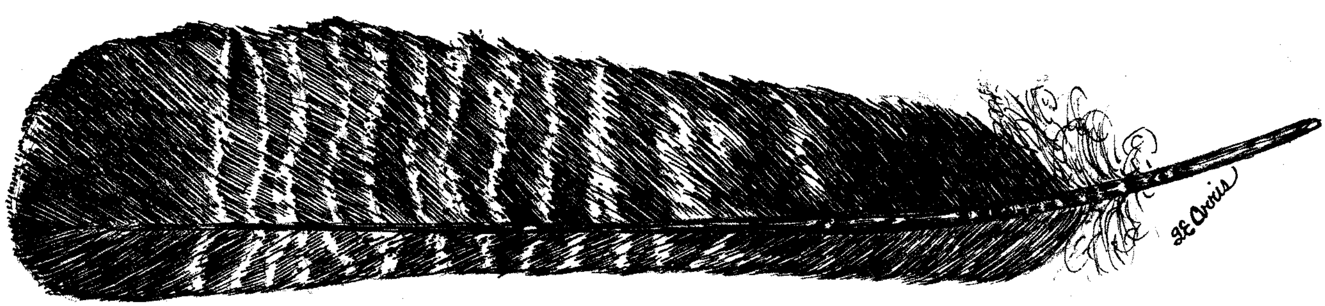
From Pattern to Principle: Discovering Science Through Observing Patterns in Nature



Illustrations by Sandy Orris

by Robert Barkman

Grade levels: 3-6
Subject areas: science, biology, ecology
Key concepts: adaptation, diversity, energy distribution
Skills: observation, pattern recognition, measurement
Location: outdoors

Lichens growing in circles, the sun's changing position at sunrise, Earth's warming trend, the "Morse code" of firefly flashes — all are patterns of nature. These and other natural patterns have inspired great questions leading to historical discoveries in science. In fact, one way to define science is as the human attempt to account for patterns in nature. When Alfred Wegener noticed that the continents seem to fit together like pieces of a puzzle, he speculated that they were once part of the same landmass; later, evidence from fossil, rock, and plant patterns supported his theory of continental drift. When Charles Darwin synthesized his theory of evolution, he drew upon repeating patterns that he had observed in living organisms during his long sea voyage on the Beagle. Our laws of heredity are a product of Gregor Mendel's careful recording of patterns of inheritance in pea plants.

Howard Gardner's theory of multiple intelligences recognizes the special gifts of these pattern-seekers as the "naturalist intelligence." Along with sensitivity to the natural world and the talent to discriminate among living things, those with a strong naturalist intelligence quickly see patterns in the natural world and grasp relationships in ecosystems. Whether studying the classification of wetlands or an organism's coloration, the recognition of patterns at all levels is critical to the science of ecology.

The power of patterns can be put to work in education. A good graphic, for example, can show at a glance both the key parts of a whole and the relationships between those parts, thereby providing a holistic view that words cannot convey. The brain is designed to perceive and derive meaning from patterns, and it resists having meaningless information imposed on it. Therefore, educators should consider beginning lessons by giving students a pattern to discover rather than a principle to memorize. Patterns inspire questions, reveal connections, and prompt predictions about what's next, leading to a deep understanding of the principles behind the patterns. By beginning with a pattern to discover, students are able to construct the big ideas of science on their own. Moreover, pattern recognition comes naturally to even the youngest child.

The following activities take students into the field and lead them from observation to pattern to principle. By studying the nest-building behavior of squirrels, the "Morse code" of fireflies, and the patterns of energy and life on north- and south-facing slopes, children can discover important ecological concepts for themselves. This active seeking fosters the need to know, persistence, respect for evidence, and the sense of stewardship and care that characterize good science.

Note that the activities refer to species that may not be present year-round or in all regions. The bioluminescent species of the firefly family, for example, are nocturnal and found only east of the Rocky Mountains. And not all squirrels are arboreal; those that do make their nests in trees are easier to spot in the winter when the leaf cover is gone.

Patterns of adaptation: Observing squirrels at home

The principle of adaptation can be constructed from studying patterns in the nest-building behavior of squirrels. Tree squirrels, like monkeys, porcupines, and sloths, belong to a large group of animals that call the tree canopy home. Trees provide a place to nest, reproduce, raise young, and find food; and the complex networks of tree branches serve as transportation and escape routes high above the forest floor.

