ARTS EDUCATION PROGRAM

LESSON PLAN

Virtual Club Pelican

Project Title: Building Blocks of the Beehive
Theme: Biomimicry: Hexagon Tessellations of Honeycomb
Age Range: 7-12 years

PROJECT DESCRIPTION/INTRODUCTION: Students will examine the shape of the hexagon in honeycomb. They will discover why this shape is important to the structure, where it is seen in other objects in nature and how it has influenced the design of objects we use in our everyday lives. Students will create a hexagon tessellation and design their own honeycomb to showcase the hard-working busy bee who brought us this phenomenon.

PROJECT MATERIALS:

- White Drawing Paper (size: 9"X 12", two pieces)
- Cardstock (size: 1/4 sheet)
- Scissors
- Drawing Pencil
- Eraser
- Black Sharpie
- Colored Markers
- Glue Stick

DISCUSSION QUESTONS:

What is honeycomb?
A honeycomb is a mass of hexagonal prismatic wax cells built by honeybees in their nests to contain their larvae and stores of honey and pollen.

What is a hexagon shape?
A two-dimensional shape that has 6 sides.

How do you think bees make honeycomb?
The glands of worker bees convert the sugar contents of honey into wax, which oozes through the bee's small pores to produce tiny flakes of wax on their abdomens. Workers chew these pieces of wax until they become soft and moldable, and then add the chewed wax to the honeycomb construction.

Why do the bees use a hexagon shape and not a circle or another shape?
Hexagons appear in honeycombs because they are the most efficient way to fill a space with the least amount of material. Some shapes tessellate, meaning they can be repeated across a surface without leaving gaps or overlapping. Tessellation ensures that there's neither wasted space nor wasted energy. If a series of circles were packed on top of each other, there would be empty spaces in between them. The only way in which

these empty spaces can be avoided is by changing the shape to a hexagon.

How do you think bees create the perfect hexagon shapes?
Worker bees use their body as a tool to make circles in the wax. As they are making circles, their body heat melts the wax which slowly slips along the network between circles as it changes into hexagon shape. The hexagonal cell is very strong, and creates a very solid structure, in relation to the weight of the wax used.

How long do you think it takes to build and make Honeycomb?
It can take about 7 days to 2 months for bees to make their honeycomb. In about 7 days from the early build up and moving in, honeybees can add from 1 to 3 pounds of honeycomb inside the structure.

What can we learn from the bee's honeycomb? Why do you think the hexagon shape is important in certain materials in our world?
The hexagon is one of the strongest shapes known. Hexagonal patterns are prevalent in nature due to their efficiency. In a hexagonal grid (like the honeycomb) each line is as short as it can possibly be if a large area is to be filled with the fewest number of hexagons. This means that honeycombs require less wax to construct and gain lots of strength under compression. It is also one of the only shapes which *tessellates* (to fill a plane with no gaps) perfectly (think tiles; if you tiled a wall with hexagons then there wouldn't be any gaps). Honeycomb shapes and materials are widely used where flat or slightly curved surfaces are needed and their high specific strength is valuable. Honeycomb offers better weight-to-strength ratios in structures and objects.

Where else do you see hexagon shapes in nature?

1. Dragonfly Eye: If you look closely at a dragonfly, its eyes are a collection of tiny eyes often known as compound eyes, each of which functions as an individual visual receptor. Each eye forms a shape of the hexagon. Over 30,000 hexagonal shaped eyes are packed together. The result is a vision that scientists call ultra-multicolor. It is the world's most advanced type of vision and is better than anything we have seen so far in the animal kingdom.

2. Snowflake: They are mesmerizing and quite mysterious on how they get the hexagonal shape. To define a snowflake in the simplest form, they are tiny droplets of water that are frozen in midair. Snowflakes come in different shapes and sizes, but the most predominant shape is the hexagon.

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3. Turtle Shells: Their shells are what protect them, and on them, we can also find hexagons. These slow-moving animals are protected with a hard shell that is made of one of the toughest compounds found in nature. If you look closely, you can see that the entire shell is formed from individual subunits- these cells have a shape resembling a hexagon.

Where else do you see hexagon shapes in our world? What mimics the honeycomb structure? Why do you think this structure is used?

1. Nuts and Bolts: A hexagonal shape is used in nuts and bolt heads. Hexagon is the predominantly used shape for nuts and bolts because of its unique features. With hexagons, the tool edges find it much easier to grip the bolt. This means that more torque can be transferred to the bolt.

