PATTERNS EVERYWHERE (60 MINUTES)

AT A GLANCE

Students will explore what patterns are and the many places they can be found.

OBJECTIVES

- Students will explore patterns that occur in a variety of different familiar materials.
- Students will discover that patterns can happen in the natural world.

KEY VOCABULARY

SYMMETRY: When one shape becomes exactly like another if you flip, slide or turn it (i.e. the human body is symmetrical because you can divide it in equally in half).

FRACTAL: An irregular shape that looks the same at any scale on which it is looked at (i.e. the branches of a tree look random but are actually similar shapes repeated over and over again with varying sizes).

TESSELLATION: A pattern arranged in a mosaic fashion (i.e. salt crystals).

FIBONACCI SERIES: A mathematical sequence of numbers that happen to represent a vast number of measured relationships in nature. The sequence (1, 1, 2, 3, 5, 8, 13…) is comprised of the first two terms being 1 and 1 and each following term is the sum of the two just before it.

VORONOI PATTERNS: A pattern where every point within a given region is closer to the "seed" inside that region than it is to any other point outside that region. Each point along a region's edge is equidistant from the two nearest seeds. It's seen in places ranging from cracked mud to giraffe skin to foamy bubbles. Voronoi patterns can help solve geometric problems like packing, strategic placements and patterns of growth.

NEXT GENERATION SCIENCE STANDARDS

SCIENCE AND ENGINEERING PRACTICES:

- Asking questions and defining problems
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Obtaining, evaluating and communicating information

CROSSCUTTING CONCEPTS:

- Patterns
- Scale, proportion and quantity
- Structure and function

DISCIPLINARY CORE IDEAS:

- LS1: From Molecules to Organisms: Structures and Processes

ADVANCE PREPARATION

CRYSTAL ANALYSIS: In each square of the crystal analysis worksheet place a small amount of the material that is indicated: salt, sugar, sugar substitute and baking powder. Place a magnifying glass at the station.

SPIROGRAPH: Put out the Spirograph and enough scrap paper with one blank side so each student can use at least one page at the station. It may be useful to show students how to use the Spirograph prior to having them try themselves.

FINGERPRINTS: Put out an ink pad, extra paper, wet wipes and the finger print worksheet.

MIRROR SYMMETRY: Put out five mirrors and the symmetry activity worksheet.

FRACTAL FEATHERS: Put out feathers, magnifying glasses and the worksheet.

MATERIALS PER GROUP

Pictures of patterns
Salt packet
Sugar packet
Sugar substitute packet
Baking power
Magnifying glass
Spirograph
Stick-um or double-sided tape
Pencils
Gel pens
Scrap paper
Fingerprinting ink pad
Wet wipes
Mirror
Feathers

WHAT YOU NEED TO KNOW

A pattern is a set of shapes or numbers that repeats in a characteristic way and can be described mathematically. Patterns are useful for sorting and classifying natural and designed objects. They can be used for identification and to make predictions.

There are many different kinds of patterns. An example of a mathematical pattern can be as simple as starting with 1 and adding 2 repetitively. That pattern would look like 1, 3, 5, 7. The same rule is applied repeatedly and you can predict what the next number in the sequence would be.

Patterns can also be geometric. Examples of objects arranged in a geometric pattern include bricks forming a wall or even desks arranged in a classroom. Many natural objects are arranged in patterns like the petals of the flower or spots and stripes used by animals for camouflage.

Patterns and shapes that make up nature and the man-made world can also be found in the human body. Out the window, through a microscope, or in the mirror—patterns surround us. They form the veins of a leaf, the spiral of a nautilus and the spots on a giraffe. Patterns also inspire us as we create or build things. Some of the patterns found in nature include fractal branching and Voronoi patterns.

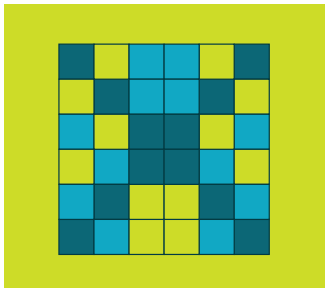
Fractal branching is a detailed pattern that looks similar at any scale and repeats itself. It takes a simple rule and applies it over and over again, resulting in complex shapes. From snowflakes to river systems to urban development, fractals can help us understand seemingly complex behavior.

