Honeycomb Lab Teacher's Guide

Observable characteristics of polygons explain why honey bees use hexagons to build their combs. The geometric concepts of tiling and area are applied to our natural world.

Introduction

As climate change, pesticide use, and habitat reduction erode the pollinator population, scientists who study ecology, horticulture, entomology and botany are researching ways to help many species that are facing extinction. Now, more than ever we need scientists in the field of Anthecology or pollination biology.

Let's put on our lab coats and see if we can come to our own conclusions about one specific pollinator: the honey bee. Honey bees build cells in a honeycomb to store honey and to raise their young. This honeycomb is the inside structure of a bee's nest. Building a single wall for the comb is a monumental task for a bee; it requires a lot of honey and a lot of bee-energy. Bees may be busy, but they certainly don't want to do extra work.

Materials:

Polygon worksheet (printed one-sided)
Lab worksheet
Scissors
Pen or pencil

Procedure:

If your students are not familiar with a honeycomb, use this link for a good image: https://www.macmillandictionaryblog.com/honeycomb

What do you notice about all the cells of a honeycomb?

They are all the same shape and size (congruent)
They all fit together
They are hexagons – or some may think they are circles.

Part 1: Cell shape needs to tesselate

Let's take a closer look at different polygons to see which other choices a honey bee might use for a cell.

Hand out the Polygon Worksheet and scissors. Have the students cut out the polygons and see which of them a bee might choose to construct the comb.

The triangle, the square and the hexagon are the only polygons that fit snuggly against each other without gapping. We say these polygons tesselate.

Why do you think they use polygons that fit together to build the comb?

If each cell shares a wall with other cells, the bees do not need to build as many walls.

If there are gaps in between the cells, the bees would need to make more wax to fill the gaps so that the structure is sound.

According to Stacy George of ScienceFriday.com: "Bees collect nectar and pollen from flowers to make honey, a sugary food, for the colony. Honey provides bees with the energy they need to survive and reproduce, as well as to build their homes. In order to make enough wax, worker bees need a lot of energy, and must therefore consume a lot of honey. Some studies estimate that bees must consume eight ounces of honey for every ounce of wax they produce. Imagine how many flowers a bee must visit to be able to convert nectar into eight ounces of honey!

On average, each bee can produce about 1/12 of a teaspoon of honey in its lifetime. If a bee colony were to provide one pound of honey, it would need to visit about 2 million flowers. The whole colony may travel about 55,000 miles in its lifetime!"

Instruct your students to save the polygons with the grey circles inside. They will use these for Part 3.

Part 2: The comb needs to be built with as few walls as possible

Three polygons, triangle, square and hexagon, can be used to build a honeycomb, so why do the bees use the hexagon? Taking a closer look at how much work and raw materials each different polygon requires may offer some explanation.

Hand out Honeycomb Lab

Instruct your students:

> For the sake of illustration, each wall is ¾ of an inch long, and each comb covers approximately 15 in^2. The heavy black frame is not considered a wall, and for the sake of estimation, count each partial wall as ½ of a wall. Include the walls on each partial cell.
>
> Work in an organized manner. Use a pencil or pen to outline the cell walls, counting as you go. When you reach the end of the row or column, enter the number of walls into the white box, then total the white boxes.

Students answer Discussion Questions

Why do you think they use polygons that fit together to build their comb? (We call these tessellating polygons.)

Answered previously

Which of the tessellating polygons required the fewest number of walls?

Hexagon

Why would this shape be beneficial for the bees?

It requires the fewest number of walls.
Each cell offers a larger space to accommodate the honey and the young.
It closely imitates the shape of a bee's body

Additional info: Why Do Bees Make Hexagons in Their Hives?
Dr. Universe
https://askdruniverse.wsu.edu/2015/11/02/why-do-bees-make-hexagons/#:~:text=When%20bees%20make%20hexagons%20in,sided%20shapes%20fit%20together%20perfectly.&text=Cobey%20showed%20me%20some%20honeycombs,bees%20bring%20to%20the%20hive

Part 3: The most efficient comb wastes the least amount of space.