2. Soccer Ball: The modern-day soccer ball is a mix of hexagons (6 sides) and pentagons (5 sides). It is made from patches of 20 hexagons and 12 pentagons. A hexagon is the only shape that resembles a circle that also allows for close packing without leaving out any wasted space. The pentagons are used to fill in the spaces that will eventually bind things up to give a near perfect spherical structure for the soccer ball.

3. Pencil: The pencils that we use are hexagonally shaped. Many believe that it is done to prevent the pencils from rolling off edges! Others theorize that the shape gives maximum holding comfort and strength when being used.

4. Artificial Honeycomb Structures: Man-made honeycomb structural materials (cardboard, automotive parts) are commonly made by layering a honeycomb material between two thin layers that provide strength in tension. This forms a plate-like assembly. Honeycomb materials are widely used where flat or slightly curved surfaces are needed and their high specific strength is valuable. They are widely used in the aerospace industry for this reason, and honeycomb materials in aluminum, fiberglass and advanced composite materials have been featured in aircraft and rockets. They can also be found in many other fields, from packaging materials in the form of paper-based honeycomb cardboard, to sporting goods like skis and snowboards.

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ART PROJECT KEY TERMS:

Biomimicry is the design and production of materials, structures, and systems that are modeled on biological entities and processes.

Honeycomb Structure is a structure of hexagonal cells of wax, made by bees to store honey and eggs, a structure of adjoining cavities or cells.

Hexagon Shape is a two-dimensional shape that has 6 sides, 6 vertices and 6 angles.

Tessellation is an arrangement of shapes closely fitted together in a repeated pattern without gaps or overlapping.

Patterning is a repeating unit of shape or form.

Composition is the way visual elements are organized, placed, or arranged in a work of art.

ART MAKING PROCESS:

STEP 1:

Take a moment and examine the Honeycomb images below (Fig. A). Consider the shape, design, and structure of the honeycomb.

- What do you notice about the honeycomb? Do you see any openings or space within the structure? Why? Why do you think this is important?

STEP 2:

Create a hexagon stencil – begin with your piece of cardstock and draw roughly a 2”-3” hexagon shape on it (you can print a copy of a hexagon, cut it out and trace it if you’d like). Cut the shape you drew out of the cardstock (Fig. 1).

STEP 3:

Consider how you will build your honeycomb image on your sheet of white paper. Think about if you want to start in one corner at the base of your paper and work from left to right, or begin in the middle of your paper, building from the inside out.

- Will your honeycomb go straight across from side to side? Will it be at an angle?
- How does a bee build his honeycomb?

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STEP 4:
Begin tracing your hexagon shape with your pencil, stacking edge to edge as you go (Fig. C). Fill your entire page with a hexagon tessellation, some hexagons will go off the edge of your paper. Use your black marker and go over your pencil lines, outlining the hexagon shapes. (Fig. 2)

STEP 5:
Use your colored markers to color in your honeycomb shapes. You can choose to have a pattern of color in your honeycomb, or have it be solid (one color), or random (several different colors). The color choice is up to you (Fig. 3).

STEP 6:
Next, notice the different parts of the bee and the shapes in its body, consider the bee proportion, and other details (Fig. D). Think about the composition of your work of art and how many bees you would like to have. You can choose to have one large bee, or a few small bees. It can be a simple line drawing, or have lots of detail, it is up to you! Think about where you will place them in your artwork.

STEP 7:
Design your bee(s): on your second white piece of paper, use a pencil to lightly draw just the body and wings of your bee(s) considering size, angle and shape. When your bees are penciled in, use a black Sharpie or marker to outline the bee and add details to the body and wings. Erase any pencil marks. Use your colored markers to color them in. (Fig. 4)

STEP 8:
Cut out each bee and use your glue stick to secure them into place on your honeycomb background. Use your black sharpie to add the antennae and legs if you'd like.

STEP 9:
When you are happy with the layout of your bees and how your artwork looks, your work of art is complete! (Fig. 5)

POST PROMPT QUESTIONS (reflect and share):

1. What do you like best about your artwork?
2. How do you like working with the structure of tessellation patterning?
3. Do you feel your art project represents a beehive?
4. What do you want people to know about your artwork?