In a Voronoi pattern, every point within a given region is closer to the "seed" inside that region than it is to any other seed outside that region. Each point along a region's edge is equidistant from the two nearest seeds. It's seen in places ranging from cracked mud to giraffe skin to foamy bubbles. Voronoi patterns can help solve geometric problems like packing, strategic placements and patterns of growth.

Throughout history, humans have replicated the natural world's patterns, intentionally or subconsciously, in their architectural concepts. This has occured across thousands of years and continents.

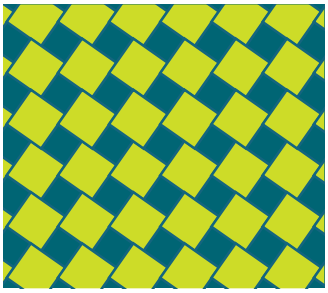
EXAMPLES OF PATTERNS

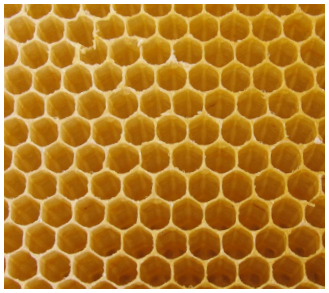
SYMMETRY LIKE TWO SIDES OF A FACE OR MIRROR IMAGE



SPIRALS LIKE THOSE FOUND IN GALAXIES AND GROWING FERNS

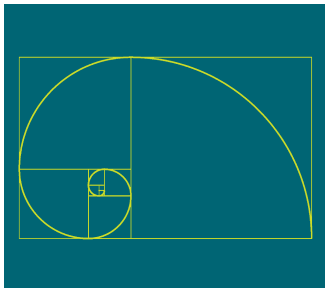
TESSELLATIONS LIKE TILE PATTERNS AND CRYSTAL STRUCTURES





FRACTALS LIKE BRANCHING PATTERNS OF TREES OR SNOWFLAKES

THE FIBONACCI SERIES AND GOLDEN RATIO



VORONOI PATTERNS THAT DESCRIBE HOW SOAP BUBBLES AND GIRAFFE SPOTS ARE ARRANGED

WARM UP

1. Show pictures of various patterns and discuss patterns with the group. Patterns can be found everywhere in the world and are in places you'd never think to look. Ask questions such as:
   - Have you ever looked closely at your classroom wall or the ceiling in your living room and seen a pattern?
   - Have you ever seen patterns in a carpet or the tiles on a wall?
2. Using the activity guide have the students go on a patterns field trip around the room. If available, have students use cell phone, iPad or Android tablet cameras to take pictures of patterns in the room.
3. With the class, walk around the room and find as many patterns as possible. Ask them:
   - What patterns do you see? How many different patterns can you find?
   - What shapes/colors are the patterns?
   - Where are they found?
   - Why do you think patterns emerge in things we build?
   - Why do you think patterns emerge in nature?
   - Do feathers have more than one pattern?
4. Discuss other places outside of the classroom where patterns exist, including in the natural world.
5. Have students make a sketch of their favorite patterns.

ACTIVITY

Tell students there will be five stations for them to explore different materials that exhibit different types of patterns. Review what the class will do at each station before splitting them into five groups and starting a rotation.

CRYSTAL ANALYSIS

Using a magnifying glass, students will observe salt, sugar, sugar substitute and baking powder under a magnifying glass. Salt and sugar are examples of crystal structures while sugar substitute and baking powder are not. The activity guide will prompt students to identify which of the substances have predictable shapes.

SPIROGRAPH

Each student will make their own Spirograph design and count the number of loops in the design after the end meets back up with the beginning. This should be exactly 13 rotations (or loops). It is important to keep the ring part stationary. Use the stick-um or tape to hold it in place. Put a piece on the ring and press it to the paper. Alternatively you can use a clipboard to keep a stack of paper and the ring can be secured using the clip.

FINGERPRINTS

Instruct students to gently press one of their fingers in the ink pad and roll that finger on page of their journal. Wipe their finger off with a Wet Wipe when done. Students then identify the type of fingerprint they have. The three basic types of fingerprints are:

- Whorl: Ridges form a circular pattern.
- Arch: Ridges form a hill or tent-shaped pattern.
- Loop: Ridges form an elongated loop pattern.

MIRROR SYMMETRY

Use the mirrors to observe images that are symmetrical. Have students predict which pictures and shapes are dividd symmetrically. Then have them place a mirror on the lines to check their predictions.

FRACTAL FEATHERS

Use the magnifying glass to observe the feather and determine what parts of the feather are similar at different scales.

