Teacher Resources

Math in Nature

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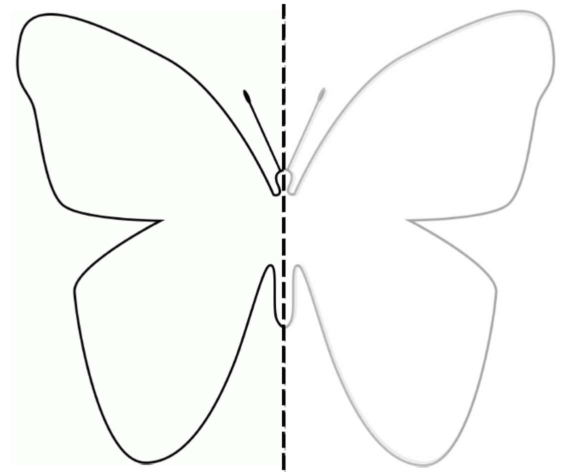
Butterfly Symmetry

Grades K-2



Objective:

- To explore symmetry in butterflies and other animals.

Materials, per student:

- Butterfly handout
- Paint
- Paint brushes
- Paint bowls

Materials for extension:

- White copy paper
- Pencil or pen

Procedure:

1. Fold the butterfly handout in half vertically along the dotted line. Open the paper flat again. The paper has been divided into two halves.
2. On the left half, where the butterfly is outlined in black, put dots of paint all over the wing. Do not paint on the right half of the paper (past the dotted line).
3. After painting the left half of the butterfly, fold the handout again on the dotted line while the paint is still wet.
4. Press firmly on the handout while it's folded, and then open it to see how the paint has transferred to the other side. Do both halves of your butterfly look the same?

Extension:

- There are many other animals that have symmetrical parts of their bodies. Draw the face of your favorite animal. Fold the paper in half. Do the images on both sides match? Follow the steps above using paint and folding your paper to see if you get the same symmetrical effect.

Science and Math Concepts:

A shape is called symmetrical if that same overall shape can be made by flipping, rotating, or moving part of it.

Regular polygons including squares, equilateral triangles, and hexagons are symmetrical. These shapes are also found in many parts of the natural world.

Many different types of animals, including humans, display bilateral symmetry. Some examples of bilaterally symmetrical creatures are blue crabs, beetles, dogs, and worms. These things can be divided along a central axis to produce two sides that are near mirror images. Most animals with this type of symmetry have the ability to move themselves forward by walking, crawling, or swimming.

Many bugs and insects, including butterflies, use their symmetrical markings to camouflage themselves from predators. Their wings might be camouflaged to look like leaves or tree bark, which helps keep them safe in the wild.

Butterfly Symmetry (continued)
Grades K–2

Curriculum Connections:
Maryland College and Career-Ready Standards for Mathematics

- Additional Standard 2.G.A.2 Partition a rectangle into rows and columns of same-size squares and count to find the total number of them.
- Additional Standard 2.G.A.3 Partition circles and rectangles into two, three, or four equal shares, describe the shares using the words halves, thirds, half of, a third of, etc., and describe the whole as two halves, three thirds, four fourths. Recognize that equal shares of identical wholes need not have the same shape.