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ART PROJECT STEP BY STEP EXAMPLE:

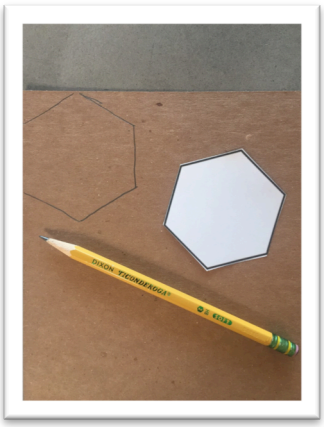

FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIG. 5

Fig. A – Honeycomb Images:

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Fig. B – Hexagon Shape

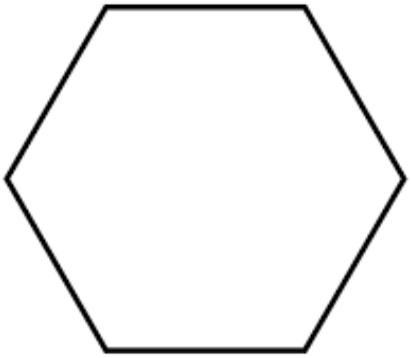

Fig. C – Hexagon Tessellation:

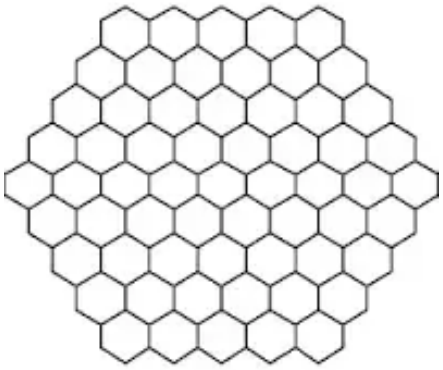

Fig. D – Bee Information:

Bees are a type of insect that has three body parts: head, thorax, and abdomen. There are three types of bees in a beehive (queen, worker, and drone) and each type performs distinct tasks to maintain the colony. Bees represent environmental protection as well as hard work.

- Bees have two large compound eyes that allow them to see all around. Each compound eye is made up of more than 6,000 small lenses, which are each like a separate eye.
- The antennae on top of a bee's head help it smell, feel, and taste.
- The middle section of a bee's body is called the thorax. Three pairs of legs and two pairs of wings are attached to the thorax.
- The rear of a bee's body is called the abdomen. Female worker bees produce the wax used to build the hive using this part of their body. Female bees have stingers at the end of their abdomens, while male bees do not.
- The queen is the largest bee in the colony and is the only one that can lay eggs.
- Worker bees, which are all female, build the hive with wax secreted in their abdomens. Workers also care for the young bees, defend the hive, and forage for pollen and nectar.
- Drones are male bees that have the sole task of mating with the queen.

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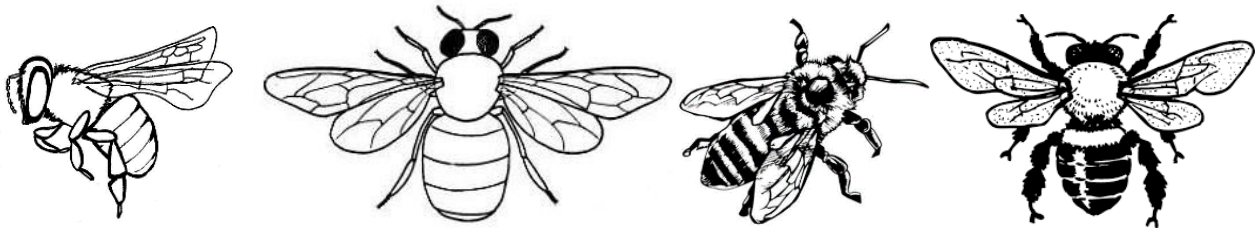

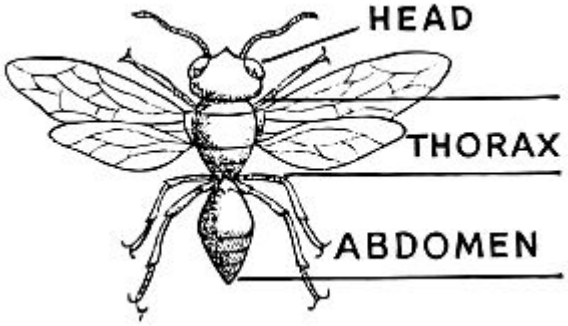

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