Match bags. Have one child in each pair begin by selecting a cone from the "Choose" bag and place it on the table. Then have that child reach into the "Match" bag to find a matching cone just by touch. The child should remove the second cone and compare it to the first to confirm the match. Once a match is made, keep the pair of matching cones on the table. Take turns matching cones by feel, until all the cone pairs are removed from the bags. Have each pair call an adult over to verify their matches, discuss similarities and differences, and help correctly reassemble their "Choose" and "Match" bags. Trade sets with another pair of children and play again.
Materials: Several sets of paper bags of matching cones, consisting of uniquely decorated pairs of "Choose" and "Match" bags.

CONE HUNT AND SORT
Objective: To sort and identify cones by their characteristic features.

Ahead of time, collect a wide assortment of cones, being sure to have cones that match any conifer trees growing on or around the school grounds, for a total of at least 100 cones. Try to collect 5 different kinds of conifer cones. Right before your workshop, scatter these cones around the schoolyard for the children to find. Cluster small cones in groups so that they are more visible. Place markers at the corners of the area in which cones are hidden to focus the hunt.

Explain to the children that they will be going on a cone hunt, and, similar to an Easter Egg hunt, the cones will be scattered about in plain view around the schoolyard. They are to collect any they see that are not attached to trees and bring them back to their small group. Using containers or plastic bags, each small group will sort their collected cones into groups based on their appearance, looking at the various similarities and differences. Bring the small groups together to share sorting criteria and compare cone collections, combining cones of the same type. Give each small group one or more labeled cones from the Cone Kit to match and identify the cones in their class cone collections.
Materials: Assortment of cones (5 different types, 100 total); containers or plastic bags; Cone Kit.

TAKE A BOUGH
Objective: To use written and picture clues to match cones to their evergreen branches.

Ahead of time, cut conifer branches to match the cones collected for *Cone Hunt and Sort*. Fresh branches will be needed after a week or so. They will keep better refrigerated in a plastic bag or other cool location.
Give each small group a set of *Take a Bough* Clues. For younger children, place the *Take a Bough* picture clues by each cone type. Assign each small group one or more of the cone species from *Cone Hunt and Sort.* Explain that they will use the clues to match their cones to evergreen branches. Give each group a set of branches. Have the children examine them, then use the clues to match the branches to their cones. For older children, include one extra branch so that the last match isn't obvious.
Materials: *Take a Bough* word and picture (photocopy of the needles) *Clues*; identified cones from *Cone Hunt and Sort*, matching evergreen branches (one set per small group), rulers.

BRANCHING OUT
Objective: To employ visual cues to distinguish and match conifer branches to their tree.

Ahead of time, mark conifers on or near the school grounds with colorful pieces of surveyor's tape and label them with the tree's name. After playing *Take a Bough*, give each pair or small group of children a branch. Have the children compare their branch to the tagged conifers outside to find the one that matches their branch. After they identify their branch, they can exchange it for a different branch and try to identify another tree.
Materials: branches from *Take a Bough* activity, one per pair or small group; surveyor's tape, *Some Conifers of New England* handouts.

JOURNAL ACTIVITY
Objective: To record observations of conifers and other seed-bearing structures in nature.

Prompt: Outside, sketch the outline of two conifer trees and note what kind they are in your journal.
Alternate prompt if there aren't conifers growing on the school grounds:
Find and draw an example of another type of container for seeds (milkweed pods, acorns, maple keys)
Materials: journals, pencils.

UPPER GRADES CHALLENGE (Grades 5-6) – Know Your Needles
Objective: *To look for patterns of similarities and differences in the needles and cones of conifers.*

Have children work with a partner or in a small group. Bring everyone outside and let them select an evergreen tree or shrub on or near the school grounds to study*. In case of bad weather, cut branches with cones ahead of time for the students to examine inside. Provide each team with a *Conifer Key*. To demonstrate how a dichotomous key works, have everyone follow along as you key out a branch that you have selected ahead of time. Then have the groups try to key out their own tree or branch. Finally, have the children compare their branch and cone to the pictures in the *Some Conifers of New England Picture Guide*. Does their branch resemble the description and picture in the guide? What characteristics helped them identify the species?
Materials: magnifying lenses, rulers, a selection of conifer branches if working inside, *Conifer Key, Some Conifers of New England.*
**(Be sure that the tree or shrub picked is one that is included in the key provided. Some cultivated ornamental trees and shrubs are not included on the Conifer Key.)*

FOLLOW THE SPIRAL
Objective: To observe and mark the spiral patterns of scales on conifer cones.

Ahead of time, collect enough cones to give one to each child.
Hand out a cone to every child and point out the scales that make up each cone. Explain that these scales are arranged in different sets of spirals around a central stalk. One set of spirals will wrap around and around the cone gradually while the other set will rise steeply from bottom to top. Have the children turn the cone in one direction and see if they can find the spiral rows of scales. When they distinguish the rows, have them select one row to follow, then, while slowly turning the cone, highlight the row with either a spot of paint or marker on the tip of each scale in the series. When children complete this assignment, have them turn the cone in the opposite direction to try to find a different row or spiral going in this new direction.
If using paint, use Q-tips as "paintbrushes" and place a dollop of paint in a jar lid at each table for children to share. Or, they can use markers or gel pens to highlight the spirals.
The spiral pattern is sometimes easier to see if the scales are closed. If soaked, cones will stay closed for a few days. However, they do need to be dry enough to hold paint for this activity.

For older grades only: As a supplemental discussion, introduce the Fibonacci sequence (see supplemental materials) and count the number of spirals.
Materials: Norway spruce or white pine cones, one per child, markers or paint and Q-tips

CLOSING THOUGHTS
Pass around a giant cone and have the children share one thing they learned about conifers.

A STEP BEYOND
Cones in the Rain: if you take a dry pine cone and place it in a jar of water, the scales will close up in about ten minutes. If removed from water, the scales will open up again in a day or two. On a tree, this insures that seeds will fall out only in dry weather when they are more likely to be blown away from the parent tree. Why would growing under a pine tree not be a good place for a little pine? (too shady, crowded, might get covered up with needles)
Snack: If tree nut allergy is not an issue in your school, you might serve toasted pine nuts as a snack. There are some kinds of pines with large, edible seeds that grow in Italy, Korea, and the

American southwest. Animals, especially birds, disperse these seeds, unlike those of most other conifers which are wind-dispersed.

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Patterns – CONIFER CLUES – Puppet Show

A Very Pine Day

Characters: Reddy Red Squirrel, Hemlock Branch, Spruce Branch, Fir Branch, Pine Branch.

Reddy Red Squirrel Oh boy, it's lime for tunch! I mean it's time for lunch. I just have to find a kine pone so I can eat some seeds.

Hemlock Don't you mean find a **p**ine **c**one?

Squirrel Of course! That's what I just said…I think. Anyway, now I've found you.

Hemlock No you haven't. I'm not a pine, and this little cone isn't a pinecone.

Squirrel You can't mool fee! I mean, you can't fool me. You're a pine. You've got needles instead of leaves, don't you?

Hemlock Yes, but see how short my needles are? Pine needles are much longer than these.

Squirrel But you've got pine cones! Right here. They're tiny ones. They're probably just babies.

Hemlock No! They're not babies. They're full-grown, mature cones.

Squirrel Well, if you're not a pine tree, then what are you?

Hemlock I'm a hemlock, and these are my hemlock cones.

Squirrel Hem-lock. Well, even if they're locked, I'll bet I can get those tasty seeds out. Let me try one. (*pretends to nibble*) Mmm, yummy, I do love hemlock seeds, but they're just too tiny. I need to pind a fine tree... Oh (*sigh*), you know what I mean. (*exits*)

Hemlock (*chuckles*) Good luck finding a pine tree, Reddy! (*exits*)

Squirrel Why, here's a tree with bigger cones and longer needles. Hello, Pine Tree!

Spruce You talking to me? I'm no pine tree.

Squirrel But you've got peedles and ninecones. I mean needles and pinecones.

Spruce Yep, I've got needles, but these here are spruce cones. There's a difference, you know. Pine cones have hard, woody scales. But the scales on my spruce cones are much softer and they even bend a bit.

Squirrel That sounds good to me. I'll just pick one and try some spruce seeds. (*Moves near Spruce*) Oh, ow! Your sheedles are narp!

Spruce Yeah, my needles are sharp. It helps for keeping pesky squirrels away until the seeds are ripe.

Squirrel Well, I only wanted to taste them. I'm going to look for a tree with nofter seedles. Oh! You know what I mean! Bye. (*exits*)

Spruce Wait, Reddy! They have to be softer and longer too! Oh well, he'll find out. (*exits*)

Squirrel Why, here's a tree with softer needles, and they have a nice smell, too. And look at those chunky pinecones. Yum!

Fir Are you referring to me? If so, then you are clearly mistaken. For these are not pinecones, they're fir cones.

Squirrel Wow! You've got furry cones?

Fir No, they're not furry, but they're called fir cones because I'm a fir tree.

Squirrel Then you're not a tine pree? I mean a pine tree?

Fir Not at all. Pine cones hang down when they're ripe, but my cones stand upright on the branches.

Squirrel They're nice and fat. I bet I'll find nice big seeds when I strip off the scales.

Fir Oh, you won't have to strip them. When my seeds are ripe the cones just fall apart and the seeds float to the ground.

Squirrel Wow! Then it'll be easy to eat fir cones. I can stop looking for a pine tree. Only, wait a minute. If the cones fall apart when they're ripe, then what are those purple cones on your branches? And what about those spikey things?

Fir The spikes are what's left of last year's cones – just the central shaft. All the scales and seeds are gone now. The purple cones are young cones – they're not ripe yet.

Squirrel Oh phooey! Then I can't eat fir seeds today. I really need to pind a fine. I mean find a pine!

Fir Well, you have to look at the needles. You see, my needles are attached one by one all along the branch.

Squirrel Just the same as hemlock and spruce.

Fir Yes, but a pine tree's needles are attached in little bunches – two or three or five needles all together in a bunch.

Squirrel Okay! Thanks! I'll look for a tree with beedles in nunches. I mean needles in bunches! (*exits*)

Fir Good luck to you, Reddy Squirrel. (*exits*)

Squirrel Here's a tree with big woody cones. I wonder if they could be pine cones.

Pine Well, they surely aren't pine-apples.

Squirrel And it looks like you have very long needles – much longer than hemlock or spruce or fir. They could be pine needles…

Pine Well, they're not knitting needles!

Squirrel But there was one more important thing I needed to look for. Now what was it? Seedles in hunches? Tweedles in lunches? Feedles in crunches? (*to audience*) Can anybody help me?
(*Audience replies, "needles in bunches"*) That's it! Needles in Bunches!

Pine Easy for you to say!

Squirrel Let me see if your needles are attached in bunches. (*moves closer to branch*) They are! Here's a bunch with one, two, three, four, five needles! And here's another one, and another one. You must be a pine tree!

Pine That I am – and it's a pine kind of tree to be.

Squirrel I'll say. I'm glad I finally found you. I don't suppose you'd like to share a cone with me?

Pine Well, it depends. Only if you promise to plant some of my seeds instead of eating all of them! Then they can grow into new pine trees, just like me.

Squirrel Plant some seeds - for new pine trees? Of course I will. Everyone knows we all treed our nees! Oh *(sigh)*, you know what I mean

Pine That we do, Reddy Squirrel. We all need our trees!

The End

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Patterns – SNOWFLAKES – Background

"*When a snowflake melted, that design was forever lost. Just that much beauty was gone, without leaving any record behind." W.A. Bentley, 1925*

Snow is magical, renewing our sense of wonder, transforming a barren landscape into a winter wonderland, and drawing us outdoors. When we look closely at falling snow, we marvel at the beauty of snowflakes. Each **snow crystal** is a unique, ephemeral work of art-yet its symmetrical, harmoniously balanced design is not random but created through a combination of physics, math and chemistry.

Snow forms in clouds at temperatures anywhere between 32F and -39F. These clouds are full of microscopic water droplets, thousands of which could fit on the dot of an i. Mixed with these droplets are "snow seeds"—tiny particles of salt, dust, pollen or airborne pollution. These snow seeds act like magnets, attracting the droplets, which adhere and freeze onto them. The chemical and physical nature of water causes these freezing droplets to form as microscopic six-sided symmetrical crystals.

While all snowflakes start out as these microscopic **hexagonal crystals**, temperature determines the specific type of snow crystal that will develop, and humidity levels influence the size and complexity of their designs. At certain temperatures vertical growth may occur creating columnar crystals while other temperatures produce flat crystals that grow primarily in horizontal planes. The trip from sky to earth takes a tiny crystal though many layers of air with different temperatures and varying amounts of moisture. All these combine to make each individual snowflake unique, as no two travel the exact same path through the sky.

Anyone who lives with snow has their own ways to describe and classify it, from children's snowball snow to the skiers' powder snow. Scientists classify snow based on crystal shape. Though some classification systems include dozens of different categories, the standard 1951 classification by the International Commission on Snow and Ice recognizes seven common shapes: needle, column, capped column, plate, stellar, spatial dendrite and irregular crystals. **Needle crystals** are long slender columns with points at either end. They often stick together in bunches and can sting your face and shatter when landing on hard surfaces.

Columns are tiny six-sided tubes of ice often hollow due to air space inside. They often form in high cold cirrus clouds with low moisture. In winter, these wispy cirrus clouds are almost solely made of column crystals.

Capped columns are combination crystals. Their columns form in high dry clouds, but as they fall to earth they pass through warmer, moister clouds. There they grow horizontally at their tips, forming plates at opposite ends.

Plate crystals are six-sided hexagons with flower-like patterns within. Increasing moisture causes the crystal to expand outward, forming fancier plates with petal-like projections on their six sides.

Stellar crystals, also called **stellar dendrites**, look like snow stars, with six points radiating out from a center, like spokes on a wheel. The star-like points get more elaborate with increasing moisture, and nearby stellar crystals easily get entangled. They often fall to earth in clusters.

Spatial dendrites are the three-dimensional versions of stellar crystals with projections growing upwards at right angles from their flat surfaces.

And finally, some of the snow crystals do not fit into any of these categories, and thus are referred to as **irregular or asymmetrical crystals**.

Of course, precipitation other than snow can fall in winter. **Freezing rain** describes liquid raindrops that fall when temperatures at ground level are below 32F. Usually freezing rain is associated with a warm front coming in above a cold front. The warm air up high allows raindrops to form. A relatively thin freezing layer of air (32F and colder) trapped near the surface chills the rains so that the drops can be colder than 32 and yet they remain liquid! When these **supercooled** raindrops reach earth, the rain freezes upon contact with the below-freezing roadways, branches, utility wires, coating everything in a layer of ice glaze.

Sleet is precipitation that falls as frozen raindrops. It typically forms when there is a layer of warm air sandwiched between two layers of cold freezing air (temperatures 32F and lower). It starts out as snow in the top freezing layers, but as it falls through the warmer layer of air with temperatures above freezing, the snow crystals almost completely melt into raindrops. These drops refreeze to tiny balls of hard ice as they pass through the thick layer of freezing air below. These transparent ice pellets are frozen raindrops and bounce when they hit the ground.