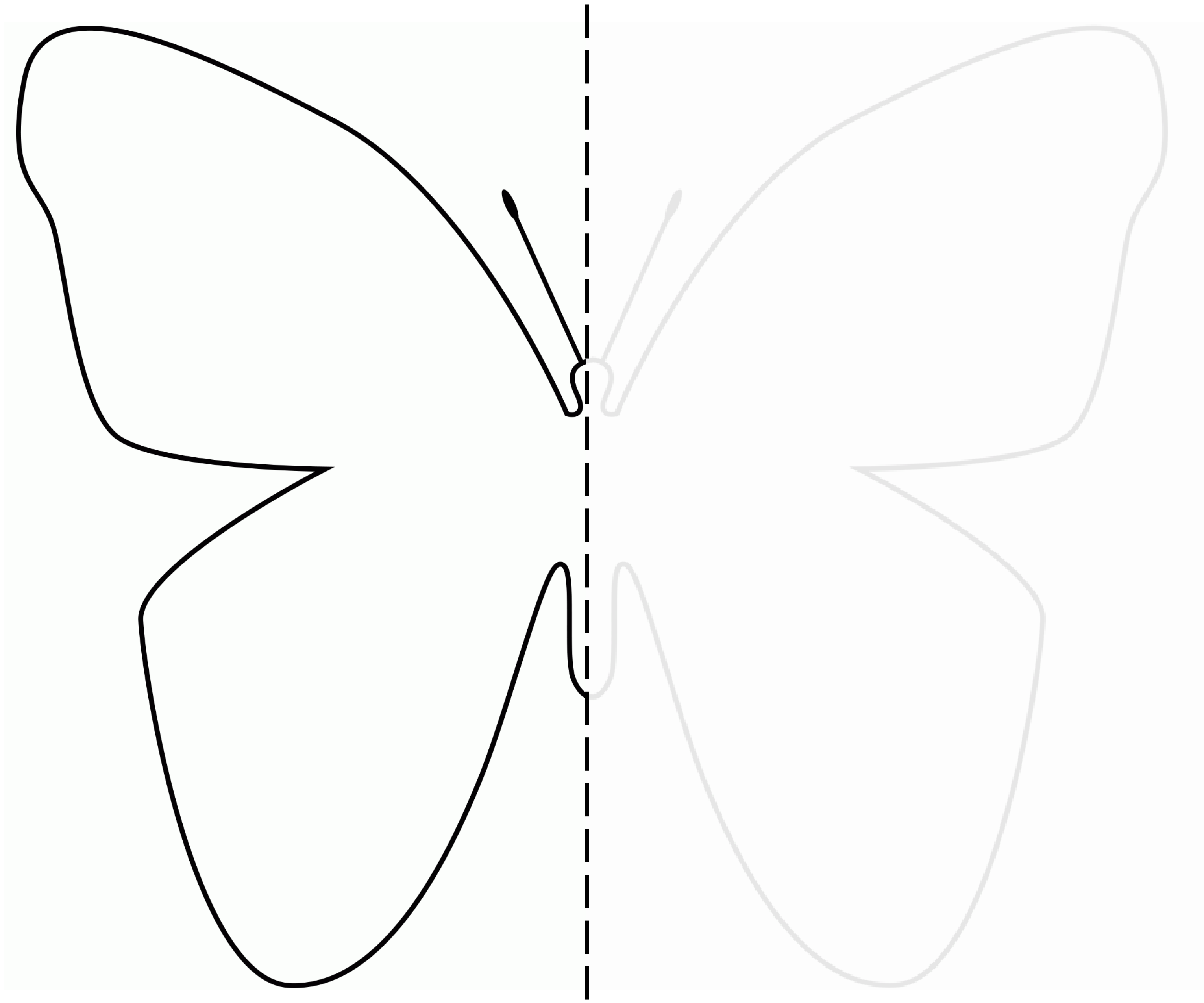
Next Generation Science Standards

- K-LS1-1 Use observations to describe patterns of what plants and animals need to survive.
- 1-LS1-1 Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air.
- 2-LS4-1 Make observations of plants and animals to compare the diversity of life in different habitats.
- Crosscutting Concepts – Patterns
    - o Patterns in the natural and human designed world can be used as evidence.
    - o Patterns in the natural world can be observed and used to describe phenomena.

References:
CBC Radio. (2018, July 20). *The reason why most animals are symmetrical has to do with their locomotion*. https://www.cbc.ca/radio/quirks/july-21-2018-bread-came-before-agriculturedriving-drowsiness-and more-1.4753031/the-reason-why-most-animals-are-symmetrical-hasto-do-with-their-locomotion-1.4753044

MathCurious. (2020, April 8). *Symmetry in Nature.* https://mathcurious.com/2020/04/08/symmetry-in-nature/

Butterfly Handout



Leaf Shapes

Grades K-2

Objective:

- To explore geometric shapes found in nature.

Materials, per student:

- Leaf handout
- Shape handout
- Pencil or pen

Materials for extension:

- Scissors
- White copy paper

Procedure:

1. Look at the different types of leaves on the handout.
2. Using the shape handout as a guide, see which shapes you can find in the leaves.
3. Draw the outline of the shapes with a pencil or pen.
4. How many different types of shapes did you find? Which shapes are the most common? Are there any shapes that don't appear at all?