It could be that your students noticed that there are fewer hexagons which means fewer number of walls. What if we made the triangles larger: large enough to accommodate the size of the bee's body? Would the fewer number of triangles mean fewer number of walls?

Instruct your students:

> Line up the polygons with the grey circles that you cut out in Part 1
>
> The grey circle represents the cross-section of the bee's body. The most efficient cell is the one that minimizes waste.

Students answer Discussion Questions

Which shape has the least amount of unoccupied (wasted) space?

Octagon

Why did we eliminate that shape in Part 1?

It did not tesselate

Can you make a conjecture about how the number of sides effects the amount of wasted space within the cell?

As the number of sides increases, the unoccupied space decreases.

Eliminate the same polygons we eliminated in Part 1

Which of the three remaining shapes is the most efficient use of space?

Hexagon

Source: Why Are Honeycomb Cells Hexagonal?
Stacy George
www.sciencefriday.com

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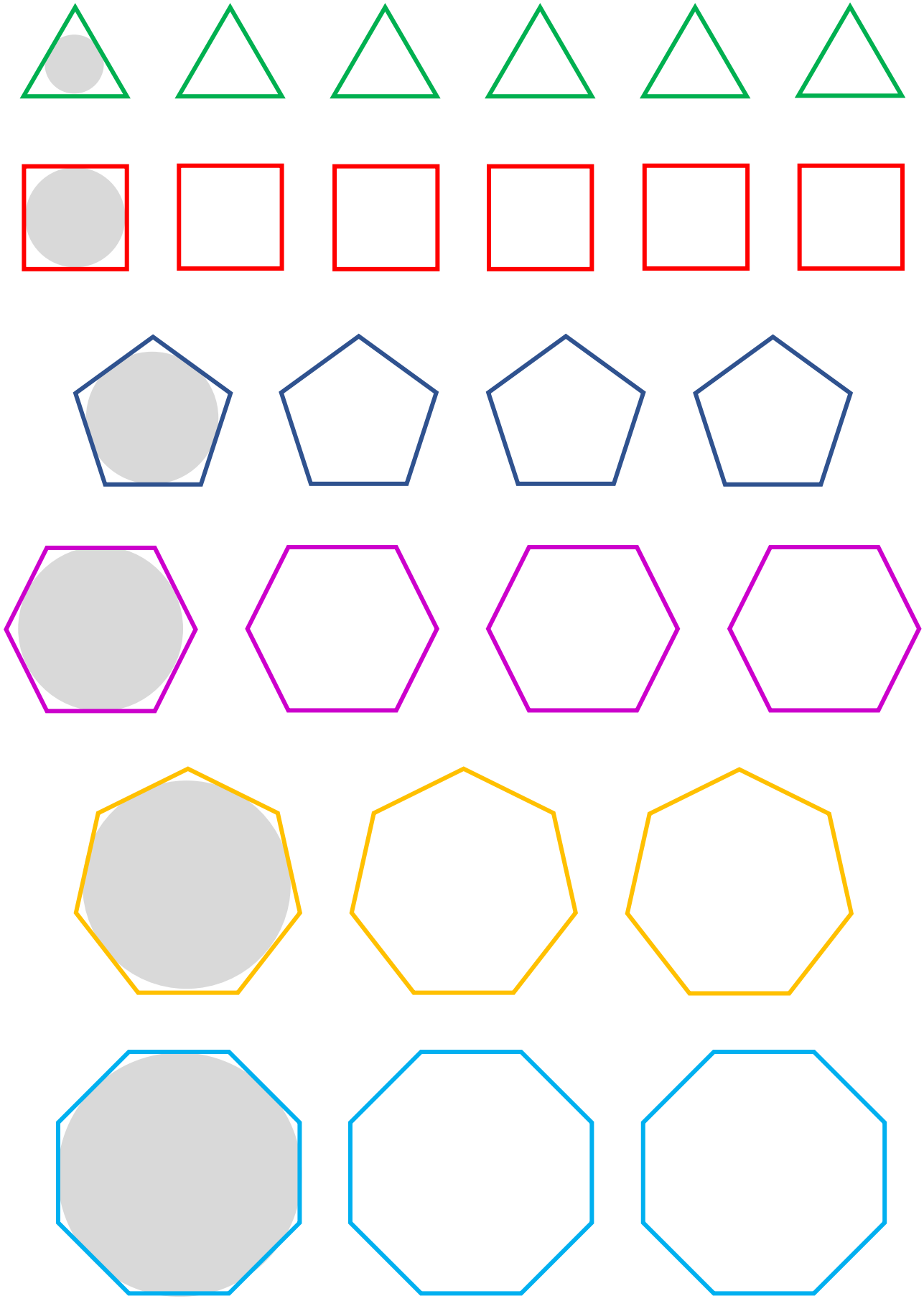
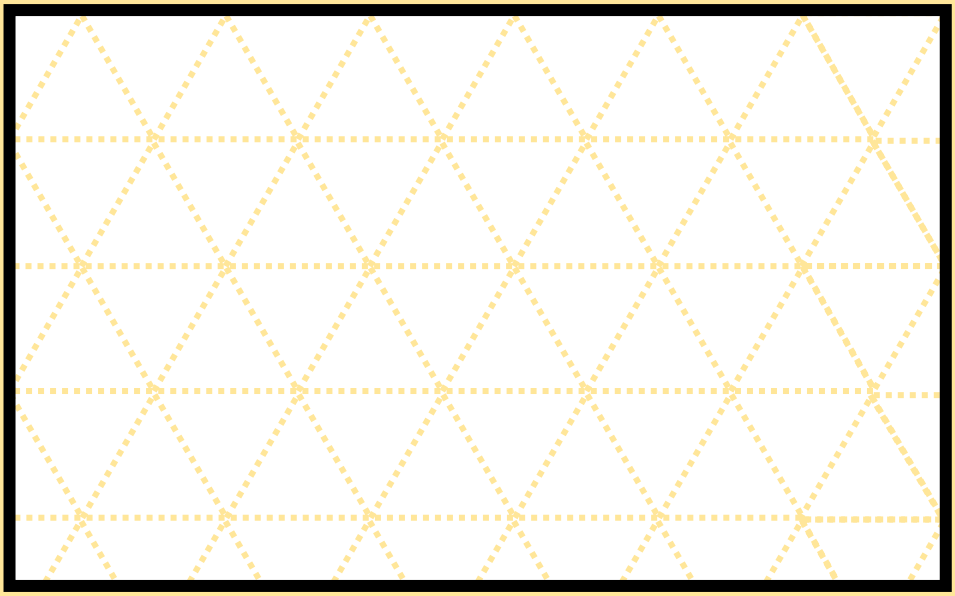
Polygons