CHECK FOR UNDERSTANDING

Have students answer the following questions in their teams or as a whole group discussion.

- What did you notice at the pattern stations?
- What have you discovered?
- Can you think of some patterns in nature that you may have seen?
- How can patterns help us find solutions to problems?

WHAT'S HAPPENING?

Spirals are curves that start from a center point and get farther away as they circle around that point. They can be found in pinecones, pineapples and hurricanes. A logarithmic spiral is a special type of spiral where the distance between each turn of the spiral is progressively larger than the one before it, as in a nautilus shell. Spirographs all fall into a family of patterns called hypotrochoids and the patterns can all be described mathematically.

Criminologists use fingerprints to solve crimes because all fingerprints are unique. The FBI has been utilizing this knowledge to track criminals for years. The bureau uses the Integrated Automated Fingerprint Identification System, or IAFIS, as a tool for identifying and matching fingerprints. The large database operates as a pattern-matching machine. Within 27 minutes of submission, the system can identify a fingerprint of someone if they are in the database. It contains the prints and criminal histories of over 70,000 people, demonstrating that use of patterns is not only for making observations and predictions in science labs.

DIFFERENTIATED INSTRUCTION

- Assign each group member a specific job at each station to facilitate teamwork. For example, one person can be in charge recording information and another person can report their results.
- Assign mixed-ability peer partners as groups and encourage students to help one another.

EXTENSIONS

1. In teams, have students create their own patterns stations and share where they found patterns with the rest of the class.
2. Have students explore and share careers that involve the use of patterns, such as:

   SOFTWARE ENGINEER: These scientists use patterns as a general reusable solution to a commonly occurring problem within a given context in software design. A design pattern is not a finished design that can be transformed directly into source or machine code. It is a description or template for how to solve a problem that can be used in different situations. Patterns are formalized best practices that the programmer can use to solve common problems when designing an application or system.

   ARCHITECT: Symmetry finds its ways into architecture at every scale, from the overall external views of buildings such as Gothic cathedrals and the White House, through the layout of floor plans to the design of building elements such as tile mosaics.

PATTERNS EVERYWHERE

NAME:

Have you ever looked closely at your classroom wall or the ceiling in your living room and seen a pattern? Have you ever seen patterns in a carpet or the tiles on a wall? Patterns can be found everywhere in the world. If you train your eyes to see them, you can find them in places you'd never think to look.

1. WHAT PATTERNS DO YOU SEE? HOW MANY DIFFERENT PATTERNS CAN YOU FIND?

2. WHAT SHAPES/COLORS ARE THE PATTERNS?

3. WHERE ARE THEY FOUND?

4. MAKE A SKETCH OF YOUR FAVORITE PATTERNS.

CRYSTAL ANALYSIS

NAME:

Examine each material under the magnifying glass.

1. WHICH MATERIALS ALL SEEM TO BE THE SAME SHAPE?

2. WHICH MATERIALS SEEM TO BE ALL DIFFERENT SHAPES?

3. SKETCH WHAT YOU SEE UNDER THE MICROSCOPE

Salt	Sugar Substitute	Baking Power	Sugar

FINGERPRINTS

NAME:

Use the ink pad and paper to make your own fingerprint. Compare your print to the pictures below and answer the following questions.