If you have ever been out in a snowstorm, you've probably seen snow that looks like miniature popcorn mixed with snowflakes. That's **graupel**—snow crystals and supercooled water droplets frozen together. Falling snow crystals (often stellar or plate-) pass through a layer of liquid water droplets, which freeze onto the crystals coating them with ice/rime. This freezing of droplets onto the crystal (called accretion) continues until the original snow crystal is no longer visible. Graupel appears opaque white, easily breaks apart and often bounces as it lands. Graupel is lightweight with many small air bubbles throughout its structure.

Each snowfall contains different types of snow crystals. The predominant crystal type determines how much the snow adheres, builds up and drifts once on the ground. Snow has different qualities depending on how much water, ice and air it contains. Snow with high water content, mostly stellar and plates that link together when compressed, is perfect for molding into snowballs and snowmen. Powder snow, on the other hand, contains mostly columns and capped crystals, is loose, fluffy, dry and hard to pack, and is the dream of skiers everywhere.

A snow crystal's life is one of constant change, from its trip through the sky to its resting place in the snow bank. For once on the ground, the crystals immediately change again. The fine arms of stellar crystals evaporate, delicate surface patterns on plates disappear and all snow crystals condense inward into small bits of ice. This change is called metamorphosis. Over time, the snows from each snowfall condense into layers, like several blankets piled on top of one another. Variable winter weather conditions change the texture of each. Slicing into a snow bank reveals its profile and tells its history, with each layer representing the change from delicate snowflake to ice particle and ultimately, back into the water cycle.

Snow has a way of bringing out the kids in all of us--drawing us outside to play. It provides us with the medium to create anything from simple snowmen to elaborate sculpture. Yet all of these designs, just like the snowflakes that made them, are fleeting. So head outside and enjoy the snow.

Suggested Reading

Libbrecht, Kenneth. *The Snowflake: Winter's Secret Beauty*. Stillwater, MN: Voyageur Press, 2003.

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Marchand, Peter. *Life in the Cold*. Hanover NH: University Press of New England, 1987.

Stokes, Donald and Lillian Stokes. *A Guide to Nature in Winter*. Boston: Little, Brown and Co., 1976.

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Patterns – SNOWFLAKES – Activities

FOCUS: A snowflake's life is one of constant change, from its trip through the sky to its resting place in the snow bank. Each one is a unique, six-sided crystal with temperature and humidity key factors determining their shape, size and design.

PUPPET SHOW "No Two Alike?"
Objective: To learn the conditions necessary for different snow crystal formation and compare the designs of five different snow crystals.

Perform the puppet show, or have a group of children perform it for the class. Afterward, review the conditions necessary for snow crystal formation and the five types of snow crystals introduced.
Materials: puppets, props, script.

SNOW CRYSTAL CATEGORIES
Objective: To become familiar with the variations in snow crystals and sort snow crystal photos into categories based on their design features.

Using the puppets and *Types of Snow Crystals* chart, review the various design features and growth patterns of five different snow crystals. Point out that as each type of snowflake grew, decorative patterns were repeated on all six sides, creating symmetrical designs. In small groups, have children sort snow crystal photos into these five categories based on their design.
Materials: two sets of 12 different snow crystal photos; puppets and *Types of Snow Crystals* charts.

UPPER GRADES CHALLENGE (Grades 5-6) – SNOWFLAKE PREDICTIONS
Objective: To use temperature and humidity data to make predictions of possible snow crystal type.

Working in pairs, interpret and discuss the Snow Morphology chart/graph, noting in particular the temperature range at which different types of snow crystals form and how their shapes are affected by moisture level (i.e. simpler when moisture levels are low and more complex at higher humidity). Give the children different temperature and humidity scenarios and have them predict the type of snow crystal that might fall.
If it begins to snow, have the students predict the type of snow crystal they might see/collect outside, then head out with materials for the *Collecting Crystals* activity.
Materials: *Snow Morphology chart,* real or fabricated temperature and humidity data, *Collecting Crystals* materials

PAPER SNOWFLAKES
Objective: To create six-sided snowflake models.

Following the *Paper Snowflakes* directions, children will fold and cut paper to create their own one-of-a kind snowflakes. For younger children, follow directions using coffee filters, as they are

easier to cut. Older children will make snowflakes from squares of paper. Once folded, point out that each cut made will be repeated six times round their snowflake, creating a similar repeating or symmetrical pattern on their finished snowflakes, similar to those seen in real snowflakes.
Materials: round coffee filters or square sheets of paper, scissors, *Paper Snowflakes* directions.

SNOWFLAKE DANCE (Grades K-2)
Objective: To act out the formation of six-sided snowflakes.

Bring children outside or to a large indoor space. Explain that they will be acting out how snowflakes form. Review the key ideas presented in the puppet show by asking children what is in the center of every snowflake and how many sides/arms do they usually have. Depending on the class size, choose two or three children to be snow seeds. Select six children to hold hands and form a circle around each snow seed. Have an adult work with or, depending on numbers, join each snowflake. Each adult will direct the children in their "snowflake" to make different arm motions, creating different snowflake shapes. The snow seed can/should change their arm position too or move around in the center of the flake. Optional: play music (Tchaikovsky's Waltz of the Snowflakes) and have the children slowly sway and move their arms pretending their snowflake is changing as it falls gently from the sky.
Materials: computer or CD and player.

WINTER WEATHER SKITS (Grade 3-6)
Objective: *To examine and act out the processes that lead to the formation of three types of frozen winter precipitation; sleet, freezing rain and graupel*.

Have the children work in small groups. Give each group role cards and props plus a skit description and diagram that explain how their particular type of winter precipitation forms. Using the cards and props, the children will act out how their type of winter precipitation forms and its possible effects on the natural world and/or people's reaction to it. The other children will try to guess what type of precipitation is being presented.

Winter Weather Skit Descriptions
The words in **bold** can be made into cards for the students to wear to help identify their role in the skit.

Freezing Rain
Freezing rain is rain that falls when temperatures near the ground are below freezing. **Rain drops** form in layers of **warm**er **air high**er **up** in the atmosphere. As they fall, they pass through a layer of **below freezing air (32F or colder) near the ground.** But rather than freezing into ice, remain liquid. When they come in contact with objects at the surface they **freeze instantly on contact** coating everything in a layer of ice or glaze. When there's a significant accumulation of this glaze, we call it an ice storm. The weight of this ice can bring down power line, snap trees, form "black ice" on roads and icing on the wings of airplanes.

Sleet (also called Ice Pellets)
Sleet is precipitation composed of frozen raindrops. It often forms when **snowflakes** pass though a **layer of warm air** where they melt into **raindrops**. When the rain passes back through a **layer of** air with **below-freezing temperatures (32F and colder)**, the raindrops freeze into **transparent pellets of ice** which often bounce when they hit the ground. Sleet stings when it hits your face and accumulated sleet on roadways can be very slick.

Graupel (also called Soft Hail, Tapioca Snow, or Snow Pellets)
Graupel is a form of frozen precipitation consisting of snow crystals and supercooled water droplets frozen together. Falling **snow crystals** pass through a layer of **liquid cloud droplets,** which freeze onto their surface. This freezing of droplets onto the crystal (called accretion) continues until the original **snow crystal** is **coated**, making it almost indistinguishable. Graupel appears opaque white, is lightweight, due to small air bubbles throughout its structure and easily breaks apart.

Materials: *Winter Weather Skit* descriptions, diagrams and role cards for sleet, freezing rain and graupel. Possible props include: clear plastic sheet for ice glaze, balls of crumpled plastic wrap or tin foil for sleet, cotton balls for graupel.

COLLECTING CRYSTALS
Objective: To catch and observe the intricate designs of real snowflakes.

Beforehand, chill felt or fabric squares outdoors or in a freezer. When snow is falling, hand out the chilled fabric squares and have children use these to collect falling snowflakes. With magnifying lenses, have them view their snow crystals up close and compare them to the snow crystals depicted on the *Types of Snow Crystals* chart.
Materials: Six-inch squares of black felt or other dark fabric, chilled in freezer or outdoors, magnifying lenses, *Types of Snow Crystals* Chart.

SNOW SCOUTING
Objective: To make observations about snow around the schoolyard.

Snow Scouting Card

Collect samples of snow in two containers- one loosely scooped, the other tightly packed. Make predictions about how much water each will contain when melted. Use markers to indicate predicted water lines. How does the volume of water compare to the volume of snow?

Using rulers, measure depth of snow in different places of the schoolyard- Any guesses for differences?

Look closely at snow on ground. Can you still see different snow crystal types? Or have they changed? And how?

Using snow shovels, dig down through the snow to see if you can find different layers. What do you think the layers represent? Is the surface snow soft or crust-like? It 's fun to collect big pieces of crust to use in the Snow Sculpture activity.

Materials: *Snow Scouting card,* containers, markers, rulers or measuring tapes, magnifying lenses, snow shovels.

SNOW SCULPTURE
Objective: To use snow along with other natural materials to create art assemblages outdoors.

Show the children examples of environmental artwork created in winter by artists, such as Andy Goldsworthy, Simon Beck and Vermont artist Sally J. Smith. Outdoors, using snow and other natural materials, have children work together in small groups to create environmental art assemblages that feature six-sided symmetrical designs. Take a tour of the finished artwork and photograph each piece. If possible, leave the artwork in place for others to enjoy.
Materials: Environmental winter art examples, camera to photograph artwork.

JOURNAL ACTIVITY AND CLOSING THOUGHTS
Objective: To record observations about snowflakes and how they form.

Provide *Hexagonal templates* for the children to use to create their one-of–kind snowflake. Faint lines drawn in between the opposite points of the hexagon divide it into six sections. Explain that to make their snowflake symmetrical, anything they draw in one of the six sections, either inside or outside, must be repeated in the remaining five. Afterwards, in small groups, have children share their snowflakes and one thing they learned about snow.
Materials: Paper or science journals; *Hexagonal template*, clipboards and drawing materials

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Patterns – SNOWFLAKES – Puppet Show

No Two Alike?

Characters: Dust, Tiny Plate, Big Plate, Needle, Column, Capped Column, Stellar Dendrite.

Dust Here I am, a tiny speck of dust floating in a cloud of snow crystals. Yoo hoo. Hello there.

Needle What's this? A speck of talking dust. Why, I was once a bit of dust, too.

Dust Really? You look like ice, not dust.

Needle I'm a snow crystal made of ice, but inside me, and every other snow crystal, is a tiny speck of dust – or salt or pollen or dirt.

Dust Do you think I could become a snow crystal?

Needle You just might. If weather conditions are just right, water vapor in the air will freeze onto you, and you'll find yourself inside a snow crystal.

Dust It sounds like magic!

Needle No, it's not magic at all. Crystals form all by themselves. It's just the shape water takes as it freezes onto us.

Dust That's amazing! Will I become a pointy crystal like you?

Needle Well it all depends on the temperature and the amount of moisture in your cloud. When I was formed, the temperature was just below freezing and there was lots of moisture in my cloud.

Dust There are other kinds of crystals?

Needle Yes indeed, lots of them. But right now we're all needles. Sometimes we fall to earth in a bunch.

Dust That sounds like fun. I hope I become a needle crystal - and I hope it's soon!

Needle Well, it all depends on where you've been and where you're going, if you get my point. Bye now - the wind is carrying me off!

Dust So long, Needle! Gee, I'm being carried by the wind, too, and I'm starting to feel different. Oh, Oh! (*exits*)

Tiny Plate (*formerly Dust*) Wow! I'm not a speck of dust anymore. I think I'm a snow crystal! But I'm not shaped like that needle crystal. I'm kind of flat - like a plate. Oh no, maybe I'm not a snow crystal!

Column Whoa, look out! I can't steer. (*tips this way and that*) Sometimes I don't know which way is up. What's the trouble?

Tiny Plate I wanted to be a snow crystal, but I don't look like a needle.

Column Well neither do I, but I'm a snow crystal.

Tiny Plate You are? But I don't look like you either. I'm flat and thin. You're tall and round - like a column.

Column Yes indeed, Cody Column Crystal, at your service.

Tiny Plate Oops, I was wrong. You're not round at all. You've got edges and flat sides.

Column That's right- I've got the same number of sides as every snow crystal. Count 'em - you'll see.

Tiny Plate Okay, turn while I count. One, two, three, four, five, six. But why six?

Column That's just the way we crystals form. We can grow into different shapes but we all have six sides.

Tiny Plate I wonder if I have six sides?

Column Let's count. One, two, three, four, five, six. See, you are a snow crystal!

Tiny Plate Yippee! I'm a snow crystal! But I'm very small and rather plain.

Column Oh, don't worry, you'll get bigger. You might grow taller and become a needle or a column like me. Or you could grow wider and become a flat plate. Why, you might even grow branches.

Tiny Plate Wow! How does that happen?

Column It depends on the air temperature and moisture. Columns and plates usually form when the air's kind of dry. But needles, fancy plates and branching crystals form when there's lots of moisture.

Tiny Plate Gee it's pretty cold in this cloud and not much moisture. Why, I can feel myself changing... (*exit; return as Big Plate*) Look at me now!

Column Wow! You're a bigger plate crystal, and now you've got little ridges and grooves making nice designs all over you.

Big Plate It's true, I'm pretty fancy now!

Column Hmm, if this cloud is just right for growing plate crystals, that means…(*exits*)

Big Plate Huh? Where's Cody? He must have blown away. Why, here's another crystal!

Capped Column Hi! Like my new style?

Big Plate Is that you, Cody Column? You've grown two caps! One on each end!

Capped Column Yup, conditions were just right, so I grew these two plates and now I'm a Capped Column. A capital improvement, don't you think?

Big Plate Yes, indeed, you can't top that!

Capped Column But now I'm feeling a bit top heavy. Down I go! (*exits*)

Big Plate Bye Cody! Gee, it feels damper now. Oh, look at the beautiful, fancy crystal. Yoo hoo! Were you once a speck of dust too?

Stellar Dendrite Yes! But now I'm a stellar dendrite.

Big Plate *Stellar*…that means star. You do look like a star. But what does *dendrite* mean?

Stellar It means branching, like a tree.

Big Plate I see! Your six arms have many side branches. It makes you look so lacey. I've never seen a snowflake just like you.

Stellar And you never will! You may see other stellar and plate crystals, columns and needles, but you will never see another one just like me… or you either.

Big Plate Really? You mean I'm the only flake like me?

Stellar One of a kind! We're all unique because we've each traveled a different path through the sky. So, ready to go?

Big Plate Is it time for the show?

Stellar Yes! It's time for us to SNOW!

All Crystals (*hop around*) Yippee, hurrah!

The End

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Patterns – TRACK DETECTIVES – Background

Animals live secret lives all around us – yet their tracks and sign can be found everywhere, starting in our own backyards. Winter is a great time for tracking as snow makes a great surface for animal tracks to register, leaving imprints for us to study and interpret. Becoming a track detective is like learning to read; in fact, it *is* reading, but with a different set of symbols. Every set of tracks tells a story. When reading these stories, consider the **place** where the tracks are found, the track **pattern** left behind, and the shape and size of the animal's foot **print**.