Squirrels choose their nest sites very carefully to ensure strong structural support, protection from predators, and access to food and sunlight. They do not build nests close to the ground or near the tops of trees unless the nests are well protected in some way. This is because the nests have to withstand high winds and other inclement weather, and must offer security from predators. Nests are often situated in the fork of large branches, close to the main trunk, for support, and they usually face south or east to benefit from the sunlight during winter months and on chilly mornings. Squirrels do not build nests in isolated trees because they need to be able to jump from tree to tree to escape threats; sometimes they will even build multiple nests in adjoining trees to avoid predators. Having other trees nearby also ensures a more abundant food supply.

In the following activity, students discover many of the adaptive factors in squirrels' choices of nest sites by identifying patterns in nest building. Note that squirrels' winter nests tend to be larger and more elaborate than their summer nests, and nests are more easily discerned against the sky when there is no foliage to hide them. Therefore, it is best to conduct this activity in winter, if possible.

Materials: paper, pencils, compass

Procedure:
1. Begin by challenging students to think like a squirrel. Ask them, "If you were squirrels, where and how would you build your nests?" Encourage them to consider such factors as the kind of tree they would select, how high in the tree they would build their nest, and in which direction they would want their nest to face.

2. Out in the field, have students test their nest-building logic against the logic of the squirrels. Explain that patterns are shapes or events that repeat three or more times. They will be observing and recording information about the location of at least three squirrel nests to determine if there are patterns.

3. Ask students to look for squirrels' nests in trees. Squirrels' nests are often confused with birds' nests, but if students look closely, they should be able to tell the difference. Squirrels' nests are usually much larger (30 to 40 centimeters in diameter) and made of twigs and leaves.

4. Stop at each tree that has a nest, and have students:

- identify the type of tree, either broadleafed or coniferous
- use a compass to determine the direction the nest faces, i.e., whether the nest is positioned on the north, south, east, or west side of the tree
- estimate the distance between the ground and the nest, and from the nest to the top of the canopy
- note the configuration of branches where the nest is secured to the tree
- note the distance between the nesting tree and any other trees in the immediate vicinity

5. After surveying several nesting sites, ask students if they can detect any patterns in the data they have collected. Through observation and reflection, they should be able to discover patterns of nest building and the adaptive logic behind these patterns. Following are some questions that may help students determine the reasons for squirrels' nesting decisions:

- Do squirrels choose conifers (e.g., pines, spruces) or broadleafed (e.g., maple, oak) trees more often? What advantages and disadvantages does each offer?
- What are the pros and cons of nesting at the bottom, middle, and the top of the trees?
- What advantages could trees whose branches overlap with those of other trees have over isolated trees?
- What kinds of branch configuration (think about geometric shapes) provide a stable support for the nest?

- What are the advantages and disadvantages of a nest that faces south? north? east? west?

Patterns of diversity: Observing fireflies on a warm night

The childhood fascination with observing fireflies on a warm summer evening can be the starting point for teaching about biodiversity. The cold light, or bioluminescence, that is produced by many species of the beetle family *Lampyridae* is the result of a chemical reaction that takes place in special cells of the firefly's abdomen. A substance called *luciferin* is acted upon by the enzyme *luciferinase*, creating a rhythm of short and long intervals of light, much like the Morse code of dots and dashes. This flashing pattern is encoded so that males and females of the same species can recognize each other. A male in the air signals "hello" to females, and when a female on the ground recognizes a male of her kind, she signals back. Because there are more than 100 species of bioluminescent fireflies in North America, there are more than 100 different codes. These distinct codes keep species separate and thus maintain species diversity.

Having students observe the light patterns of fireflies inspires questions such as the following:

- Why do fireflies flash lights at night?
- Why do some fireflies flash light from the air, and others from the ground?
- What is the purpose of the pattern of flashing?
- Do fireflies all use the same flashing pattern?
- What makes the firefly light work?
- If fireflies did not recognize their own codes, what impact would it have on their individual species and on the diversity within the firefly family?

Materials: pencils, paper, penlights or flashlights, colored cellophane

Procedure:
The best time to observe fireflies is during their mating season, from late summer to early fall, when the nights are still warm. A good place to observe them is over a grassy area or marsh. Alternatively, students can collect fireflies in jars and bring them to class for study.

1. Have students use dots and dashes to record the "Morse codes" of the flashing lights they observe (for example, · · · or · – ·). It is not unusual for two or more species of fireflies to occupy the same area, so students should look for two or more patterns to compare.

2. Ask students to watch and record the flash pattern of one firefly for a minute or longer to determine if the firefly repeats the same pattern.

3. Challenge students to try to duplicate one of the observed light patterns with a penlight or flashlight.

4. Have students work in pairs to create their own codes for saying "hello" based on their observations. Just as each firefly species encodes a greeting that is recognized only by members of the same species, students may vary the frequency of flashes or the intensity or color of the light.