Arch

Loop

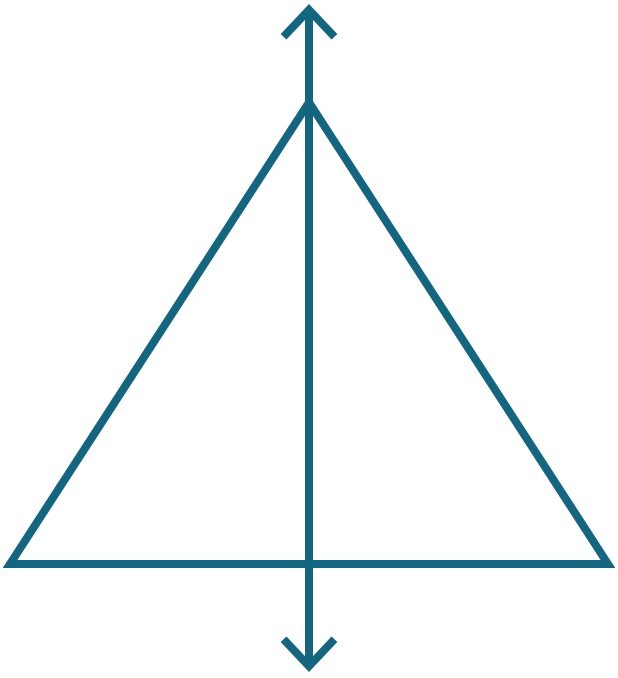
Whorl

1. **ARE YOUR FINGERPRINTS ALL THE SAME PATTERN?**

2. **COMPARE YOUR FINGERPRINTS TO OTHERS IN YOUR GROUP. HOW MANY HAVE ARCHES? LOOPS? WHORLS?**

SYMMETRY STATION

Predict which lines divide the shapes into symmetrical sides. Place the mirror on the lines on the pictures and shapes to test your prediction



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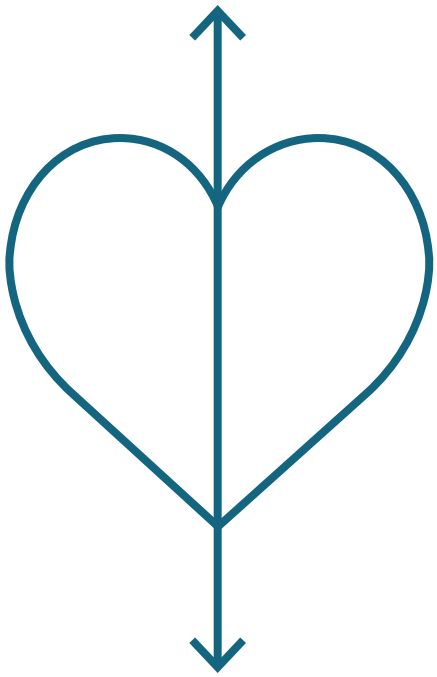