The place where you find tracks can be an important clue. A good track detective tries to think like an animal and consider where it might go to find food, water and a place to take cover. What animals might live in and around the area where these tracks are found? The animals likely to pass through the playground are different from those that only leave trails deep in the forest. What animal might balance and walk on a fallen log? Tracks that tunnel under the snow, slip into a stream or end at a tree trunk give important clues about the behaviors and abilities of the animals who made them. Look closely at the surrounding vegetation for browsed twigs, stripped cones and other clues indicating food is being stored or eaten. Do any impressions indicate an animal rested or took cover nearby? **Scat** or animal droppings, urine and markings are other signs that can help you determine whose home territory overlaps with yours.

There are four different kinds of track patterns made by animals as they move: straight **walking**, **waddling**, **hopping** and **bounding**. The repeating design of prints in each pattern gives information about the body structure, build and gait of the animal that made them. Occasionally tail drags and slides are part of a track pattern, providing additional clues about the track maker and its behavior.

Walkers include animals in the cat family, the dog family and hoofed animals. Their bodies, from shoulder to rump, are about the same length as their legs. They walk or trot on their toes, moving the front foot on one side of their body followed by the hind foot on the opposite side and leave a single line of footprints.

Waddlers typically have heavy bodies with short legs. Bear, porcupine, skunk, opossum, beaver and muskrat are all waddlers. They walk slowly, on flat feet, moving both feet on one side of their body, one at a time. Their back legs are longer than their front legs and their hind foot often oversteps their front foot. Their track pattern shows smaller front and larger back footprints in pairs.

Hoppers include members of the rodent family (mice, squirrels, chipmunk) and rabbits and hares. Their large hind feet are much longer than their front feet. They push off with their strong back legs and land first on their smaller front feet, with their back feet swinging outside and ahead of these, ready to push off again. Their track consists of four footprints—their two larger back feet ahead of their smaller front feet.

Bounders are all members of the weasel family. They have long narrow bodies and short legs with five toes on each foot. Their movements mimic the opening and closing of a toy Slinky™.

They start in a crouch and spring forward pushing off with their back feet, fully extending their body in mid-air. Then they touch down, one front foot at a time. Both front feet lift up, and the back feet land in their place, ready to repeat the pattern. Bounder tracks are paired prints set on the diagonal.

Additional measurements can help distinguish between animals with similar patterns. **Stride** is the distance between two consecutive prints or between track sets and can vary greatly depending on the speed of the animal, in addition to its sex, age, and size. In slower gaits, tracks are closer together, while they get farther apart as the animal speeds up. A more reliable measurement is **straddle**, the width of an animal's tracks, measured from the outside edges of two prints. This measurement varies only slightly and correlates with the animal's body width. The overall path each track pattern takes provides another valuable clue. Meandering, looping tracks often belong to domesticated animals. Fido knows a full dinner bowl awaits him at home, while Mr. Fox moves in straighter, more direct path, conserving energy, for dinner is never guaranteed.

The best clue, but often the most difficult to find, is a perfect footprint or impression. Tracks come in all shapes and sizes, from the tiniest mouse, vole and shrew prints to the finger-like paws of raccoon and opossum to the large tracks of bear and moose.

Counting the number of toes in each print can help with identification. Animals walking on two toes include deer, moose and many domesticated hoofed animals like cows, goats, and pigs. Their hooves tend to be heart-shaped with the pointed end facing the direction of travel. In deep snow, two additional smaller impressions may register; these are the **dewclaws**, tiny remnants of former digits.

Cats and dogs both have four toes visible in their prints. A dog foot is more oval in shape and their nails are often visible in their prints. The toes are arranged in pairs and an X can be drawn in the space between these toes. A cat's footprint is rounder, and the toe pads are arranged asymmetrically around the heel pad. No claws are visible in cat tracks for their claws are retractable, to keep them sharp for hunting.

Prints with five toes belong to members of the weasel family including ermine, mink, martin, fisher, and otter. As you follow these trails, be on the lookout for distinctive slides as they use their long bodies to slide downhill or across the ice. Skunks also leave five-toed tracks as they waddle and wander about.

Some animals have front paws that are differently shaped from their back paws, for example the beaver with its big webbed hind feet and smaller front feet. Some, including most rodents, don't have the same number of toes on their front and back feet. Using all these clues along with size measurements can help identify the maker of each track.

While most wild animals stay out of sight when humans are around, they leave behind signs we can learn to read. Track detectives put together clues about place, pattern and print to try to determine what creature went walking by. There are many stories waiting to be read in the tracks and sign all around us.

Suggested Reading

Elbroch, Mark. *Mammal Tracks and Sign*. Mechanicsburg, PA: Stackpole Books, 2003.
Levine, Lynn. *Mammal Tracks and Scat*. E. Dummerston, VT: Heartwood Press, 2000.
Rezendes, Paul. *Tracking and the Art of Seeing*. 2nd edition. New York: Harper Collins, 1999.
Stokes, Donald and Lillian Stokes. *Stokes Guide to Animal Tracking and Behavior*. Boston: Little, Brown and Co., 1986.

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Patterns – TRACK DETECTIVES – Activities

FOCUS: Tracks in the snow give us hints about the lives of animals that live nearby. Learning to recognize tracks and sign helps us identify animals and their activities from the clues they leave behind.

PUPPET SHOW "Tracking the Tracker"
Objective: *To learn the four basic patterns of animal tracks and other important sign or clues used to identify animals and their activities.*

Perform or have the children perform the puppet show. Afterward, use the puppets and track pattern props to review the four basic track patterns. What other signs do animals leave behind that give us clues to their behavior and can help us identify them?
Materials: puppets, script, track pattern props.

WALK, WADDLE, HOP AND BOUND
Objective*: To act out the four basic track patterns made by animals when they move and learn the connection between body shape and size to these track pattern variations.*

Start by dividing the children into small groups, and have them crawl on their hands and knees over to their teachers, spread around in the classroom. When they settle in their small group circles, ask which of their limbs moved at the same time as they crawled? (right hand, left knee; left hand, right knee) Hold up the *Walker Movement Pattern* fold-out poster showing how this represents a bobcat's walking pattern. It also illustrates the crawl. Using the *Movement Pattern Notes*, describe the bobcat's body and movement features. Lay out the straight walker pattern on the floor using the footprint ovals introducing the terms stride and straddle as you do so. What is happening with their front and back feet to create just a single line of tracks? (back feet are landing on the ground exactly where the front feet had been). Who walked like this in the puppet show? (deer) Can they think of other animals, similar to the deer and bobcat, that might walk this way? Then hold up puppets, stuffed animals or photos to confirm their correct guesses. (all hoofed animals, cats and also dogs). Have the children pretend to be one of these animals and imitate their straight walker movement patterns. Hold up another *Movement Pattern* fold-out poster and repeat the process for the other movements.
Materials: Footprint ovals (two sizes), cut from non-slip rug padding, 4 *Movement Pattern* fold-out posters, 4 *Movement Pattern Notes* handouts, Four Winds puppets, stuffed animals or photos of representative animals.

PRINT MATCH PUZZLES
Objective: *To compare similarities and differences in size, shape, and number of toes in different animal footprints and match prints with the animals that make them.*

Ahead of time, create a few sets of the *Print Match Puzzles*, enough so that each small group of children can have one. Working in small groups, hand out the puzzle pieces that just show the animals footprints. Look for similarities and differences among the prints. Then ask the children

to sort them based on the number of toes seen in the print. End by asking them to line up the prints from biggest to smallest, then guessing to which animal each print belongs. Confirm their guesses using the remaining puzzle pieces to pair print to animal.
Materials: *Print Match Puzzles*, one set per small group, and each set copied onto a different color of cardstock.

TRACK DETECTIVES SLIDE SHOW
***Objective**: To recognize and compare the tracks of different animals and some common signs of winter activity.*

Show the interactive Track Detective slide show, asking the children to guess each track maker's identity based on clues.
Materials: Track Detective slide show and projector, or Track Detective power point and computer, script, screen.

ANIMAL TRACK SEARCH
***Objective**: To look for animal tracks and sign outside and make guesses as to what the animals were doing.*

Ahead of time, scout on and around the school grounds for signs of animal activity. Working in small groups, head outside to different areas to look for tracks and signs of animals. Try to identify the animals by using the *Pattern and Print Identification* cards. Take turns making up stories about what the animals were doing in their schoolyard.
Materials: *Animal Track Pattern and Print Identification* cards, one per child; other Tracking reference field guides.

TRICKY TRACKS
***Objective**: To practice making and identifying our own tracks and patterns in the snow.*

If you have limited animal activity in the schoolyard, have each small group make their own tracks for the other small groups to guess. Give each small group a few cards from the *Tricky Tracks* handout, so that each has a different set of suggestions. Groups may use these or come up with their own creative ideas to challenge each other. Go to separate areas of the schoolyard and create a set of tracks in untouched snow. If necessary, use brooms to clear away old footprints. Then, together view each group's tracks, guessing how they were created. Each group can confirm, then demonstrate how their tracks were made.
Materials: *Tricky Tracks* handout, copied onto cardstock, cut into cards, and divided between small groups, brooms.

ONCE UPON A TIME TRACK TALES (Grades K-2)
***Objective**: To practice interpreting track stories using pattern, place, prints and other sign as clues to an animal's identity and activity.*

Ahead of time create poster-sized versions of the *Once Upon a Time Track Tales*, using different colored markers for each animal's tracks. Explain that you will be showing them some tracks and sign for them to interpret. Unroll the *Track Tale* scroll slowly, revealing one animal at a time. Ask them: Where the story takes **place**? What is the animal's track or movement **pattern**? Can they identify the **print**? What do they think each of the animals depicted were doing? If time is limited, use the *Once Upon a Time Track Tales* as a closing activity, in place of *Animal Track Booklets*.

Materials: Enlarged version of *Once Upon A Time Track Tales* handout, drawn onto a large sheet of paper, then rolled up like a scroll.

TRACK TALES (Grades 3-6)
***Objective**: To practice interpreting track stories using pattern, place, prints and other sign as clues to an animal's identity and activity.*

Ahead of time make copies of the *Track Tales* and *Track Tale Characters,* one for every pair of children. Explain that they will be examining and interpreting tracks and sign. Pairs should use the *Track Tales Character* sheet to locate one animal at a time, and figure out what it was doing, using the questions as a guide. Remind them to consider: where the story takes **place**, what track or movement **pattern** is depicted, and can they identify any **prints**. What do they think each of the animals in the *Track Tales* were doing? If time is limited, use the *Track Tales* in place of *Track Stamp Stories* as a closing activity.
Materials: *Track Tales* and *Track Tale Characters* handouts, one set per pair of children.

ANIMAL TRACK BOOKLET (Grades K-2) AND JOURNAL ACTIVITY
***Objective**: To review and record some familiar animal tracks.*

Prompt: Use stamps to print one or more different kinds of animal tracks in your journal and label them with the name of the animal. Older children can include information and illustrations about track patterns.
Materials: journals, pencils, track stamps (created using *Track Stamp* kit), inkpads.

TRACK STAMP STORIES (Grades 3-6)
***Objective:** To create a picture that tells a story about animal activities using only crayons and track stamps.*

Ahead of time, create a set of animal track stamps using the *Track Stamp Kit*. Divide the children into twos or threes and give them each an animal stamp. Each team will be making a story without words by drawing and printing with these stamps. Once they have a story plot, children should draw the setting, or place where their animal lives. Next, review their characters' track patterns and then hand out inkpads to use with their stamps. Once completed, taking take turns sharing drawings and guessing their stories.
Materials: Track stamps created using *Track Stamp Kit* plus blocks of wood; large sheets of paper or newsprint; crayons, inkpads.

UPPER GRADES CHALLENGE (Grades 5-6) – SIZING UP TRACKS
Objective: *To use rulers to measure and distinguish between tracks with similar patterns.*

Working in small groups, give children a *Sizing Up Track Sheet* that shows the life-sized prints of animals that make similar track patterns, either a white-footed mouse, chipmunk, red squirrel or gray squirrel. The prints are grouped in sets of four – two front and two hind prints – as they would appear outside. Ask children to measure and record the trail width for each set of prints. All measurements should be taken in centimeters. They should measure ten sets of prints, find the average and compare their measurements for average trail width to those given in the table on the *Sizing Up Track Sheet* (shown below). According to the data gathered, which animal could have made these tracks?

Average Trail Width*

White-footed Mouse	3.5 - 4.5cm
Chipmunk	5 - 8cm
Red Squirrel	7.5 – 11cm
Gray Squirrel	8.25 - 14cm

Answer: chipmunk when using 11 x 17" paper; white-footed mouse on 8 ½ x 11" paper.

*(adapted from Rezendes, Paul. *Tracking and the Art of Seeing*. New York, NY: Harper Collins,1999.)

Materials: For each small group: *Sizing Up Tracks Sheet*, metric ruler, pencil, optional: calculator.

A STEP BEYOND

Sole Search: If snow conditions aren't cooperating, use the *Sole Search* activity adapted from *Project Seasons* where children make a rubbing of their right shoe with paper and crayon. They then trace the outline of their left shoe around their rubbing. Divide into small groups, collect rubbings and have children place their left shoes in a central spot. Hand out the shoe rubbings (don't take your own!) and ask children to study the print for important clues. Then have them inspect the soles of the shoes in the center to find one that matches their print. Take turns, having children explain what clue helped them select a shoe and have the shoe's owner confirm the match and receive their shoe and rubbing back.

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Patterns – TRACK DETECTIVES – Puppet Show

Tracking the Tracker

Characters: Harry Hare, Sally Squirrel, Fiona Fawn, Ollie Otter, Peter Porcupine.
Props: Hopper Pattern, Bounder Pattern, Waddler Pattern, Walker Pattern, Hare Pattern (2X).

Harry Hare Oh boy! Snow on the ground. What fun! *(hopping back and forth)* Hippity-hoppity, hoppity-hippity. *(hold up Hopper Pattern)* Oh, look! Here are some tracks. Four prints together, then a space, then four more together. Maybe I can find a clue about who made these. Hmm…they go right to a tree. I know! These must be squirrel tracks!

Sally Squirrel You're a good track detective, Harry! Those <u>are</u> my tracks.

Hare You must be a hopper like me.

Squirrel Yup. I push off with my front feet, my back feet swing forward and land ahead of them. I can even hop right up a tree trunk. Bet you can't catch me! *(exits; tracks down)*

Hare Now that's a hare-brained idea! Sally's right, though. I am a good track detective…*(hold up Straight-Walker Pattern)* and here are some tracks to sniff out. They're all in a straight line, and all the same size. These are Straight-Walker tracks! They cross the clearing, go into the woods, and (*gasp*) wait a minute. I know who makes a single line of prints—fox and coyote and bobcats! Oh my! This is one set of tracks I better not trail!!

Fiona Fawn Harry Hare! You scared me!

Hare Fiona Fawn? Phew! I forgot that deer are straight-walkers too. A lot of predators make a single line of prints like yours. I'm afraid my curiosity got the better of me.

Fawn You know Harry, they say curiosity killed the cat.

Hare Well, it nearly snared a hare! I'm glad it was just you, Fiona.