Extension:

- Use the scissors to cut out the individual shapes from the shape handout.
- Design your own leaves by arranging the shapes on top of the blank paper and tracing the outlines.

Science and Math Concepts:

Leaves absorb sunlight and produce food for plants. Leaves contain chlorophyll which converts sunlight into energy through photosynthesis. Plants also absorb carbon dioxide gas from the air and release oxygen gas back into the environment through their leaves.

Leaves provide space for water to evaporate through transpiration. This process keeps plants cool and helps regulate their temperature.

Plants can have different shaped leaves depending on their environment. The shape can change based on the amount of sunlight, how much water is present, and if there are other plants nearby competing for space and light. Trees can be classified by the shapes of their leaves and how their leaves are arranged. There are many types of leaf shapes including oval, round, and heart shaped. Tree leaves that are made of a single blade per leaf are called simple leaves. Tree leaves that are made of several smaller leaflets together are called compound leaves.

Leaf Shapes (continued)

Grades K–2

Curriculum Connections:

Maryland College and Career-Ready Standards for Mathematics

- Additional Standard K.G.A.2 Correctly name shapes regardless of their orientations or overall size.
- Additional Standard K.G.B.5 Model shapes in the world by building shapes from components (e.g., sticks and clay balls) and drawing shapes.
- Supporting Standard 1.MD.C.4 Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another.
- Additional Standard 1.G.A.2 Compose two-dimensional shapes (rectangles, squares, trapezoids, triangles, half circles, and quarter-circles) or three-dimensional shapes(cubes, right rectangular prisms, right circular cones, and right circular cylinders) to create a composite shape and compose new shapes from the composite shape.
- Additional Standard 2.G.A.1 Recognize and draw shapes having specific attributes, such as a given number of angles or a given number of equal faces. Identify triangles, quadrilaterals, pentagons, hexagons, and cubes.

Next Generation Science Standards

- K-LS1-1 Plants need water and light to live and grow.
- 1-LS1-1 All organisms have external parts. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow.
- 1-LS3-1 Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.
- 2-LS2-1 Plants depend on water and light to grow.