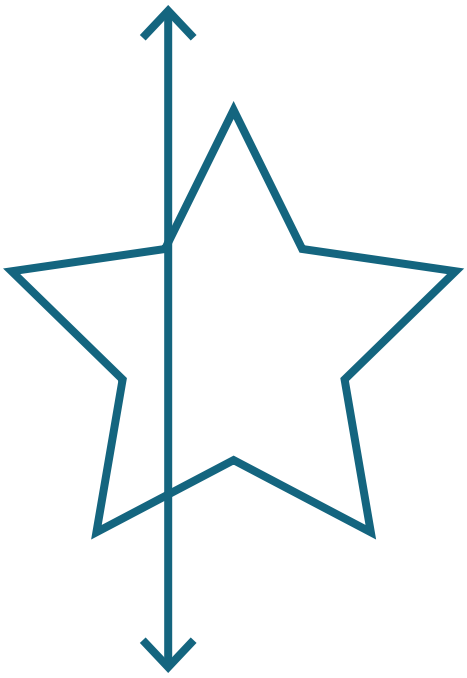

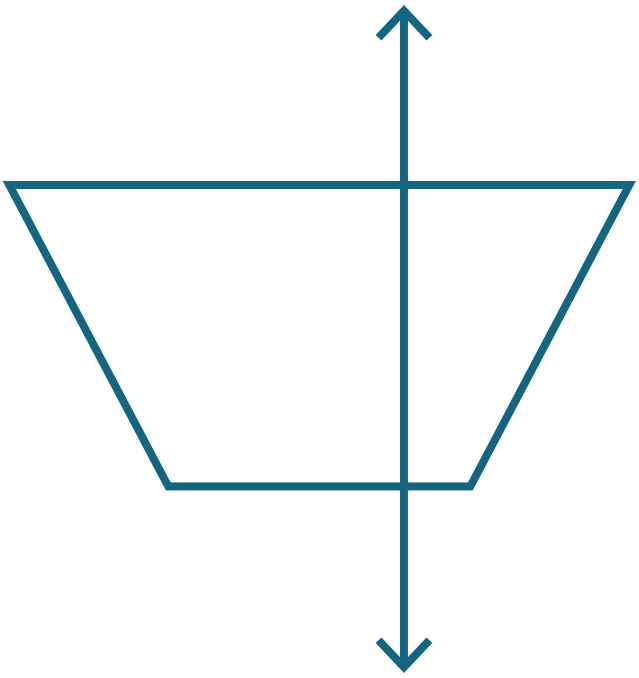

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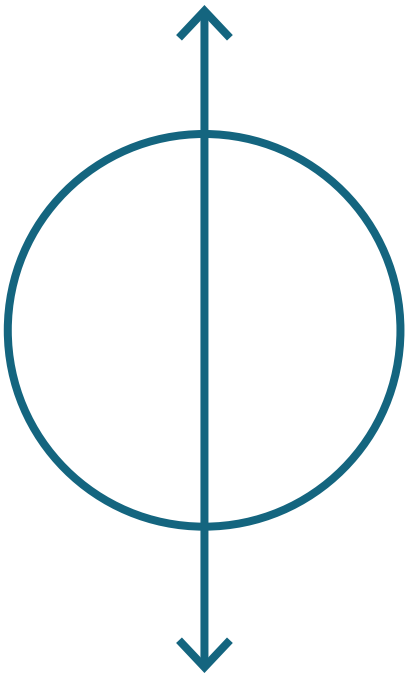

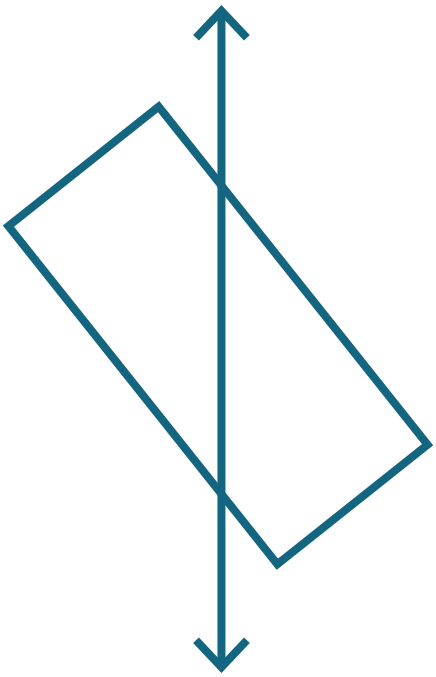

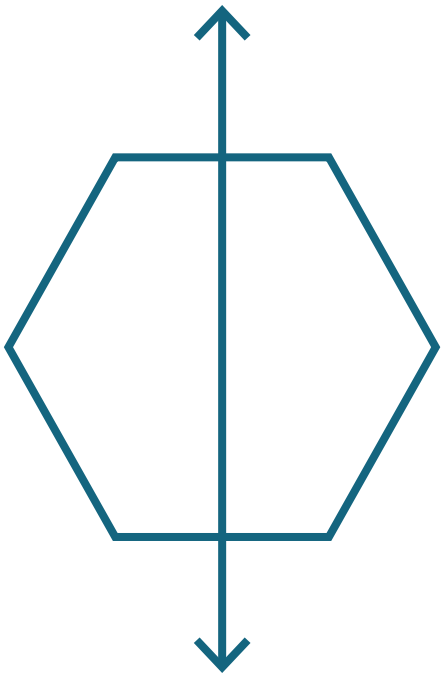

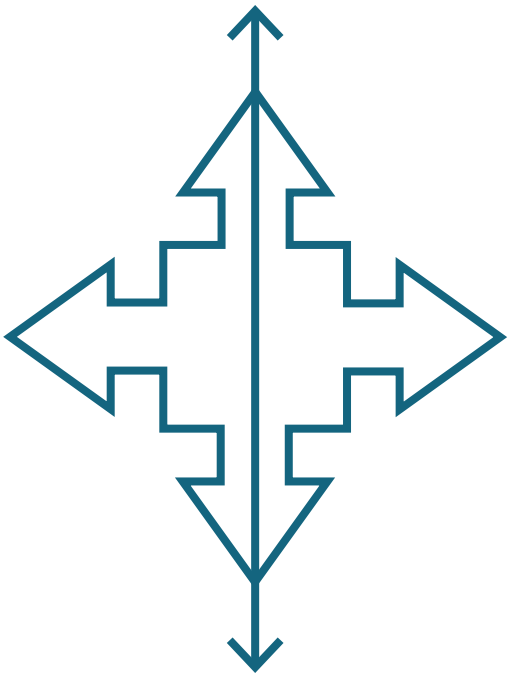

FANCY FEATHER STATION

NAME:

Use the magnifying lens to look at the feather and observe the individual barbs or pieces of the feather.

1. WHAT DO YOU NOTICE?

2. DO YOU SEE A PATTERN?

3. DO FEATHERS HAVE MORE THAN ONE PATTERN?

4. SKETCH WHAT YOU SEE.

SYMMETRY STATION (ADVANCED)

Draw lines of symmetry for the following shapes. Where could you place the mirror so that the reflection completes the original shape?