Fawn And I'm glad it was you, Harry. Now I'm going to hoof it to the deer yard to join my herd. Bye, Harry. Safe tracking! *(exits; tracks down)*

Hare Bye, Fiona. Now I'd better back track right home. (*hold up Waddler pattern*). But wait, look at these tracks. There's a big print right next to a little print, then a little print by a big one. They alternate. Big, little, little, big. An important clue! I just don't know what it means.

Peter Porcupine Hi, Harry Hare. Are you following me?

Hare Oh, so it's you, Peter Porcupine! I was just looking at your tracks. Your prints are very close together.

Porcupine True. With my short legs and chunky body I can't take very big steps. I move my feet one at a time. My big back feet land next to my smaller front feet as I shift my weight and sway from side to side.

Hare So you're a waddler. But what'll you do when the snow gets deep?

Porcupine You mean <u>waddle</u> I do! (chuckles) Why, I'll just waddle along, same as ever, making a nice deep path in the snow. Makes it easy to get around in winter—following my own trail.

Hare That's fine if you're not in a hurry.

Porcupine Not much reason to hurry if you're a porcupine. I've got a prickly surprise for anyone who tries to "tail" me.

Hare I guess so! But I don't have quills so I have lots of reasons to hurry. Good thing I'm a super hopper.

Porcupine Well hop to it then! Bye Harry. *(exits; tracks down)*

Hare Bye, Peter. *(hold up Bounder Pattern)* Oh, look. Here are some more tracks. Two prints, then a space, then two more prints. These tracks keep going right down to the brook. And it looks like someone went sliding here. Uh oh, I'm sliding too! Heeelp!

Ollie Otter Hello Harry. If you slide on your belly instead of your back, you can paddle then slip right into the water.

Hare Well I don't want to slide, and I certainly don't want to slip into the water! I was just nosing out your tracks and I fell.

Otter Oops! So, what about my tracks?

Hare Well, you've got four feet just like me. So how come your tracks show only two prints at a time?

Otter Because I'm a bounder, like mink and weasel. With my long body and short legs, I can stretch out then arch over like a slinky. My back feet land right where my front feet did, so I only leave two prints in the snow instead of four. You otter try it!

Hare Oh, that wouldn't work for a roly-poly hare like me!

Otter No, I guess not. Well, nice talking to you, but I have to get back to fishing. I'm otterly famished! *(exits; tracks down)*

Hare I'm hungry, too, and I shouldn't be out here in the open. I'd better go home. (*hold up hare tracks*). Wait, what are these tracks? Two small feet and two VERY BIG FEET.

Squirrel Hi, Harry. Still tracking?

Hare You bet! Check out these big footprints. *(walk above tracks towards squirrel).*

Squirrel Gee, they're awfully big. I don't think we should follow those bigfoot tracks!

Hare *(walks back)* Just looking for clues. *(put up 2nd set of hare tracks)* Yikes! Now there are two sets, side by side! There must be two of them!

Squirrel Two Bigfoots?! Harry, I'm scared!

Hare Me, too! We'd better hide! Follow me! (*squirrel hops behind hare*)

Squirrel Hey, wait a minute, Harry. Your back feet are very big.

Hare Yup, I'm called a Snowshoe hare because my big back feet help me travel on top of the snow.

Squirrel Then I think these big-footed hopper tracks are yours, Harry.

Hare Huh? Why, you're right, Sally. Guess I'm not much of a track detective after all.

Squirrel I don't know about that. You're a fine tracker. I'm just glad it's not Bigfoot, or we'd be in big trouble. Bye, Harry. *(exits)*

Hare Bye, Sally. Guess it's time for me to stop playing detective and make tracks for home!

The End

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Patterns – FEATHERING THE NEST – Background

It is illegal to collect birds' nests, feathers or eggs without federal and state collecting permits.

Birds' nests, hidden behind leafy curtains in the summer, often surprise us in the fall when they appear among the newly bare branches of trees. After the first snowfall, nests stand out as little snow-capped baskets perched on limbs or tucked away inside hedges and thickets. Although the birds that built them are probably far away, the size and shape, materials and placement of nests can often give us clues about their identity. Birds build their nests without any prior instruction, and yet each builds a nest that is characteristic of its species.

All birds are **warm-blooded**, and the eggs they lay must be **incubate**d in order for the young to develop and eventually **hatch**. The rounded eggs need to be kept together and kept warm. Both eggs and the **brood**ing parent need protection from predators. A nest keeps the young safely together in one place where the parent can tend them.

The designs of bird nests are related to the habits and habitat of each species. Some birds simply lay their eggs on bare ground or a rock ledge. Others build simple nests on the ground, like the Killdeer, which makes a shallow scrape in the loose gravel, or the Ruffed Grouse, which makes a shallow leafy nest on the forest floor. The downy young of these birds are **precocial**, able to run and hunt for food within hours of hatching, and so spend little time in the nest.

Other birds build more elaborate nests. Many of these have **altricial** young that are helpless and must be fed and cared for by the parents until they have grown their flight feathers and learned how to fly. Some birds build **platform nests**. Doves build loosely woven platforms of twigs. Ospreys and eagles build huge platforms out of branches and sticks that last for many years. Grebes build floating platform nests in wetlands. **Cavity-nesters** like woodpeckers excavate holes in dead trees for their nests, while chickadees find already-hollow trees in which to nest. Kingfishers and Bank Swallows dig tunnels in sandy banks and build their nests deep inside the ground. Some of the most elaborate and carefully woven nests are **cup nests,** the bowl shaped nests that are built by songbirds. Cup nests may sit on a branch, they may fit into the crotch of a tree, or they may hang from a branch. The Red-eyed Vireo builds a **pensile** nest, attached by its rim to a forked twig. Orioles, instead, weave bag-like **pendulous** nests that swing in the breezes, suspended from the tips of twigs, like cradles in the treetops.

Some birds do not build nests or even tend their own eggs. Cowbirds lay their eggs in the nests of other birds. When the baby hatches, it will be fed by the foster parent birds, and often it will push the other nestlings out of the nest. Cuckoos usually build their own nests, but occasionally leave their eggs in other's nests, especially those of other cuckoos.

The location of a nest is critical for its success, and is predictable for each species. Phoebes choose a spot under the eaves of a barn or house and often under a bridge, giving them the nickname, "bridge birds." House Finches are apt to build nests in wreaths or hanging planters, which can be inconvenient for the homeowner. Goldfinches fasten their thistledown-lined cup nests within the upright crotch of a tree or shrub, and Brown Creepers hide their tiny nests behind the loose bark of a standing snag.

The materials used in nest construction give us clues about the nest-builder. Orioles weave their hanging nests out of fibers stripped from the dead stalks of last-year's milkweed plants. Red-wing Blackbirds build their nests out of sedges, rushes, and grasses, using milkweed fibers to bind them to cattails. Robins line their nests with mud that the female molds to the shape of her body like a potter smoothing out a bowl. Red-eyed Vireos decorate their nests with curls of birch bark or paper from hornets' nests. The Ruby-throated Hummingbird shingles its nest with bits of greenish-gray lichen. Chimney Swifts break off twigs with their feet while on the wing, and build delicate shelf-like nests using their sticky saliva for glue. Their Asian cousins, the swiftlets, build nests entirely with their bubbly saliva - a delicacy collected for birds' nest soup.

Some birds include surprising items in their nests. The Great-crested Flycatcher usually includes a snake skin in its cavity nest, but may instead include a strip of plastic. Many species may include colorful yarn, string, or twine found during nest building. House Wren nests usually include a variety of natural materials such as hair, wool, spider egg-cases, strips of bark, moss and feathers, but some have been found to contain hairpins, nails, tacks, staples, hooks, and rusted pieces of wire!

An obvious choice for a soft lining that is warm and insulating is, of course, feathers. In some birds, like Mallard Ducks and Great Horned Owls, the female will pull feathers from her own breast and use them to line her nest. The expression, "feathering one's nest," meaning to enrich oneself, probably comes instead from songbirds like swallows and House Finches that collect other birds' feathers for lining their nests.

The process of nest building and rearing young can have many variations. In many songbird species, the female builds the nest alone. The Bluebird female gathers nest material while the male stands guard on a fencepost, or fights off competitors like Tree Swallows, which may attempt to usurp the nest cavity. In other species, such as in some swallows and waxwings, male and female work together. In the House Wren, the male claims and defends several nest cavities, building a basic nest in each. The female inspects and selects one of these for her use, or rejects them all and starts anew. Nest building generally takes a few days to a week. After that, females will usually lay an egg each day until the **clutch** is complete and then begin incubating. In this way, all the eggs will be ready to hatch at the same time.

The nests of birds, tucked away in nooks and crannies, serve to cradle and conceal both eggs and young. They are the visible results of complex innate behaviors that are critically important to the birds' success in raising young. Comparing nests from different species of birds allows us to notice similarities in form and function as well as differences in location, material and design.

Suggested Reading

Dunning, Joan. *Secrets of the Nest*. Boston: Houghton Mifflin, 1994.

Ehrich, Paul R., David S. Dobkin, and Darryl Wheye. *The Birder's Handbook: A Field Guide to the Natural History of North American Birds*. New York: Simon and Schuster, 1988.

Harrison, Hal H. *A Field Guide to Birds' Nests*. Peterson Field Guide Series. Boston: Houghton Mifflin, 1975.

Stokes, Donald W. and Lillian Q. Stokes. *A Guide to Bird Behavior, vol. I-III*. Boston: Little, Brown, 1983.

Cornell Laboratory of Ornithology website: www.birds.cornell.edu/AllAboutBirds/BirdGuide.

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Patterns – FEATHERING THE NEST – Activities

It is illegal to collect birds' nests, feathers or eggs without federal and state collecting permits.

After handling nests, be sure to wash hands.

FOCUS: Although all birds' nests are made to contain and conceal the eggs, the design and construction of nests varies greatly and is characteristic for each species.

PUPPET SHOW "Birds of a Feather"
Objective: *To meet some common birds and learn about differences in their nest designs.*

Perform the puppet show or have a group of children perform it for the class. Afterward, hold up each bird puppet and ask the children what they remember about the characteristics of its nest.
Materials: puppets, script.

NEST DETECTIVES AND JOURNAL ACTIVITY
Objective: *To examine a variety of birds' nests and inventory the materials used in their construction.*

Ahead of time, place the five nests from the Bird Nest Set at five separate stations. Label each station with the letter listed on the paper tag attached to each nest. Divide the children into small groups. For younger children, an adult should work with each group. For older children, provide each group with lenses, rulers, paper, pencil and clipboard. To begin, assign each group to a different nest and have them examine and draw it as a journal activity, recording shape, size and materials used in construction. Then have groups examine the other nests, station by station, noting similarities and differences. Afterward, discuss as a group what materials were found in each nest. What can be learned about the bird's habitat from its nest? What can they tell about the bird itself from the nest?
Materials: Birds Nest Set (provided), magnifying lenses, rulers, paper, pencils, clipboards.

THAT'S MY NEST! (Grades K-2)
Objective: *To match bird puppets with their nests.*

Have children sit in a circle with the labeled collection of nests from *Nest Detectives* in the center. Using the *That's My Nest!* scripts, have each bird puppet appear in turn and describe its nest to the children. Ask the children to call out the number of the nest they think belongs to each bird. Place each bird puppet with its matching nest.
Materials: Bird Nest Set (provided), *That's My Nest!* scripts, matching bird puppets.

KEYING OUT NESTS (Grades 3-6)
Objective: *To use a dichotomous key to identify five birds' nests.*

This activity works best following the *Nest Detectives* activity. Provide each small group with a *Bird Nest Key and Identification Form* on which to record their answers. Have children examine

a nest, answering the questions in the dichotomous *Bird Nest Key* to try to determine what kind of bird made it. Once they decide the identity of each nest maker, they will write that bird species' name on their form next to the letter that matches the nest tag. If time allows, have groups rotate around the stations until they have had a chance to identify each nest. Afterward, have the children gather in a circle and place the nests, one at a time, in the center. Working together as a class, answer the *Bird Nest Key* questions for each nest to decide the nest maker's identity. Optional: Confirm each nest's identity by having the matching bird puppet describe their nest using the *That's My Nest!* Scripts. Discuss any difficulties they encountered using the key along the way. For younger children, try using the *Bird Nest Flow Chart* instead of the *Bird Nest Key* to identify the nests.
Materials: Bird Nest Set; For each small group: *Bird Nest Key and Identification Form*, magnifying lenses, rulers, pencils; optional *That's My Nest!* Scripts and/or *Bird Nest Flow Chart*.

FEATHERING THE NEST SLIDE SHOW
Objective: *To review some of the different types of nests and the birds that built them.*

Show pictures of a variety of nests from the simplest scrape ground nests, to platform and cup nests; from simple cavity nests to elaborate hanging nests, and if possible, pictures of the birds that made them.
Materials: slides or CD, projector, screen.

CONSTRUCTION CHALLENGE
Objective: *To construct a nest with dried vegetation in order to appreciate the difficulties faced by a bird when building its nest.*

Divide the children into small groups and give them each a sturdy forked branch. (You can provide younger children with berry baskets or paper bowls instead of a branch). This activity can also be done outside, with each small group selecting their own nest site around the school yard, i.e. in shrubs, on fence posts, in the tall grass, etc. Explain that each group will be working together to construct a nest on their branch. Describe the possible nesting materials they may gather outdoors and/or set out a collection of nesting material around the schoolyard, at a distance from the groups. Explain that only one "bird" at a time may collect nesting materials, and they can only pick up one "beakful" (using just the index finger and thumb of one hand as their "beak") at a time. Have children take turns collecting nesting material, holding the branch, and weaving. Tell them they must try to construct a nest that will hold an egg for each member of the group. When they have all finished building, gather in a circle and have each group share their nest design and construction. Then test each nest by carefully placing one egg per group member into their nest. What did the children find to be hardest about nest building? Display the nests around the classroom or disassemble them and place useful building materials outside for real birds to use.
Materials: sturdy forked twigs, one per group; nesting material such as dried grasses, cattails, irises or lilies; a bag of foil-covered chocolate eggs or small stones. Optional: manmade materials such as yarn, string or raffia, pipe-cleaners, shredded paper.

UPPER GRADES CHALLENGE (Grades 5-6) – BLUEBIRD NEST BOXES
Objective: *To provide a home for a bluebird or other cavity-nester.*

Ahead of time, prepare the wood for building several bluebird houses. Depending on the amount of time available, you may wish to cut the pieces ahead of time and pre-drill holes for screws.

Have children work in small groups to assemble the houses. They may nail or screw the pieces together following the instructions on the *Bluebird Nest Box Plans.*

When the houses are assembled, bring the children outside to install them. Discuss bluebirds' preferences (east or south-facing, near a mowed field or lawn, hole 4-5 feet off the ground, nearby bushes for young to fly when they fledge but at least 100 feet from wooded area.) Choose some likely sites to mount the birdhouses, being sure they are at least 100 feet apart.

Have children watch the boxes for birds investigating or nesting in them. This may take a few hours to a few days or weeks. Why is there so much competition for nesting cavities?
Materials: *Bluebird Nest Box Plans*, six feet of 1"x6" board for each house, saw, nails or screws, drill, 1 ½" butterfly bit.