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Allen, G. (1883, March 15). *The Shape of Leaves.* Nature 27, 464–466.
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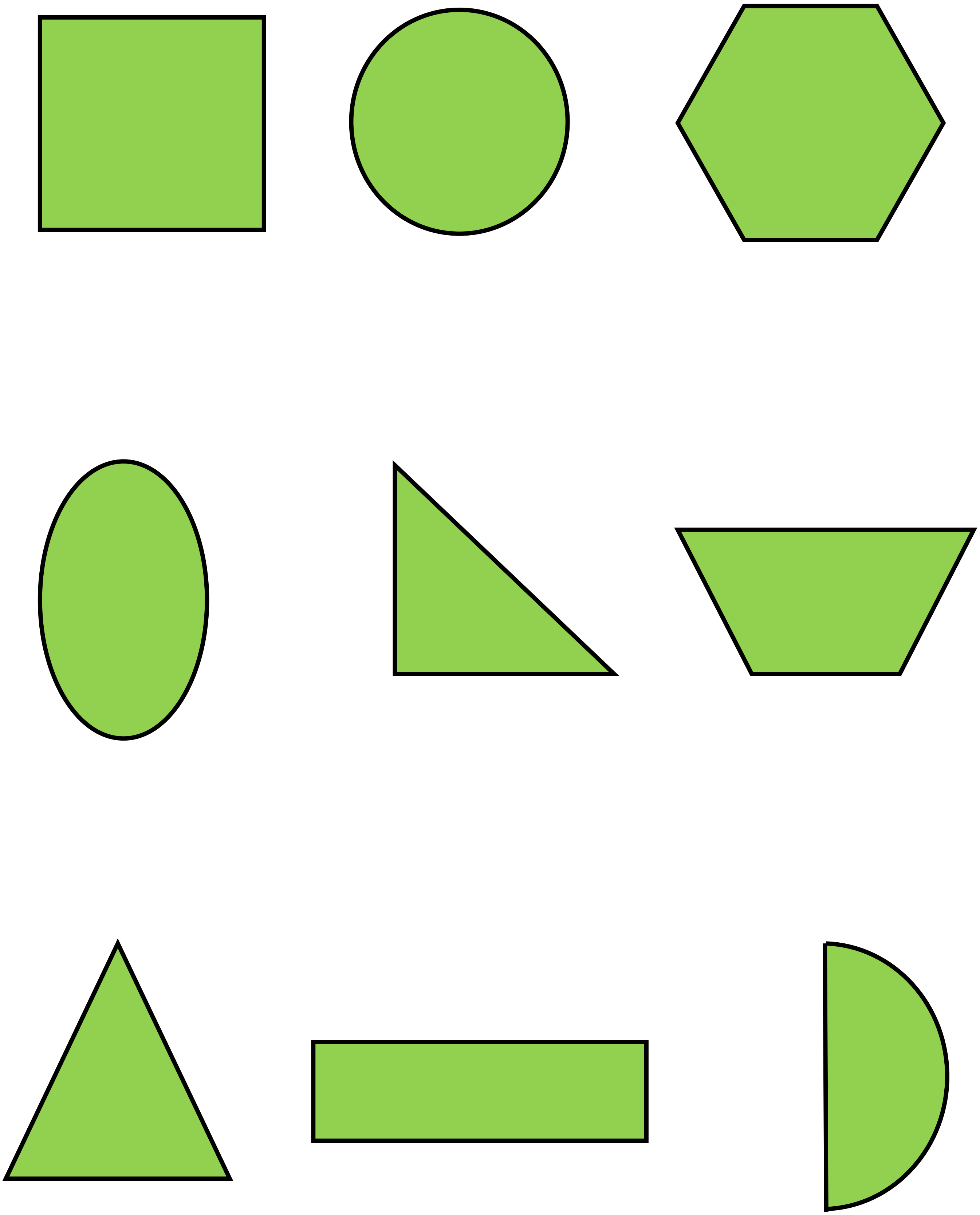
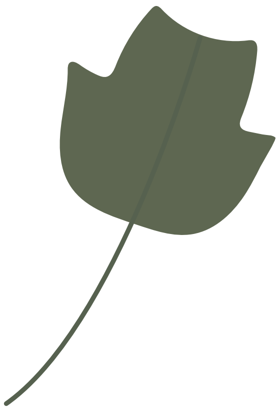
The Pennsylvania State University. (2009, July 12). *Leaf Shapes and Strategies.* The Virtual Nature Trail at Penn State New Kensington.
https://www.dept.psu.edu/nkbiology/naturetrail/leaves.htm

Villazon, L. (n.d.). *Why have trees evolved such a variety of leaf shapes?* BBC Science Focus Magazine.
https://www.sciencefocus.com/nature/why-have-trees-evolved-such-a-variety-of-leaf-shapes/

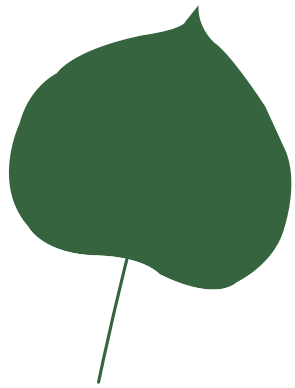
Shape Handout



Leaf Handout



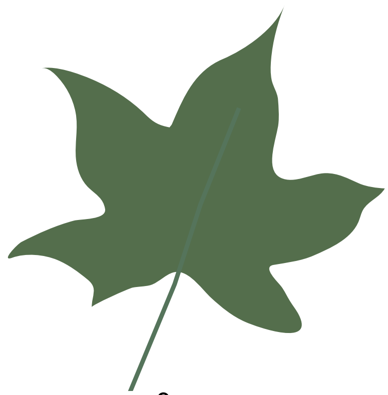
Tulip Polar
(Liriodendron tulipfera)



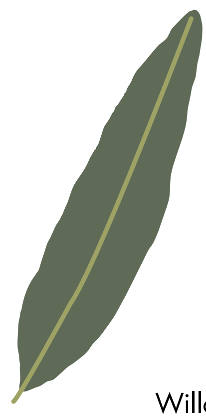
Eastern Redbud
(Cercis canadensis)

Sassafras
(Sassafras albidum)