Honeycomb Lab



walls row 1

walls row 2

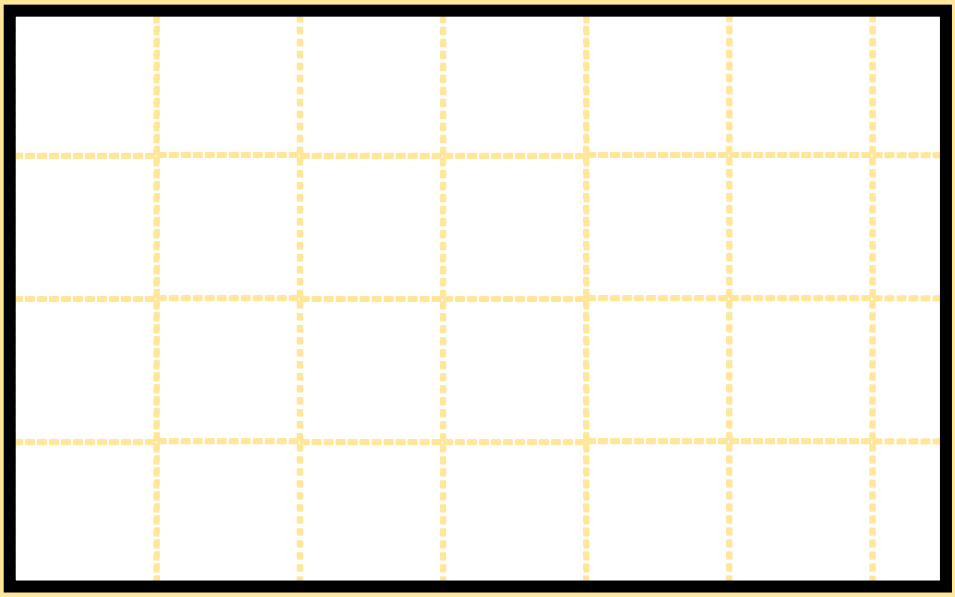
walls row 3

walls row 4

walls row 5

Total # walls

Number of walls needed to build a honeycomb using **triangles**



walls row 1

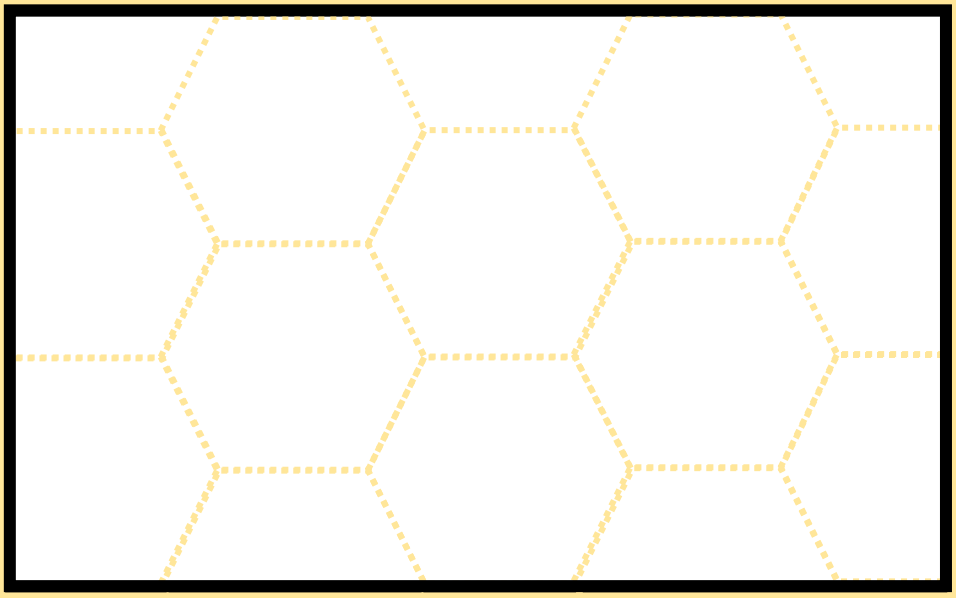
walls row 2

walls row 3

walls row 4

Total # walls

Number of walls needed to build a honeycomb using **squares**



walls column 1

walls column 2

walls column 3

walls column 4

walls column 5

Number of walls needed to build a honeycomb using **hexagons**

Total # walls

Discussion Questions:

Honeybees build cells in the honeycomb to store honey and to raise their young. Building a wall is a monumental task for a bee; it requires a lot of honey and a lot of bee-energy. Why do you think they use polygons that fit together to build their comb? (we call these tessellating polygons)

Which of the tessellating polygons required the fewest walls?

Why would this particular shape be beneficial for the bees?

What do you wonder?