A STEP BEYOND
For the Birds: Have the children poke pieces of yarn, string, dryer lint, or batting into an old mesh onion or produce bag. Keep nest material pieces shorter than 3" to avoid entangling nestlings. Dog, cat, horse, human, or rabbit fur combings and clippings are a great favorite of nest builders. Hang this nesting material bag outside on a nearby tree and watch to see if any birds come to take pieces. Which textures or colors are most popular? Go on a nest hunt and see if you can find a nest that contains some of the materials you provided?
Draw a Nest: Have children draw or paint a picture of their favorite bird on its nest. Help students find out where the bird builds its nest, what type of nest it uses, and what kind of habitat it might choose for nesting. Could they find this bird near where they live?
Nest Search: Take the children on a walk around the school grounds or through the neighborhood to look for nests or potential nesting sites. How would these nesting sites be different in spring and summer, and how would that help the birds? What nesting materials might birds use?
If in a city environment, ask what birds normally nest in the city? Where? Then, have pairs of children pretend to be birds looking for nesting sites. Assign each pair a specific kind of common city bird: robins, jays, pigeons, house sparrows, woodpeckers, phoebes, chickadees, or chimney swifts. When choosing a nesting site for their bird, children should consider: What food is nearby? What predators (including pets) might pose a threat? Some birds find that the dense branches of ornamental shrubs or cedar hedges make well-hidden nesting locations. Some birds prefer nesting in garages or on buildings; for example, pigeons and phoebes make nests under eaves, on building ledges or on air conditioners. A dead tree or a hole in a building may provide a cavity for nesting. A ground nester might find a suitable spot in a backyard, park, or rooftop.

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Patterns – FEATHERING THE NEST – Puppet Show

Birds of a Feather

Characters: *Mrs. Bluebird, Mr. Bluebird, Red-eyed Vireo, Phoebe, Goldfinch*

Mrs. Bluebird Well, that's the last straw!

Mr. Bluebird What is it, my dear? Is something the matter?

Mrs. Bluebird The matter? No, I just said that's the last straw. I've just added the last piece of straw to our nest, and now it's done.

Mr. Bluebird And a more beautiful nest I've never seen. I always admire your great talent in nest building. It must have been hard to learn.

Mrs. Bluebird Why no, not at all. I just seemed to know what to do. It must be instinct.

Mr. Bluebird And I suppose now you'll be starting to incubate our eggs.

Mrs. Bluebird Well, not just yet, dear. After all, I'll only lay one egg a day until I have a full clutch – say 3 or 4 eggs - and then it'll be time to incubate. That way, all our babies will arrive at the same time.

Mr. Bluebird And they'll all be ready to learn to fly at the same time. That's what I call good planning. [*tapping noise*]. Uh oh, sounds like an intruder looking for a nest box just like ours. Well, he'd better look somewhere else or he'll have me to deal with! [*exits*]

Mrs. Bluebird There's so much competition for nest cavities. It's nearly a full-time job for my mate just to keep intruders away.

Mr. Bluebird [*returning*] Well, I took care of him!

Mrs. Bluebird Who was it this time, dear?

Mr. Bluebird That was a house wren trying to bring a twig in here to start a nest.

Mrs. Bluebird The idea! Do the male house wrens build the nests instead of the females?

Mr. Bluebird Not really. The males start nests of twigs wherever they can find a good cavity. When the female comes along, she'll pick one of his nests and then rebuild it to suit herself. She adds feathers and grasses and even spider egg cases.

Mrs. Bluebird Such clutter!

Mr. Bluebird Some birds put all kinds of things into their nests, like hair, bark, spider silk. Why, the Great Crested Flycatcher often puts in a snake skin!

Mrs. Bluebird [*shudders*] Ooo! Makes my feathers stand on end. I think I need a bit of fresh air. Is the coast clear?

Mr. Bluebird All clear for take-off. [*Mrs. Bluebird exits; Vireo enters*]

Red-eyed Vireo Did I hear you mention spider silk-eo?

Mr. Bluebird Who are you? I haven't seen you in these parts before.

Vireo If you want to know me, dear-eo, then come a little near-eo. Look at my eyes, and not at my ear-eos!

Mr. Bluebird You've got red eyes – hey, you must be the Red-eyed Vireo.

Vireo Hear, hear, hear-eo, I am a Vireo! I'm not much to look at, but my nest is very dear-eo. I hang it from a branch with spider silk, and cover it with birch bark curl-eos.

Mr. Bluebird Sounds very fancy. You must hate to leave behind such a nice nest every fall.

Vireo Yes, I shed a tear-eo. But those old nests might have parasites in them. And, besides, after the winter, they're very mess-eo. It's better to start fresh-eo. So, Cheerio, Mr. Blue, I must get right to work! [*exits*]

Mr. Bluebird Cheerio, Vireo. [*Phoebe enters*]

Mr. Phoebe Phoebe, Phoebe! Phoebe, Phoebe! Now where is she?

Mr. Bluebird Hello, are you looking for someone?

Phoebe Well, what do you think, buddy. I'm looking for my wife, Phoebe. Phoebe! I've got a great piece of real estate I want to show her.

Mr. Bluebird Not this real estate! This is my house!

Phoebe Hey, don't get all ruffled, Feathers! I'm not looking for a cavity. We Phoebes build our nests on ledges – in barns, on houses, and if we're really lucky, we get a spot under a bridge.

Mr. Bluebird I've heard you called "bridge birds."

Phoebe Sure, and it's not because we play a lot of cards!

Mr. Bluebird How do you Phoebes get your nests to stay up there?

Phoebe Oh, that's easy. We start with a little mud. Dries hard as cement and sticks like glue.

Mr. Bluebird I've heard of birds using mud for nest-building – like robins and wood thrushes.

Phoebe Don't forget barn swallows. Sometimes we build our nests on top of old swallows' nests, and sometimes they use ours. Hey, I'd better stake out my territory before someone else gets there first. Phoebe, Phoebe! [*exits; Goldfinch enters*]

Mr. Goldfinch Potato chip, potato chip.

Mr. Bluebird Hello, Goldfinch. You don't seem to be busy defending a nest.

Goldfinch Nah, competition for nest sites is too high in the spring. You ought to do what we Goldfinches do.

Mr. Bluebird What's that?

Goldfinch Well, we wait until later in the summer when the thistles bloom and go to seed. Then we have plenty of thistle seed to feed our families, and we can line our nests with thistle down. It makes a fine, soft cradle.

Mr. Bluebird Well, that may be a great idea for Goldfinches, but we bluebirds don't eat thistle seeds. We eat insects. And we don't line our nests with thistle down. We prefer grasses.

Goldfinch Well, guess you'll do what works for you. I've got to fly! [*Exits*]

Mr. Bluebird Good bye! [*Mrs. Bluebird enters*]

Mrs. Bluebird Hello, dear. You look troubled. What's the matter?

Mr. Bluebird Barns and bridges! Spider silk, snake skins, and thistle down! What a bunch of bird-brained ideas!

Mrs. Bluebird What <u>are</u> you talking about?

Mr. Bluebird Feathering the nest, that's what! But I think we should stick with our plain nest of grasses. It's simple but elegant.

Mrs. Bluebird I'm happy you like it, dear. I guess you and I are just birds of a feather.

Mr. Bluebird That we are, Mrs. Blue. That we are!

The End

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Patterns – ANIMAL DISGUISE AND SURPRISE – Background

Insects in leaf litter, birds in thickets, frogs on the pond's edge, all around us animals are hidden in plain sight. They have evolved a myriad of different disguises in response to constant pressure from keen-eyed predators. Animals can be variously colored, patterned or shaped to blend into their surroundings, their disguise being most effective when they remain perfectly still. While some animals are concealed by **camouflage**, others warn off predators with bright colors, announcing danger, in the form of bad taste, smell or poison. While avoiding being eaten is an obvious benefit of effective camouflage, the ability to go unnoticed helps predators, too. It allows them to get closer to their prey before attacking, thus increasing their chances of success. In the end, whether predator or prey, those with the best disguise or surprise increase their chances of survival so that they might pass along these important characteristics to their offspring.

Many animals avoid detection because either their color or shape creates an effective disguise. **Matching color** is the most common kind of disguise, where skin, feathers, or fur are colored to match elements in the environment. Some animals are the same color as their typical habitat while others are patterned so they blend in with the food they eat or habitat in which they live. These animals can practically disappear when at rest; however any quick movement might draw the attention of a watchful predator or nervous prey.

Some animals change their color with the season to blend in with their surroundings. To get ready for winter, the Snowshoe Hare and Short-tailed Weasel's coats change color from brown to white, making each less conspicuous when the ground is covered with snow. Even large animals can blend in with their surroundings. The White-tailed Deer changes its reddish-brown summer coat to a grayish one that better matches the colors in the winter woods.

The matching coloration of many female birds keeps them hidden when they are nesting and caring for young. From camouflaged eggs to newly hatched chicks, blending in with the surroundings protects animals from potential predators.

Sometimes the shape of an animal helps it go unnoticed. Many insects are shaped to look like something unpalatable in their environment. Walking sticks look like slender twigs with branches; thorn bugs both look and act like thorns, orienting themselves lengthwise on a branch; while some caterpillars look like bird droppings.

Many animals display **disruptive coloration** – a series of patterns, spots, or stripes that break up the outline of the animal's body, protecting them by making their shapes hard to discern. A fawn's white spots look like sun-dappled leaves on the forest floor so it can lay hidden while its mother is away feeding. A Raccoon's telltale round black eyes are hidden in its black eye mask, eliminating an important clue to its presence. And the matching stripes on a Green Frog's legs when at rest create false contours that confuse would-be predators.

The effect of light and shadow helps many animals remain hidden. One color pattern, with a lighter underside and darker upper body, is called **countershading** and is especially common in birds and many aquatic animals. The animal blends in with the light sky when viewed from below and with the shaded ground when seen from above. So the light belly of a frog blends in with light on the water's surface when seen from below. And its dark-patterned back blends in with the bottom of the pond when viewed from above. This pattern also balances the sunlight on an animal's back and obscures the shadow below so that its side profile also blends in with its surroundings.

Some creatures have a different strategy for concealment called **masking**. They create a protective covering from materials that are common in their habitat. Not only does it provide camouflage, but it also provides a structure to hide inside. The larva of the caddisfly makes a home out of sand grains, small rocks, or bits of vegetation it picks up from the stream or pond bottom where it lives. Bagworm larvae hide themselves within cases made from nearby twigs and leaves. Spittlebugs hide in a self-made disguise of bubbles. These immature plant hoppers (nymphs) feed on the juices of plants. Excess sap is extruded out their abdomen and mixed with air to create a soapy foam that covers and hides them from view. In addition to concealment, the foam offers air-conditioned comfort, protection from drying out and is thought to be distasteful to predators.

In contrast to animals with cryptic coloration, some are striking in the boldness of their colors. Bright **warning coloration**, like the prominent black and white coloring of a skunk, is protective because it warns others to stay away! White, yellow, red, and orange with conspicuous yet simple black markings are common warning colors. Animals sporting these colors are often bad tasting, foul smelling, poisonous, or can bite, sting or otherwise irritate anything that might try to eat them. Potential predators learn this from experience and avoid brightly colored creatures. Insects like Monarch Butterflies with their brilliant orange and black wings, and bumblebees with bright yellow and black striping, employ this strategy for survival. Warning colors are a way for animals to advertise unpleasantness and their unsuitability as food, and so avoid being hunted.

The art of disguising one's true identity by resembling the color, shape or behavior of another unrelated animal is a form of protection called **mimicry**. There are two different types of mimicry. One is Mullerian mimicry- where both animals are noxious and benefit from mutual protection. The other is Batesian; here an animal gets protection by resembling a noxious animal but is not so oneself. The Viceroy Butterfly, whose color pattern mimics the Monarch, was long thought to be a form of Batesian mimicry. Scientists recently discovered that Viceroys, too, taste unpleasant, thanks to a diet of willow, so both they and Monarchs employ Mullerian mimicry as protection from predators, who quickly learn to avoid their black and orange colors.

Sometimes an animal has a second line of defense it uses if discovered**.** Often drab-colored animals, which usually go unnoticed, have hidden markings resembling a head or eyes that can be used to divert attention away from the animals' main body. If approached, it uses **flash coloration,** displaying these hidden markings to surprise and distract would-be predators. These markings appear aggressive and can startle or intimidate a predator who either hesitates long enough for prey to get away or simply leaves it alone. So when an Io Moth senses danger, it spreads its wings and flashes the large colorful owl-like "eyes" on its under-wings, startling would-be predators, and allowing the moth a split second to escape.

Some animals are brightly colored to announce their presence to others of their species. The bright colors of many male birds help them be seen by others of their species when they are setting up territory and trying to attract a mate.

To be seen, or not to be seen, that is the question. Many wonderful examples of camouflage and warning colors can be found among animals that live in our own backyard. Next time you are outside, see if you can find any animals hidden in plain sight. Looking for them makes for a challenging game of hide and seek!

Suggested Reading

Attenborough, David. *The Trials of Life: A Natural History of Animal Behavior*. London: Little, Brown and Company, 1990.

Eiseman, Charley and Noah Charney. *Tracks and Sign of Insects and Other Invertebrates: A Guide to North American Species.* Mechanicsburg, PA: Stackpole, 2010.

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Patterns – ANIMAL DISGUISE AND SURPRISE – Activities

FOCUS: All around you there may be animals hidden in plain sight. They can be variously colored, patterned or shaped to blend into their surroundings. Some animals are concealed by camouflage, while others warn off predators with bright colors. Those with the best disguise or surprise will survive and pass along these important characteristics to their offspring.

PUPPET SHOW
Objective: To introduce some different types of animal disguise or protective coloration.

Perform the puppet show, or have a group of children perform it for the class. Afterward, review the type of protective coloration exhibited by each of the characters in the puppet show.
Materials: puppets, script.

HIDE AND SEEK SHAPES
Objective: To use camouflage to hide cutout shapes on backgrounds of matching color and pattern.

K-2 version: Beforehand, cut insect shapes out of different multicolored and patterned wrapping papers or wallpaper samples, using the template provided. Cut enough so that there are one or two insect cutouts per child. Cut matching 8x11″ rectangles of the each of the paper patterns. Place these paper rectangles on tables around the room. Give each child 1-2 insect cutouts. Have them place their insect cutout on the paper that would provide the best hiding place. Take a tour to try and find everyone's hidden insect. What do real animals have to do to stay hidden? (*Blend in with its specific environment; be still or move very slowly*) Where would your insect really stand out and be especially visible?

3-6 grade version: Working in small groups, have the children select a wrapping or wallpaper sample. Have them cut an 8x11″ piece off their sample to use as background. Using the remaining paper, have them cut out 5-8 secret shapes, no smaller than their thumbnails, to hide on their background paper, carefully gluing them flat. Have 2-3 small groups stand in a circle and take turns placing their background paper on the floor in the center of the circle. The other children should try to find as many of the shapes as they can. Hold the paper up to the light to reveal the location of all of the hidden shapes. Repeat until each group has had a chance to share their work.
Materials: Assortment of colorful and patterned wrapping paper or wallpaper samples, scissors, glue sticks. *For K-2: Insect Shape template*

ANIMAL DISGUISE AND SURPRISE SLIDE SHOW
Objective: To see examples of different types of protective coloration.