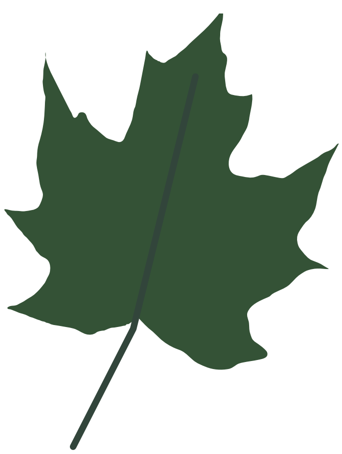
Northern Red Oak
(Quercus rubra)



Sweetgum
(Liquidambar styraciflua)

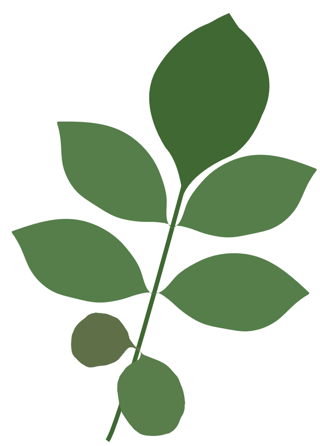


Willow Oak
(Quercs phellos)



Sugar Maple
(Acer saccharum)

Honey Locust
(Gledistia triacanthos)



White Ash
(Fraxinus americana)

Follow the Flow

Grades 3-5

Objectives:

- To model the flow of water through a watershed.
- To investigate a repeating pattern found in nature.

Materials, per group of three to four students:

- White copy paper
- Four washable markers of different colors
- Spray bottle filled with water

Procedure:

1. Take a sheet of paper and crush it into a ball with your hands.
2. Open the paper back up but don't flatten it too much. The wrinkles, ridges, and valleys should simulate a natural landscape.
3. Visually divide the paper into four equal parts and use a different marker to color just the tops of all the wrinkles and folds in each part. Think of these as the highest point of your landscape.
4. Lightly spritz water over the landscape using the spray bottle to represent rain or other precipitation. Try not to saturate the paper so much that it starts to fall apart.
5. Observe what happens. Follow the water as it flows down to the lowest parts of the landscape.
6. Follow the colors from the highest points of the paper to the lowest parts. Do the colors flow separately, or do they mix? Is there one single area where water collects or several smaller areas? What might these areas represent in a real landscape?

Science and Math Concepts:

A watershed is an area of land where all of its water flows into the same larger body of water. The area of land for a specific watershed can range in scale from very small to very large. Water travels downhill to form rivers, lakes, or reservoirs, or flows out into bays and oceans.

Satellite images of Earth show how water flowing over land can form interesting patterns known as fractals. A fractal is a repeating pattern that looks similar at different scales.

Mathematical fractals such as the Mandelbrot set, the Koch snowflake, and the Sierpiński triangle involve repeating very specific shapes or patterns through multiple smaller and smaller iterations to create complex images.

Fractal patterns that appear in the natural world, such as those seen in watersheds, are not often exact copies. These fractals are self-similar, but not identical, at different scales, unlike mathematically created fractals.

Living organisms can exhibit natural fractal patterns, such as tree branches and twigs, the veins of leaves, and the fronds of certain ferns. Other natural phenomena, including lightning bolts and mountain ranges, can also exhibit fractal patterns.

Follow the Flow (continued)

Grades 3-5

Curriculum Connections:

Maryland College and Career-Ready Standards for Mathematics

- Supporting Standard 3.G.A.2 Partition shapes into parts with equal areas. Express the area of each part as a unit fraction of the whole. For example, partition a shape into 4 parts with equal area, and describe the area of each part as ¼ of the area of the shape.

Next Generation Science Standards

- Crosscutting Concepts - Patterns
    - o Patterns of change can be used to make predictions.
    - o Patterns can be used as evidence to support an explanation.
    - o Similarities and differences in patterns can be used to sort and classify natural phenomena.
    - o Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena.
- Connections to the Nature of Science – Scientific Knowledge Assumes an Order and Consistency in Natural Systems
    - o Science assumes consistent patterns in natural systems.