Extension: The female firefly of one species has learned how break the rules. Nicknamed "femme fatale," she imitates the codes of other species. When she flashes their code instead of her own, the males interpret this as an invitation to land. And when a male lands nearby, she invites him to dinner — but he soon finds out that he's the dinner. She is a voracious predator, known to eat four or five males daily. Ask students to mimic the behavior of "femme fatale" by observing a male firefly signal and then making "conversation" by flashing the same pattern with a flashlight. When students signal, does a firefly fly toward their light?

Patterns of energy: Observing sides, north and south

An activity that leads to an appreciation of how patterns of energy create diversity can be done right outside the classroom doors. Solar heat is not distributed equally over the Earth's surface. Because of the motion of the planet and because Earth is a sphere, the intensity of the solar energy that strikes Earth's surface varies with latitude. The level of radiation is highest at the equator and decreases toward the poles. As a result, south-facing slopes in the Northern Hemisphere receive more energy than north-facing slopes. The north-facing slope of a mountain, for example, may be covered with snow while the south-facing slope is snow-free. Even in winter, the organisms living in or on the south-facing side may enjoy spring-like warmth.

Any school grounds can be used to compare north- and south-facing slopes. By comparing the temperature, light intensity, and soil moisture between the north- and south-facing sides of buildings, students discover that solar radiation is not distributed equally in the environment. The unequal distribution of energy creates, in turn, different patterns of plant and animal diversity. This understanding can be applied to explaining the difference between north- and south-facing sides of natural systems such as mountains and valleys.

Materials: paper, pencils, compass

Procedure:

1. Sketch a map of the outside perimeter of the school building. Using a compass, identify the north- and south-facing sides and label them on the map.

2. Have students make predictions about different patterns they will find on the north- and south-facing sides of the building, such as differences in temperature, light, soil moisture, and vegetation.

3. On a sunny day, go outside and have students touch the north- and south-facing walls with their hands. Does the south-facing wall feel warmer? Confirm the difference by measuring and recording the temperatures of the two sides. Ask students which wall is likely to give off more heat at night.

4. Have students take soil samples from the north- and south-facing sides and compare them by crumbling the soil with their fingers. Does the soil of the south-facing side feel drier? Students can measure soil moisture by weighing scoops of soil before and after drying them overnight in an oven. The difference between the two weights represents the moisture lost.

5. Have students compare the plant diversity on the two sides of the building. Are there differences? If the same species lives on both sides, compare the stature and development of individual plants on the two sides. Which are larger? Which bloom first?

6. Have students note any differences in the number and diversity of animals on the two sides of the building. Cold-blooded animals, such as insects, choose warm habitats over cold ones. They take advantage of the sun's warmth, which enables them to crawl, run, and fly faster. Even in winter, insects such as snow fleas will darken the snow on the south-facing sides of trees. Looking like tiny black dots, they leap about much like actual fleas, appearing to celebrate the warmth of the sun.

***Robert Barkman** is a Professor of Education and Biology at Springfield College in Springfield, Massachusetts, a recipient of the Sears Roebuck Foundation Award for Teaching Excellence, and the author of* Science Through Multiple Intelligences: Patterns That Inspire Inquiry *(Zephyr Press, 1999), from which these activities are adapted.*

References

Barkman, Robert C. *Science Through Multiple Intelligences.* Zephyr Press, 1999.

Barkman, Robert C. "Patterns, the Brain, and Learning." *Classroom Leadership* 4:3, November 2000, pp. 1, 4-5.

Brooks, Jacqueline Grennon, and Marin G. Brooks. *The Case for Constuctivist Classrooms.* Association for Supervision and Classroom Development, 1993.

Caine, Renate Nummela, and Geoffrey Caine. *Making Connections.* Addison-Wesley, 1994.

Cale, William, Geoffrey Henebry, and J. Alan Yeakley. "Inferring Process from Pattern in Natural Communities." *Bioscience* 39:9, 1989, pp. 600-604.

Durie, Veronica. "Multiple Intelligences: And Now There Are 8." *Mindshift*, April 1997, pp.1-2.

Gardner, Howard. *Frames of Mind: The Theory of Multiple Intelligences.* Basic Books, 1993.

Jones, Beau Fly, Jean Pierce, and Barbara Hunter. "Teaching Graphics to Construct Graphic Representations." *Educational Leadership,* December 1988/January 1989, pp. 20-25.

Judson, Horace F. *The Search for Solutions.* The John Hopkins University Press, 1987.

Roth, Karen. *The Naturalist Intelligence.* Skylight Training and Publishing, 1998.