Show photographs of the different types of protective coloration—matching color, disruptive coloration, countershading, masking, warning and flash coloration. Can the children think of examples of other animals displaying these types of coloration patterns?
Materials: Animal Disguise slide show and script, projector, screen.

COLOR HUNT AND PECK
Objective: To experience how color can help objects blend in or stand out.

(This activity works best with smaller groups. Divide the class in half. Have one group start with Color Hunt and Peck while the other does Where in the Wild, then have the two groups switch. Set up two Hunt and Peck areas so the second is ready to go when the next group arrives.)

Beforehand, scatter 100 pieces of different colored yarn, one at a time, in a designated "feeding" area or "worm yard", marking the boundaries with cones. Have children line up shoulder to shoulder, facing you, with their backs to the feeding area. Explain that they will pretend to be hungry birds hunting for food. Their food, worms represented by colored lengths of yarn, can only be picked up one at time, using their "beak" - their thumb and forefinger pinched together. They will have 10-15 seconds to gather as much food as they can. Tell children on "go!" they will turn around and begin to hunt for worms. When you say "stop!" have all the children come together. To tally results, designate different children to collect one of the different colors of yarn from their classmates. Give each of them a container or sign labeled with the color they are collecting. Ask the children collecting yarn to count up the number of "worms" found. Have them line up from highest number of worms collected to least. Which color of worm was the easiest to find? Which was the hardest? Any ideas why? Give the children a second chance to find and collect the remaining worms -- noting that the remaining worms are the survivors and will make the next generation of worms.
Materials: 2-inch pieces of different colored yarn or elastic hair ties (100 total: 5-10 colors; 20-10 pieces of each); containers or signs labeled with each of the colors used (for collecting samples after each round).

WHERE IN THE WILD?
Objective*: To search for household objects along a trail, noting how color, texture and shape can make them hard to detect.*

(This activity works best in smaller groups. Divide the class in half. Have one group start with Where in the Wild while the other does Color Hunt and Peck, then have the two groups switch.)

Ahead of time, hide 10-20 household objects along a trail, school garden path or the edge of a playground. Explain to the children that they will be searching for objects you have placed along both sides of a trail. Ask them to quietly keep a count of the objects seen and not to speak or point to any of them. Lead the children along the trail, walking single file. When everyone is finished, ask them to share the number of objects seen. Which one was the hardest one to find/see? Finish by walking back along the path, allowing each child to reveal/share the location of one object.
Materials: 10-20 household objects or toys, which could include a metal coat hanger, wooden ruler, wooden clothes pin clipped on a low branch, old toothbrush, plastic comb, rubber duck, etc., list of objects used, collecting bag.

CRITTER CAMOUFLAGE
Objective: To construct a model of a creature that will blend in a chosen habitat.

Working in small groups, have the children choose a nearby location (patch of grass, shrub, garden bed) then each build a creature that blends in with this habitat/environment. They can construct their creatures using both materials you provide and any they can find outside. When

completed they should secretly place their critter in its habitat. Lead the children on a tour to each of the habitats to see if they can find the hidden critters. Clues to each critter may be given as needed. (This activity can be done indoors if necessary, assigning each group a different location in the classroom.)
Materials: Assorted materials including twigs, popsicle sticks, coffee stirrers, colored tissue and construction paper, fabric, pipe cleaners, modeling clay, glue, scissors, markers, tape.

UPPER GRADE CHALLENGE (Grades 5-6) – DISGUISE OR SURPRISE?
Objective: To test one of the types of protective coloration by building a creature designed to either blend in or stand out in a particular location.

Have students work singly or in pairs to build an animal model out of various materials that you provide. The animal should be disguised to occupy a particular habitat or microhabitat that the students choose, either outdoors or inside the classroom. Students should consider the different protective coloration strategies discussed throughout the lesson (and listed below) and choose one of these as a defense for their critter. Have the students place their completed critters in the chosen habitat. Now lead the students on a tour of the different habitats giving them a chance to discover the hidden creatures. Afterward, have each team introduce the disguise strategies they designed for their critter.

PROTECTIVE COLORATION

Matching color of background
Matching texture and color of background
Matching shape and color of background *(looking like a twig)*
Masking *(attaching debris to body)*
Disruptive coloration *(high-contrast stripes or spots that interrupt body shape)*
Counter-shading *(light underside, dark upper)*
Warning coloration *(yellow, red, or orange-with or without black markings; or black and white)*
Looking scary *(puffing up)*
Flash-coloration *(eye spots)*
Mimicry *(looking like a poisonous or stinging animal)*
Diverting structures *(antennae-like tentacles on tail)*

If approached by a predator, how would each of these critters behave? How is behavior a necessary part of any deception?
Materials: *Kinds of Protective Coloration Chart*, twigs, popsicle sticks or coffee stirrers, pipe cleaners, yarn, many colors of tissue or construction paper, fabric, markers, modeling clay, glue, scissors, tape.

JOURNAL ACTIVITY
Objective: To create a setting in which a creature blends in using color, shape, etc.

Give each student an insect cutout made of colorful paper or cut from a magazine. Have the children glue the insect into their journal and then draw a habitat in which it can hide.
Prompt K-2: Draw a habitat in which your insect can hide.
Or
Prompt 3-6: Draw a hidden insect picture. Share with your neighbors to see if they can find the insect hidden in your drawing.
Materials: Paper or science journals; clipboards and drawing materials

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Patterns – ANIMAL DISGUISE AND SURPRISE – Puppet Show

Characters*: Beulah Bumblebee, Greta Grouse, Wilbur Walkingstick, Farley Fawn, Benny Bagworm, Eddy Eft*
Props: branch

Beulah Bumblebee
How nice to be a bumblebee,
Flying along as free as free.
Gathering nectar from flowers I see,
To feed my bumble-y sisters and me!
(Grouse enters) Oh! Hello! Who are you?

Greta Grouse I'm Greta Grouse.

Bumblebee I'm Beulah Bumblebee. This is my first day out of the nest. I have to gather nectar for honey. It feels grand!

Grouse Well, that's good, Beulah, but you'd better watch out. There are lots of animals that would love to eat a nice plump insect like you.

Bumblebee Really? What kind of animals? Animals like you?

Grouse Oh no. We grouse like buds and seeds. But lots of animals do like to eat insects – toads, skunks, foxes…

Bumblebee Oh dear! And do they eat grouse, too?

Grouse Some of them do! We have to look out for hawks, owls, foxes, coyotes…

Bumblebee Well, then, how do you keep from being eaten?

Grouse Oh, that's easy.
My feathers are colored to match the forest floor, so it's easy to hide here if I stay still. That's my secret to staying alive!

Bumblebee You're lucky! With my black and yellow colors, I stand out anywhere. I think I need a different way of fooling those insect-eaters.

Grouse I guess you do. Well, good luck. Time for me to do my disappearing act. So long. *(exits)*

Bumblebee Bye, Greta.
How nice to be a bumblebee
Flying along as free as free.
But I wish I weren't so easy to see,
By things that want to eat me!
(Walkingstick enters) Uh oh! Who are you? And wh-wh-what do you eat?

Wilbur Walkingstick Wilbur Walkingstick's my name; eating plants is my game! Stick with me and you'll be safe.

Bumblebee That's a relief. I'm worried about all those animals that might want to eat me. I can't blend in like a grouse. How do you stay safe?

Walkingstick That's easy. Turn your back a minute, and when you turn around again, try to find me. *(Bee turns away, Walkingstick moves in front of branch).*

Bumblebee *(turns back)* Now where'd he go? Wilbur, where are you? *(Walkingstick moves).* Why, there you are! You look just like a twig!

Walkingstick There's nothing to it, Beulah. I'm shaped like a twig, so if I stand still, everyone thinks I'm just part of the branch.

Bumblebee That's a great way for you to stay safe, Wilbur, but I sure don't look like a twig. I'm as plump as a blackberry!

Walkingstick You are kind of plump. And fuzzy too. No, you don't look anything like a twig! Guess you can't stick with me after all. So long! *(exits)*

Bumblebee Bye Wilbur.
Oh woe to be a bumblebee,
I hope no one is after me!
I better collect some nectar and hurry home. (*Fawn enters*) Why here's a patch of white flowers.

Farley Fawn Hey, those aren't flowers. They're my spots!

Bumblebee A fawn! I couldn't see you!

Fawn I'm Farley Fawn and I'm pretty hard to spot! Get it?

Bumblebee I do, but it's surprising because your spots are very bright.

Fawn Even so, they make it hard for a predator to see my shape – as long as I stay very still, and don't make a sound…Oops! I'm not supposed to talk!

Bumblebee Well I won't give you away. I've got to find some flowers and get back home before I get eaten! So long, Farley. (*fawn exits*)
How sad to be a bumbling bee
With no white spots disguising me.

Benny Bagworm Psst. You could hide like me.

Bumblebee Who's there? I can hear you, but I can't see you – unless you're inside that bundle of sticks.

Bagworm That's just where I am. Here, I'll show you. *(pokes head out of case)* Benny Bagworm, at your service.

Bumblebee Wow! You've got a cover made of tiny sticks!

Bagworm That's right, I made this case from bits of plants glued together. It's very safe.

Bumblebee I couldn't fly with all those sticks on my back.

Bagworm I guess that would be hard for you with those wings. I'm a larva – so I don't have wings yet.

Bumblebee I guess a case won't work for me.

Bagworm I guess not. Well, good luck, Beulah! And in case you need my help, I'll be hanging around somewhere nearby. So long. *(exits)*

Bumblebee G'bye, Benny Bagworm.
Gee it's sad to be a bee.
Wish I could hide more easily!

Eddy Eft But you don't have to hide Beulah, and neither do I!

Bumblebee Why, hello Eddy Eft. What do you mean we don't have to hide?

Eft I mean we don't have to worry about being eaten. You have a stinger, don't you? And I taste very bad. No one dares to eat us.

Bumblebee But my stinger's so tiny, no one can see it. And how would any animal know that you taste bad until they take a bite of you?

Eft If an animal tastes an orange eft once, it will never, ever, want to eat an orange animal again.

Bumblebee Oh, I get it! If something tries to eat a bee, it will get stung and then it will never, ever, eat a black and yellow insect again!

Eft That's right! We have warning colors that tell other animals to stay away.

Bumblebee So I don't have to hide or look like something else or make a case to live in?

Eft That's right, Beulah. Hiding works for other animals, but our bright colors help us to be safe.

Bumblebee Gee, thanks, Eddy Eft!
Oh joy to be a bumblebee
Buzzing very busily,
Flying along as free as free,
My warning colors protecting me!

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Patterns – FROGS and TOADS – Background

The warm rains of spring awaken an explosion of activity in our nearby pools, ponds and muddy puddles. If you visit at dusk, you are sure to be greeted by a chorus of many and varied voices as one or more species of frogs comes a-courting, in a celebration of sound. This singing is an important part of their yearly breeding cycle and provides the music for spring and summer nights.

Frogs and toads, along with salamanders, are classified as **amphibians**. The word amphibian is from the Greek words meaning double life and refers to the fact that these animals have "two lives" – a larval stage and an adult stage that are often very different from each other. Most amphibians begin their lives in water and as adults are able to live on land, often returning to water to breed. They undergo an amazing transformation, or **metamorphosis**, from aquatic larva to terrestrial adult involving physiological, anatomical and behavioral changes.

With very few exceptions, amphibians lay their eggs in water. The eggs are encased in a clear, translucent jelly that protects the developing embryo. The number of eggs laid, their appearance, and the shape of the egg masses vary from species to species and can be used as an aid to identification. The round, gelatinous egg masses of the Wood Frog can contain 2,000 to 3,000 eggs while a Bullfrog lays as many as 20,000 eggs in a surface-floating mass. Spring Peepers can lay up to 900 individual eggs, attaching them to submerged vegetation, whereas the American Toad lays long, double spiral strings of eggs encased in jelly, which can contain over 1,500 eggs each. Spotted Salamanders attach their oval egg mass to twigs floating in the water while Red-spotted Newts lay their tiny eggs singly on underwater plants and sunken leaf litter. The time it takes for these eggs to hatch varies by species and ranges from days to weeks.

The larvae that hatch from the frogs' eggs are called **tadpoles** or **polliwogs**, bearing little resemblance to their parents. A tadpole's all-in-one head and body are undifferentiated, forming a round or oblong shape, ending in strong, keeled tail to aid in swimming. They have small eyes on the sides of their head and **gills** for breathing underwater. Tadpoles have tiny mouths with specialized mouthparts to help them gather minute algae and bacteria that are either free-floating or scraped off rock surfaces or leaf litter on the pond bottom. The rate at which they grow and the length of time it takes to develop depends on the species as well as food availability and water temperature. Wood Frog tadpoles may transform in a little more than two months, whereas a Bullfrog can spend two winters as a tadpole, transforming in its third summer.

Over time, these tadpoles undergo an amazing transformation, which includes a major revamping of body shape along with incredible internal and external changes. First hind legs form and begin to grow. Their eyes develop lids, start to bulge and migrate to the top of their heads. The tiny mouth broadens to hold a long sticky tongue. The whole digestive tract changes to match the change in diet from herbivore to carnivore. Lungs develop to replace gills, allowing for life and breath out of water. Lung development is complete once front legs are noted, as they often erupt through the old gill openings! Gradually the tail is absorbed into their body and disappears. The transformation from tadpole to frog is then complete.

There are nine families of frogs in North America, each with unique physical and behavioral adaptations that distinguish one group from another. The family of true frogs (Ranidae) includes many of the "pond frogs" commonly encountered by children (Bullfrog, Green Frog, Pickerel Frog, Leopard Frog). Most have large, jumping hind legs and hind toes that are connected by webbing. Members of the tree frog family (Hylidae), on the other hand, are relatively small and most species have rounded sticky discs on their un-webbed toes that make their life in the trees easier (Spring Peepers, Gray Treefrogs). And the true toads (Bufonidae), like the familiar American Toad, have thick skin and short hind legs.

Certain physical characteristics can be used to identify frogs. Look for **dorso-lateral ridges**, two raised ridges of skin running down a frog's back. The presence or absence of these can be used to separate look-alike species – Green Frogs have a ridge running down their back, Bullfrogs do not. Distinctive patterns or marking can also help distinguish one species of frog from another. Eye patches, the shape and color of spots, striped versus spotted legs, even a hidden flash of color underneath hind legs are **field marks** that can aid in identification.

The various sounds frogs make is another important clue to identification as each species of frog has its own distinct call. In spring and early summer, males gather in pools and ponds to breed and make their presence know with loud advertisement calls to attract females. Males have **vocal sacs** that they inflate when calling to amplify their songs. They make an impressive assortment of sounds from croaks, peeps, trills, barks, and snores. The duck-like "quack" of Wood Frogs is usually the first call to be heard in the spring, followed by the sharp, piercing peeps of the Spring Peeper. Later in spring, the American Toad's long, high trill can be heard, lasting up to a minute. Green Frogs are recognized by a dull "katunk," reminiscent of the plucking of a loose banjo string, while Bullfrogs make a deep, throaty "jug-o-rum" call. Once breeding is complete, the chorus of frog voices quiets. Intermittent calls may come from the pond and surrounding vegetation, but the symphony of frog voices is silent until courting season comes again next spring.