References:

Challoner, J. (2010, October 18). *How Mandelbrot's fractals changed the world.* BBC News. https://www.bbc.com/news/magazine-11564766

Exploratorium Teacher Institute. (2021). *Fractal Patterns.* Exploratorium Science Snacks. https://www.exploratorium.edu/snacks/fractal-patterns

Fractal Foundation. (2016). *Watersheds and Rivers.* https://fractalfoundation.org/resources/fractivities/fractal-rivers/

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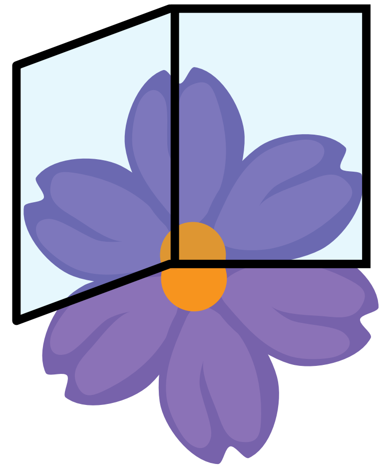
Symmetry Search

Grades 3-5



Objectives:

- To identify common objects that display simple symmetry.
- To learn the difference between bilateral and radial symmetry.

Materials, per student:

- Square or rectangular mirror, hand-sized is best
- White copy paper
- Pencil or pen
- Access to an outdoor area

Materials for extension:

- An additional small mirror
- Masking tape

Procedure:

1. Take a trip outside and look for items with interesting shapes. Look for things such as trees, plants, flowers, rocks, insects, or birds.
2. Start by investigating smaller items that are easy to pick up like leaves or flower petals.
3. Imagine a line dividing the object in half and hold the mirror against this line. Try different ways of dividing it in half.
4. Observe the reflections in the mirror. Does it produce an image that looks just like the whole object?
5. For objects that can't be tested directly with the mirror, such as a tall tree or an insect that might crawl away, draw or sketch the object as accurately as possible on a piece of paper and then hold the mirror against the drawing and observe the reflection.

Extension:

- Some objects are symmetrical around a central point rather than a straight line.
- To test for this type of symmetry, hold two mirrors together so the reflective sides face each other, and the edges form a narrow angle. Secure the mirrors with a few pieces of masking tape to make a hinge.
- Place the hinged mirror against an object. Open or close the mirrors at the hinge and observe the images in both mirrors. Experiment with different angles to see if you can produce a reflection that looks like the whole object.

Science and Math Concepts:

A shape is called symmetrical if that same overall shape can be made by flipping, rotating, or moving part of it.

Regular polygons including squares, equilateral triangles, and hexagons are symmetrical. These shapes are also found in many parts of the natural world. Symmetry is especially common in living organisms but can also be found in other natural objects.

Many insects, crustaceans, and vertebrates, including humans, display bilateral symmetry. These things can be divided along a central axis to produce two sides that are near mirror images. Many animals that exhibit this type of symmetry have the ability to move themselves forward by walking, crawling, or swimming.

Many marine invertebrate animals, as well as non-living objects such as snowflakes and spiderwebs, display radial symmetry. These things are symmetrical when rotated around a central point. Animals that exhibit this type of symmetry are often stationary or move very little.

Symmetry Search (continued)

Grades 3-5

Science and Math Concepts (continued):

Flowers can exhibit bilateral or radial symmetry. Scientists believe certain flowers may have evolved this way to attract pollinators such as bees or butterflies.

While many natural objects exhibit symmetry, there are some living things that can't be equally divided. Some examples of this asymmetry include the fiddler crab, which has one claw that is significantly larger than the other, and snails with spiraling shells.

Curriculum Connections:

Maryland College and Career-Ready Standards for Mathematics

- Supporting Standard 3.G.A.2 Partition shapes into parts with equal areas. Express the area of each part as a unit fraction of the whole. For example, partition a shape into 4 parts with equal area, and describe the area of each part as ¼ of the area of the shape.
- Standard 4.G.A.3 Recognize a line of symmetry for a two- dimensional figure as a line across the figure such that the figure can be folded along the line into matching parts. Identify line symmetric figures and draw lines of symmetry.