The symphony of spring is sung in a thousand small voices, calling you outside to explore pools, ponds and wetlands.

Suggested Reading

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Patterns in Nature – FROGS and TOADS – Activities

FOCUS: Wetlands come alive in spring as frogs and toads serenade us with their chorus of voices. We'll learn to distinguish who's who in the pond by studying different amphibians and their pattern of development, observing field marks of frogs, and listening closely to their distinct songs. A field trip to a frog pond is a must!

PUPPET SHOW

Objective: To learn about the basic characteristics of amphibians, their pattern of development, and some variations that distinguish one amphibian from another.

Perform the puppet show. Afterward, ask the children to list the key characteristics that make amphibians different from other animals. Why were they given a name that means, "two lives"? (They live part of their lives in water, breathing with gills, and part on land, breathing with lungs.) Discuss differences among the different kinds of amphibians, and between the frog and toad, in the puppet show.
Materials: puppets, script, props.

AMPHIBIAN LIFE CYCLE SORT

Objective: To sequence and review the life cycle of three common species of amphibians, noting similarities and differences in their patterns of development.

Divide the children into three small groups and hang a *Life Cycle Sort card* around each child's neck. Challenge them to put their cards in order by lining up from the youngest to the oldest stage in their amphibian's life. Review the stages and ask them to turn their lines into circles to show how the life cycle stages repeat themselves over time.
To make this more difficult for older children, hang the cards on their backs, where they can see other children's cards, but not their own. Ask them to work together to line themselves up without talking. When it comes time to reveal/review the life cycle stages in order, have each child guess the stage depicted on his or her card from observations made of the stages depicted on the other children's cards.
Afterward, as a whole group, review similarities and differences in each amphibian's pattern of growth. Note how all share the same life cycles stages, and yet differ in shape, color, etc.
Materials: Three sets of *Life Cycle Sort cards*, with strings to hang them by; *Life Cycle Sort charts* for Frog, Toad and Spotted Newt

FROG LOOK AND LISTEN

Objective: To observe similarities and differences among some common frogs by viewing photos and listening to their calls.

Show slides of five to nine species of common frogs, noting the distinguishing characteristics or field marks of each. While viewing each slide, play an audio recording of that species's call. Ask the children to imitate each call and describe what it sounds like. Show only the first five frogs for grades K-2. Now display all the frog photos together on a poster or slide. Play the calls again, in a different sequence, asking students to identify which frog is singing which song.
Materials: frog slide show and frog call audio CD or frog PowerPoint with audio.

FROG FINDER JOURNAL ACTIVITY (Grades 3-6)
Objective: To create a visual and audio field guide to identify common frogs.

Before viewing the slide show, pass out *Frog Finder ID sheets* and colored pencils. Tell the students they will be using these sheets to create their own field guide to help them identify some common frogs and toads. After viewing each frog photo and listening to its call, they will use colored pencils to diagram important field marks and note distinctive features of each species's call on their *Frog Finder ID sheet.*
Materials: frog slide show and frog call audio CD or frog PowerPoint with audio; for each student: *Frog Finder ID sheet* and colored pencils.

JOURNAL ACTIVITY (Grades K-2)
Objective: To record observations about some common frogs.

For younger students, have them draw and color one or more of their favorite frogs or provide them with pictures of frogs from the *Frog Finder ID* sheet or *Calling All Frogs cards*. Have children glue pictures of their three favorite frogs in their journals and write what each one's call sounds like.
Materials: journal or paper, *Frog Finder ID* sheet or *Calling All Frogs cards*, colored pencils, scissors, glue.

GOING ON A FROG HUNT
Objective: To look for frogs and other amphibians at a pond or wetland.

Ahead of time, scout out a frog pond and get permission from the landowner to use the site. Find a place where there is easy access for everyone.
Before going to the pond, remind children that amphibians are very fragile creatures and need to be handled with care. With younger children, use toy frogs to practice the correct way to handle frogs; either "caged" in your hands, or by the legs, but not grasped around the middle. If you have nets, let the children practice catching small objects and scooping them up in the net. Remind them that whatever is on our hands can pass through the frog's permeable skin and might harm them. Have children wash hands ahead of time so they are free of bug repellant, suntan lotion or soap. Have them wet their hands in pond water before holding any frogs. Also remind the children that the frogs they collect are wild animals that need to be handled gently and returned to the pond afterwards.

At the pond, have children work in small groups with one or more adults. Each group should have a white dish basin and a clean 5-gallon bucket, as well as some nets and small containers. Fill the dish basins about ¼ full with pond water. The 5-gallon bucket is ideal for larger frogs, and if filled with 6-8 inches of water, will keep most frogs from escaping. Use the larger containers as collection points where all the children can view captured animals. The smaller dishes can be used for close-up viewing of individual animals.

After the children have collected frogs and tadpoles, have them show the group which animals they caught themselves and share stories about their experience. Ask children to share their observations about how the frogs moved and behaved. Use this opportunity to review what you have already discussed about frogs. Afterwards, take the frogs and tadpoles back to the water's edge and gently tip them back into the water. Have the children say goodbye and thank the frogs for helping them have so much fun learning!
Materials: For each small group: white dish basin, clean white 5-gallon bucket, small plastic containers and jars, nets of soft mesh, field guides, rulers, magnifying lenses.

CALLING ALL FROGS
Objective: To imitate the different courtship calls of 5 different species of frogs.

Begin by reviewing the courtship calls of the 5 frogs depicted on the *Calling All Frogs* cards and having everyone practice imitating them. Pass out a *Calling All Frogs card* to every student, asking them to keep the identity of the frog on their card a secret. Ask the students with blue dots on the back of their card to form a large circle. Ask the students with red dots to stand in the center of the circle. Explain that the students forming the circle (blue dots) will be the singers and those in the center (red dots) will be the listeners. When you say "go," the singers will start to sing and the listeners will seek out a frog that is singing "their" song and stand beside it. When everyone has found their match(es), go around the circle and review the various frog calls.
Materials: Two sets of *Calling All Frog cards*, one set with blue dots marked on the back, and the other with red dots.

FIELD MARK FIND
Objective: To observe distinguishing identification features close up and match these field marks to different species of frogs and toads.

Divide the students into 2 groups. Hand out pictures of frogs to half of the group and pictures of their specific field marks to the other half. Have these two groups stand across from each other and display their cards. Ask the children to find their match; then form a circle, with partners standing side-by-side. Have each pair introduce their frog and its key field mark to the whole group. Place photographs of each frog in the middle of the circle and ask teams to find theirs.
Materials: *Field Mark Find cards, Frog Identification chart, Frogs and Toads of VT and NH*

A STEP BEYOND
Capture the Fly
Turn children into fly-catching frogs by creating frog headbands from paper strips and sticky frog tongues from party blowers. Use strips of green paper with two circles or bumps in the middle to represent the bulging eyes of a frog. Wrap the paper strips around each student's head, then cut and staple the paper strip to fit. Create fly-catching tongues by unrolling party blowers and attaching a small strip of hooked Velcro to the tip of each blower. Be sure the Velcro is on the top surface of the unfurled blower. Tie small pieces of yarn into tiny bows to create "flies" and scatter these around the room. Give each of the "frogs" a party blower and have them catch flies by blowing and unfurling their "sticky tongues".

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Patterns – FROGS AND TOADS – Puppet Show

Characters: *Toad Tadpole, Frog tadpole, Toad, Frog, Eft, Mink.*
Prop: *Sign saying "Months Later"*

Freddy Tadpole Hello Teddy Tadpole

Teddy Tadpole Hello Freddy Tadpole.

Freddy When I grow up, I'm gonna be a frog. I'm not going to have a tail anymore and I'm gonna have four long legs so I can leap! How about you?

Teddy I'm gonna be a toad! I'll have four legs too, so I can hop.

Freddy And I'm gonna have a great big mouth instead of this little round one, so I can eat flying insects!

Teddy Me too! And we're gonna have great big eyes to see them with.

Freddy Yeah, and they're going to be on top of our heads to see above water, not on the side like our little eyes. And you know what else? We're gonna have lungs and breathe air!

Teddy Yeah, no more gills for us.

Freddy Boy, we sure are lucky to be amphibians!

Teddy Yeah, we sure are…um…what's an amphibian?

Freddy You know, it means we have two lives. We start out as tadpoles with gills and end up as frogs and toads with lungs!

Teddy I get it! We live in the water now, but we'll be able to live on land when we grow up!

Freddy Of course we're not the only amphibians around here.

Teddy Of course not…we're not?

Freddy No, salamanders are amphibians too.

Teddy You mean like Spotty Salamander and Nora Newt?

Freddy Sure. They have metamorphosis too.

Teddy Meta – what?

Freddy Metamorphosis. It means changing form. Like us, they start out in the water with gills and no legs, and then they grow four legs and lungs.

Teddy Only <u>they</u> keep their tails.

Freddy That's right.

Teddy Right now, I'm glad I'm still a tadpole.

Freddy Me too! And I'm a <u>tad</u> hungry, so let's go nibble some algae!

Teddy Algae – yum! (*both exit; put up sign saying "Months Later"*)

Eft Hello there. I haven't seen you before.

Toad I'm new here. I used to be a tadpole in the pond, but now I'm a toad on the ground. Are you a lizard?

Eft No, no! Lizards have scaly skin, and sharp teeth. I have damp skin like yours, and no teeth.

Toad You're certainly not a toad or a frog, so what are you?

Eft I'm a young newt, a special kind of salamander. I used to have gills and live in the pond, but now I have lungs and I live on the ground.

Toad Then you're an amphibian too!

Eft That's right. I'm called a Red Eft. When I grow up, I'll be a newt and I'll live in the pond again.

Toad Then you have three lives!

Eft In a way, but I won't change again. I'll still breathe with lungs when I go back to the pond. Right now, I'm still an eft, and I'm hungry! Eft-er all, I haven't eaten in two whole minutes! Bye. (*exits*)

Toad So long Emmy Eft. Hmm, I hear something hopping my way. Maybe a grasshopper…. no, a frog!

Frog Hello. You look familiar. Have we met before?

Toad I think so! When we were both tadpoles in the pond – remember? You must be Freddy, I mean Fredrick!

Frog I am! And you must be Ted, um, Theodore. We were pretty cute back then with our wiggly tails and gills.

Toad Yes. Look at us now – legs, lungs, googly eyes. We're quite distinguished and mature.

Frog Yes. No more childish chasing each other around the pond. However, it's so dry today, I'm going for a swim. We amphibians need to keep our skin moist, and catching insects is thirsty work.

Toad If I get thirsty, I just sit in a puddle and soak up water through my skin.

Frog My, my! I can't do that! I'm going to the pond for a dip. I hear there are lots of bugs there today. Care to join me?

Toad I don't know. It'd be dangerous hopping all that way.

Frog If we take big hops, we'll get there in no time.

Toad Well, OK. Let's go then. (*frog makes big hops, toad makes little ones*). Fred, Fred, wait for me! I'm falling behind!

Frog Can't you take bigger hops?

Toad No. My legs are shorter than yours! You're a leap frog, but I'm just a hop toad.

Frog True. Well, we're almost there.

Toad Uh oh, there's Mindy Mink coming our way!

Frog Quick, just one more hop to the pond!

Toad No Fred. It's too late. You go on without me.

Frog But Ted! I can't leave you here to die!

Toad Don't worry. I've got a secret weapon. I promise I'll see you in the pond. Off you go now.

Frog OK - good luck Ted! (*exits*)

Mink Oh ho! A tasty treat for me. Hello toad. Down the hatch you go!

Toad Not so fast Mindy Mink. Can't you see my bumpy skin?

Mink Bumpy or smooth, it's all the same to me.

Toad And can't you see my short, stubby legs?

Mink Short or long, stubby or sleek, it's all the same to me.

Toad And can't you see the lumpy bumps behind my eyes?

Mink Lumps and bumps, it's all the same to me! Now down the hatch you go and no more arguments! (*lunges at toad, then jumps backward*) Oh, oh, oh. You taste terrible!

Toad Of course! Don't you know we toads have poisons in our skin?

Mink I didn't know! Ugh! I will never eat a bumpy-skinned, short-legged toad again! (*exits*)

Frog Theodore Toad! You're still alive!

Toad Of course! I toad you I'd be safe.

Frog Well I'm glad. And, I'm glad we're amphibians so we can enjoy our second lives together.

Toad Me too. And with these legs we're sure to live hoppily ever after!

The End

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Patterns – FIDDLEHEADS TO FERNS – Background

Nature made ferns for pure leaves to see what she could do in that line. Henry David Thoreau

Ferns surpass other plants in the varied and graceful designs of their leaves. Like other green plants, ferns capture sunlight and turn it into energy to grow and reproduce. But, unlike many other kinds of plants, ferns do not produce flowers or seeds. Instead, they reproduce by means of **spores**, particles so small that they float in the air like so many specks of dust. Carried by wind and storm, the spores of ferns have reached every part of the globe; and nearly every habitat on the earth, from tropical jungle to icy mountaintop, is home to some ferns.

Although there are only 10,000 species of ferns in the world, compared to 300,000 species of flowering plants, many ferns have worldwide distribution. The lovely Bracken Fern of our northeastern forests is also found in England and Europe, Asia, New Zealand, and Australia. The tropics have not only the largest number of ferns, but also the largest ones. Tree ferns can reach heights of 40 feet. Even in New England, a hundred different species of ferns are found, and it's not hard to find a dozen species living within a short distance of each other.

The arrival of spring is heralded by the appearance of fuzzy spirals poking up through the soil and leaf litter. As these little curls grow taller and begin to unfurl, they resemble the scrolled neck of a violin, giving them their common name of **fiddleheads**. Each fiddlehead is a single coiled leaf, or **frond**, of a fern plant, its delicate growing tip protected inside the coil. As the stem unfurls, the lower leaflets uncoil and begin their work, providing energy for the frond to grow longer and fill out until the full new frond is complete. All fern leaves begin as fiddleheads, and some kinds of fiddleheads can be cooked and eaten for a tasty spring dish.

The leaves of most ferns follow a basic body plan with narrow stem and broad, triangular **blade**. The lacey nature of fern fronds comes from divisions of the blade into **leaflets** and **subleaflets**. Some ferns, like the Walking Fern and Hart's Tongue Fern, have a solid or "entire" blade, with no divisions or lobes.

In some ferns the blade is divided horizontally into many smaller leaflets, extending at right-angles from the stem. These are called **once-cut** ferns. The Christmas Fern, so-called because its dark green foliage keeps its color through the winter, is a once-cut fern, as is the Sensitive Fern which is found in fields and damp places with lots of sunlight. Another once-cut fern is Common Polypody, which grows on limestone rocks and cliffs.

Ferns in which each leaflet is further divided into subleaflets are called **twice-cut** ferns. The Ostrich Fern, named for its very tall, plume-like fronds, is twice-cut, as is the Cinnamon Fern, named for the cinnamon-colored fluff that cloaks its stems, and the Interrupted Fern, common along roadsides.

The laciest of all the ferns are those with **thrice-cut** leaves. In these, every subleaflet is further subdivided into tiny lobes. The Hayscented Fern, a pale-green lacey thrice-cut fern, lends its wonderful fragrance to upland meadows and sunny openings in the woods. The graceful vase-

like Lady Fern is another thrice-cut fern which grows in circular clumps. It is more common in shady glens than open fields, and can be recognized by the dark scales on its light green stem.

Looking at the overall shape of the frond, most ferns can be grouped into one of three basic shapes. A frond can be **triangular**, narrowest at the tip and broadest where stem meets blade. Another common shape is **semi-tapered**. In these ferns, the leaf tapers very slightly back towards the stem. A third common form is a leaf that is **tapered** at both the tip and where it meets the stem so that it is broadest somewhere in the middle of the blade.

Besides the fronds, a fern plant consists of a **rootstock**, akin to a trunk, from which the leaves grow upwards and the roots below. In most northern ferns, the rootstock grows beneath the soil so that the leaves appear to originate at or near ground level. In tropical tree ferns, the rootstock grows above ground and can be very tall, supporting a crown of 12-foot long fronds high above the ground. Ferns do not grow taproots, but have thin, wiry, branching roots that spread out through the soil in search of nutrients and moisture. Some ferns are vase-like, growing from a central rootstock and forming a circular grouping of leaves, each plant distinct from its neighbors. Other ferns have **rhizomes**, root-like stems that creep along just under the soil, which send up fronds at intervals so that a bed of these ferns appears to be made up of many individuals.

Another clue that is most useful in fern identification comes from the design and location of the **fruitdots** on the undersides of fronds. The name fruitdots is a misnomer, for ferns produce neither flowers nor fruits. In fact, the botanical name for these structures is **sori** and they contain the spore cases and spores by which ferns reproduce. Sori are found on the undersides of the fronds in some ferns like Christmas Ferns and Polypody, or under the rolled-up edges of leaflets in Bracken and Maidenhair Fern. In the Interrupted Fern, all the sori are carried on several leaflets midway up the frond, giving this fern its “interrupted” appearance. In some ferns, spores are carried on separate specialized structures called **fertile fronds**. The Ostrich Fern and Sensitive Fern have separate hard, brown spore-bearing fronds that remain standing after the leaves have died back, scattering their spores throughout the winter. Cinnamon Ferns have a separate fertile frond that produces spores in early spring and then dies back, making it hard to find by late summer.

When the spores are mature, the sori rupture and the spores are released, to be carried by wind to their future destinations. Those that land in suitable places take root and produce a tiny heart-shaped leaf, no more than a half an inch long, called a **prothallus**. This is an intermediate stage in the life cycle of the fern. On the underside of the prothallus, two types of structures form. One kind contains unfertilized eggs and the others contain sperm. The sperm cells need moisture, from rain or dewdrops, to find their way to neighboring prothalli where they may fertilize an egg. The fertilized egg develops into a new fern plant, sending a root down into the soil, and a shoot upwards to become the first frond of a new fern plant. Many ferns also reproduce by sending up shoots from spreading rhizomes, though these will be **clones** of the parent.

Though all ferns follow a similar pattern of blade and stem, the designs of their leaves are like so many variations on a theme. From delicate miniatures to leafy giants, ferns add beauty and variety to our landscape.

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Patterns – FIDDLEHEADS TO FERNS – Activities

FOCUS: All ferns have leaves with a blade and a stem, but the many variations in leaf design, spore-bearing structures, and preferred habitat make each species unique and recognizable.

PUPPET SHOW
Objective: To meet some common ferns and learn how ferns can be sorted into three basic groups based on the design of their leaves.

Perform or have the children perform the puppet show. Afterward, ask the children if they can name one way in which ferns are different from other plants. Hold up the fern puppets and ask the children to name some ways in which the ferns are alike. In what ways are they different from each other? Review the difference between once-cut, twice-cut or thrice-cut ferns.
Materials: puppets, script, props.

ONCE, TWICE, THRICE
Objective: To see how ferns can be grouped according to the number of divisions of the blade into leaflet, subleaflet and lobe.

Have children work in small groups with a leader. Give each child one frond of one species of fern to examine, noting the axis, blade, stem, and roots, if present. Provide each group with the *Three Types of Ferns* chart, noting the differences between once-cut, twice-cut and thrice-cut ferns. Give each group a set of real pressed ferns or fern pictures and have them sort these into one of the three categories. What other characteristics might be used to sort the different ferns? Older children can try to identify their ferns using the *Ferns of New England* handouts.
Materials: *Three Types of Ferns chart*; photos or drawings of a variety of ferns or real, pressed fern leaves, *Ferns of New England* handouts (optional).

BUILD A GIANT FERN
Objective: To construct a large fern in order to understand the structure of fern leaves.

Working in small groups, have every child cut one or more subleaflets out of green paper using the *Fern Leaflet Pattern* template and directions. On a piece of white paper, have them assemble their set of 5 subleaflets into a leaflet, as pictured on the *Fern Leaf Pattern* handout, then glue or tape it down. Mount a long, thin strip of green paper 4' X 2" onto a bulletin board to make the stem and axis of the fern frond. Have each group bring up their leaflet and tape it along the fern's stem to create a thrice-cut fern frond.
Materials: *Fern Leaflet Pattern*, green paper, scissors, bulletin board or white board, tape.

FERN AND FIDDLEHEAD HUNT
Objective: To look for different parts of a fern and different stages in its life cycle.

Ahead of time, the leader can scout on and around the school grounds for items listed on the *Fern Hunt Card*, marking those found with surveyor's tape. Divide the children into small

groups with a leader and, using the *Fern Hunt card*, try to find the different fern features described.

FERN HUNT CARD

----- A fiddlehead – open one gently to see how the leaves are furled inside.

----- Rootstock

----- Once-cut fern

----- Twice-cut fern

----- Thrice-cut fern

----- Fern with a smooth stem

----- Fern with fuzz on its stem

----- Fern with brown scales on its stem

----- A fern with fruit dots on the underside

----- A fern with its spore cases on a separate, hard, brown, fertile frond

Materials: *Fern Hunt Cards*, pencils, magnifying lenses, surveyor's tape, marker.

FERN MATCH
Objective: To look closely at the design of fern leaves while comparing them to pictures of ferns.

Divide children into pairs or small groups with a leader. Give each child a small *Ferns of New England* booklet that shows silhouettes of many ferns that grow in the region. Have the students try to find and identify ferns pictured in their booklet. Can they find a fern that is not in this booklet?
Materials: *Ferns of New England* booklets, one per child.

JOURNAL ACTIVITY (Grades K-2)
Objective: To closely examine and record observations of a fern.

Ask each child to find and draw a fiddlehead and a fern leaf.
Materials: journals, pencils.

UPPER GRADE CHALLENGE (Grades 5-6) – FIDDLEHEAD SKETCHES
Objective: To look for patterns of similarities and differences in the fiddlehead design of some common ferns.

Ahead of time, try to find an area on or near the school grounds with several different types of fiddleheads. Bring the children outside and provide them with paper, pencils and clipboards. Ask them to find and draw at least two different kinds of fiddleheads, Afterwards, ask the children what similarities they noticed among the fiddleheads found? What differences did they notice? How many different kinds of fiddleheads did they find in the study area? Optional: Mark each of

the different types of fiddleheads with surveyor's tape. Have the children check on them as they unfurl to see if they do indeed become different types of ferns.
Materials: paper, pencils, clipboards, rulers, magnifying lenses, surveyor's tape and markers.

FERN PRINTS
Objective: To capture the design of a fern leaf on paper by making a print of it.

A few days ahead, press a variety of fern fronds. In class, have the children select and lay their fern frond out on a piece of newspaper, paint it with watercolor paint, then carefully lift their frond and place it, painted side up, on a fresh piece of newspaper. Have each child lay a half-sheet or full sheet of white paper over his or her frond, press it down firmly, then lift the paper off carefully and allow to dry. Have them sort their fern prints into three groups, based on whether their fern was once-cut, twice-cut or thrice-cut. Older children can label their fern print using the *Ferns of New England* handouts.
Materials: pressed fern leaves, one per child; white paper, watercolor paint sets, soft watercolor paint brushes, newspaper, *Ferns of New England* handouts.

CLOSING THOUGHTS
Have the children hold hands in a line with an adult at each end. One adult leads the group in a circle around the second adult who remains more or less stationary, tightening the circle with each rotation to form a spiral. Then reverse direction and open the group into a circle. Pass a Senstive Fern fertile frond from child to child around the circle as the child holding it shares one fern-related word or phrase. No repeats allowed!

A STEP BEYOND
Fern Garden: Transplant some wild ferns into pots or a freshly dug bed, mulched with some leaves. Keep them watered well, and watch them grow new leaves.
Fern Trail: Help students to identify ferns on the school grounds using field guides. Make plant labels for each and set them near each fern. Invite others on a fern walk and explain the characteristics that help to identify each species.
Fern Sun prints: On a sunny day, make a print by placing a pressed fern on a piece of blue or purple craft paper and placing it in a sunny window for an hour or two until the paper fades. The fern will leave a print that is darker than the surrounding paper. This can also be done outside with sun-print paper following the directions on the package.

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Patterns – FIDDLEHEADS TO FERNS – Puppet Show

Characters: Girl, Genie, Ferns: Polypody, Christmas, Interrupted, Ostrich, Hayscented, Lady
Props: Fiddlehead - curl one end of a pipe cleaner into a spiral; magnifying lens.

Girl Oh gee, I've been studying ferns all day and I just can't tell them apart. I wish I had some genius for this kind of thing. (*Genie enters*) Huh? Who are you?

Genie A Genie. That's who. You said you wanted some kind of a Genie and so here I am.

Girl But I said genius. I was talking about ferns.

Genie Talking ferns? You want talking ferns? Your wish is my command. Just step right up on my magic carpet and I will take you on a ferntastic journey. Here we go! (*both exit*)

Polypody Hi honey. My name's Polly Pody and I'm right glad to meet you.

Girl A talking fern! Or, are you a fern? I think of ferns as being really, well really lacey.

Polypody I'm just a once-cut fern. See how my frond looks like it's cut into smaller leaflets?

Girl Yes, I do see. And what are those pretty golden dots on the underside of your leaflets?

Polypody They're fruit dots. They hold my spores.

Girl Don't you mean seeds? Fruits have seeds in them.

Polypody No I don't mean seeds. Ferns don't have seeds, or flowers or fruits. We have spores – that's what's inside our fruit dots.

Girl This is confusing. Fruit dots aren't fruits and spores aren't seeds. So what are the spores for?

Polypody Why honey, it's quite simple - they're for making new ferns. Anything else you'd like to know?

Girl Well, how come you're called Polypody?

Polypody Why, I don't know for sure, honey. But I think it must be because I'm pody nice. (*exits*)

Girl Pody silly, if you ask me. (*Xmas enters*) Oh, hello there! Another fern! Let's see, dark green, once-cut...you're another Polypody!

Xmas Nope. Use my hand lens to take a closer look.

Girl OK, thanks. Hey, you are different! Every one of your leaflets has a thumb, just like my hand! Here's your lens back. (*fern drops it*)

Xmas Oops. Sorry - I'm all thumbs.

Girl What's your name, then? Thumb Fern?

Xmas No, but, I'll give you a clue: My leaves stay green all year long.

Girl Green – Green? In winter, too, like a Christmas Tree? Hey, I'll bet you're the Christmas Fern!

Xmas That's right! Merry Christmas! (*Xmas exits, Genie re-enters*)

Girl Bye – and Merry Christmas to you, too!

Genie And a Happy New Year! Time to fern over a new leaf.

Girl You again! Where are we going now?

Genie Roadsides and ditches.

Girl You know Genie, the ferns we've met so far were not very lacy or fern-like.

Genie That's because they were all once-cut ferns. Are you ready for some twice-cut ferns?

Girl Twice cut – I bet that means each leaflet is cut into smaller leaflets. (*Genie exits, Interrupted enters*) Here's a big, lacy, twice-cut fern, only there's something wrong with some of its leaflets.

Interrupted You are probably referring to my fertile leaflets which carr…

Girl (*interrupting*) Gee those shriveled up leaflets are all covered with brown speckles.

Interrupted As I was saying, those are my spore-bearing leaflets and they are extremely…

Girl (*interrupting again*) I guess those must be your spores.

Interrupted Certainly those are my spores. I should be extremely unhappy were I to carry…

Girl *(interrupting again*) I must say you're certainly very tall.

Interrupted Yes, as a matter of fact I am among the three tallest ferns in this …

Girl I'm sorry. I don't know what's gotten into me, interrupting like this – it's rude of me!

Interrupted Oh, it's not your fault. Happens all the time. I'm used to it. After all, I am the Interrupted Fern. So long!

Girl Good bye. (*Ostrich fern and fiddleheads appear*) Why, look at the pretty curlicue plant coming up out of the ground. It looks just like the neck of a fiddle.

Ostrich Those are my fiddleheads, my babies.

Girl Fiddleheads? Mmm they're good to eat.

Ostrich To Eat!! Stay away from my babies!

Girl Ok, I won't eat them. Let's see, if those are fiddleheads, then you must be a Fiddle Fern!

Ostrich Fiddle fern! Fiddlsticks! There's no such thing as a fiddle fern.

Girl Sorry. You're so tall and lacy. You look more like a feather than a plant. Like an ostrich plume. That's it – you must be the Ostrich Fern.

Ostrich At's right matey, and that's no - strich of the imagination either. (*exits*)

Genie I always say, ostrich in time saves nine.

Girl I thought you'd left.

Genie Me? I would never leaf you! Here we go. How do you like this field? (*Genie exits, Hayscented enters*)

Girl Mmm, this field smells like freshly mowed hay.

Hayscented Zat is me. Zat is my perfume. I am zee Hayscented Fern.

Girl Oh it's a lovely perfume. And you're the laciest, most beautiful fern I've ever seen. You must be a thrice-cut fern. Every one of your leaflets is cut into the tiniest of tiny leaves.

Hayscented Yes, I only wear zee latest fashion. Now sit right here for the show. (*girl exits, Lady enters*)

Lady Fern Speakin' of fashion, let's not get carried away, Girls. I'm thrice-cut, too, and you won't catch me putting on airs like Miss Hayseed.

Hayscented Oh, how dare you speak to me zat way. And you call yourself a lady.

Lady Fern I most sointainly do. I'm a Lady Foin. I'm just as dainty as you, Madame Hayscent.

Hayscented Perhaps, but you do not have zee perfume like moi!

Lady Fern Poifume! Is that what you call it? Whatever it is, it's givin' me hayfever.

Hayscented In zat case, perhaps I should leave.

Lady Don't bother, I was just goin' myself. (*both exit, Genie and Girl re-enter*)

Girl Those two thrice-cut ferns are very lovely and delicate, but they sure are silly.

Genie Yeah, they're a couple of cut-ups.

Girl Thanks for a great trip Genie. Now that I've met some ferns, I really can tell them apart.

Genie Sure you can, and remember my motto: if at ferns you don't succeed, then try, try again.

THE END

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