Next Generation Science Standards

- 3-LS3-1 Different organisms vary in how they look and function because they have different inherited information.
- 3-LS4-2 Sometimes the difference in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.
- 4-LS1-1 Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.
- Crosscutting Concepts - Patterns
    - o Patterns can be used as evidence to support an explanation.
    - o Similarities and differences in patterns can be used to sort and classify natural phenomena.
    - o Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena.
- Connections to the Nature of Science – Scientific Knowledge Assumes an Order and Consistency in Natural Systems
    - o Science assumes consistent patterns in natural systems

References:

CBC Radio. (2018, July 20). *The reason why most animals are symmetrical has to do with their locomotion.* https://www.cbc.ca/radio/quirks/july-21-2018-bread-came-before-agriculture-driving-drowsiness-and-more-1.4753031/the-reason-why-most-animals-are-symmetrical-has-to-do-with-their-locomotion-1.4753044

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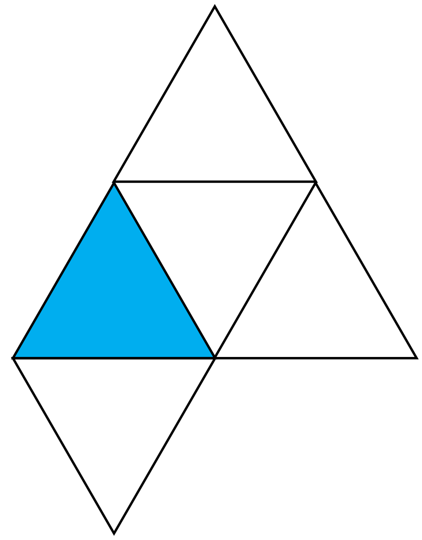
Tessellated Tiles

Grades 6-8



Objectives:
- To learn which polygons tessellate.
- To compare regular and non-regular tessellated patterns.

Materials, per student:
- Shape handout
- Scissors
- Several sheets of white copy paper
- Pencil or pen

Materials for extension:
- Tape
- Several more sheets of white copy paper

Procedure:
1. Cut out each of the shapes from the handout.
2. Choose a shape and line up one of the edges with the side of a blank sheet of paper. Trace the shape.
3. Move, flip, or rotate the cutout so that its edges are lined up with the first trace. Trace it again. Continue this over and over to create a pattern that covers the paper.
4. Repeat this process with the remaining shapes on their own sheets of paper.
5. Determine which shapes created a tiled pattern that can cover the paper with no gaps or overlaps. Compare these patterns to ones you've seen in nature. What do they remind you of?

Extension:
- Choose two or more shapes from the handout. Lay the shapes next to each other so they share a similar line or angle and tape them in place. Use this new shape to create another pattern.
- Alter the shape by rotating it around a central point or by flipping it upside down to create a mirror image. Can you make the new shape tessellate?
- How is this pattern different from the one you created before?

Science and Math Concepts:
A tessellation is a pattern of repeating shapes that fit together with no gaps between them.

Tessellations can be made of only one shape or a combination of shapes. Regular tessellations are created from a single polygon and semi-regular tessellations are created from more than one polygon.

Polygons are two-dimensional shapes created with three or more straight lines. If all the sides of the shape are the same length and the angles of the corners are the same, the shape is considered a regular polygon.

Equilateral triangles, squares, and hexagons are the only regular polygons that can tessellate on their own. Tessellated patterns from these shapes can be observed in honeycomb, snake skin, turtle shells, and the skin of a pineapple.

Voronoi patterns are another type of tessellation often seen in natural objects such as dried mud, dragonfly wings, giraffe spots, human skin cells, or a cluster of bubbles. These patterns consist of irregular shapes where each shape forms outward from a central seed point. The individual shapes that form around the seed can be dictated by chemical processes or biological growth.

Tessellated Tiles (continued)

Grades 6-8

Curriculum Connections:

Maryland College and Career-Ready Standards for Mathematics

- Standard 8.G.1 Verify experimentally the properties of rotations, reflections, and translations
- Standard 8.G.4 Understand that a two-dimensional figure is similar to another if the second can be obtained from the first by a sequence of rotations, reflections, translations, and dilations; given two similar two-dimensional figures, describe a sequence that exhibits the similarity between them.

Next Generation Science Standards

- Crosscutting Concepts - Patterns
    - Patterns can be used to identify cause and effect relationships.
- Connections to the Nature of Science -Scientific Knowledge Assumes an Order and Consistency in Natural Systems
    - Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

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D'Agostino, S. (2019, January 22). *Voronoi Tessellations and Scutoids Are Everywhere.* Scientific American.
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Shape Handout