Beehive World Lesson 3: Beeswax

Students learn how bees make and use wax, then they explore tessellation and perimeter-to-area ratios to find out why bees build hexagons.

Guiding Ideas

This project was developed with the American Beekeeping Federation's Kids and Bees program. Explore three new Minecraft worlds, created by Lifeboat, and use new lessons to introduce students to bees' dynamic and fascinating roles in their own hives and in broader ecosystems. Beeswax is Lesson 3 of 5 for Beehive World.

Learning Objectives

⬡ NGSS Crosscutting Concepts: Patterns; Scale, Proportion, and Quantity
⬡ NGSS Science and Engineering Practices: Using Mathematics and Computational Thinking; Constructing Explanations
⬡ NGSS Disciplinary Core Ideas: ETS1.C: Optimizing the Design Solution
⬡ CCSS.MATH: Ratios & Proportional Relationships, Grades 6 & 7
⬡ CCSS.MATH: Geometry, Grades K-8
⬡ CCSS.MATH: Measurement & Data, Grades K-5
⬡ Understand the importance of beeswax in the hive: how it's made, stored, and used
⬡ Apply computational thinking to develop an argument for why hexagons are the most efficient shape for bees to use

Performance Expectations

This lesson will enable students to:
⬡ Describe how bees make beeswax
⬡ List bee and human uses for wax
⬡ Defend hexagons as the most efficient shape for bees to use

Skills

Collaboration, Creativity, Critical Thinking

Total time needed

55-95 minutes

Materials needed for classroom activities

1 pipe cleaner for each pair of students
1 ruler for each pair of students
3 sheets of blank paper for each pair of students
Optional: 1-pound and 10-pound weights (or objects with similar weights), one set to pass around the whole class
Optional (for art activity): Index cards or sticky notes, one for each student; scissors, one pair per student; blank paper, 1-2 sheets per student; colored pencils

Introductory questions

⬡ Have you ever used beeswax? What did you use it for?
⬡ Where does wax come from?

Student Activities

Introduction (whole class) 5 minutes
Turn students' attention to the topic of beeswax using the first introductory questions above: have you ever used beeswax, and if so, what for? Guide the discussion to include candles, skin care products, lip balm, furniture polish, cheese rind, crayons, dental floss, envelope seals, and waxed produce boxes.

Then ask students where they think beeswax comes from -- guesses are great! After a brief discussion, show them this image of a honeybee with wax scales. Explain that bees eat honey to get nutrients and energy, and using those resources, they make wax scales in their wax glands. Share with students this amazing fact: it takes about 8 pounds of honey to make 1 pound of wax! If available, pass around 8 pound and 1 pound weights (or objects of approximately those weights) for students to feel the difference.

Tell the group that in today's lesson, they will be learning about how bees make the very best use of this precious resource, so that they don't waste any.

Minecraft Beehive (explore as individuals) 20-30 minutes
Students will meet a scientist in a lab outside of the beehive. The scientist will instruct the students to gather a bee costume, a camera, and a quill and paper from the chest. Students will transport to the hive and meet the NPC Bee Girl outside the hive and receive a welcome and introduction to the beehive.

Once they have arrived inside the beehive, and found the beeswax section, bee guide Isabella will tell students about hexagons in the hive by showing them the video "Why do honeybees love hexagons?". Students may also visit with bees Luciana and Jada, who share information about beeswax, and how it's used by both humans and bees.

Next, students visit Emma for directions on what to fill the comb with.

Finally, Victoria shares with students the video "World's Weirdest: Honey Bee Dance Moves" to learn about the waggle dance bees do on the comb.

When they are through building their honeycombs and filling them with eggs, bee bread, and honey, students return to the classroom for a tessellation activity.

Please note that other bee NPCs exist in Beehive World; students will interact with them in other lessons. Also note that many of the NPCs have videos to share, so make sure students have headphones. If the students are having difficulty finding the sections of the hive, they can just ask the queen to send them to where they need to go!

In-Class Exercise and Discussion (whole class, individual, and small groups) 30-60 minutes
Reiterate with students that it takes a lot of work and resources to make wax: bees can turn about 8 pounds of honey into just 1 pound of wax. That means, that if you were a bee, and

you had to do all that work to make that wax, you would probably want to be as efficient as possible when building -- no gaps, no overlaps.

The special word for this kind of pattern is “tessellation”. Tessellation is when shapes can be put directly next to each other with no gaps and no overlapping. Ask students for what shapes they think can be tessellated; each time a student gives an answer, ask the whole class to give a thumbs up to show agreement, thumbs down to show disagreement, and thumbs sideways to show they’re not sure. Ask a few students to defend their responses.

Guide the discussion toward squares, equilateral triangles, and hexagons. Ask students to each make a hypothesis: out of those three shapes, which do you think are the most efficient? That is, which ones use the least amount of wax (perimeter) to make the most amount of space (area) inside? Ask for a show of hands for each of the three shapes to see students’ hypotheses. Let the group know that they will be working in partners to determine which of the three shapes is the most efficient. Pass out one pipe cleaner, one ruler, and three blank sheets of paper to each pair of students.

Explain to the class that they will use the same pipe cleaner to make three different shapes: square, triangle, and hexagon. For each shape, the students will make a tessellation on one of the blank pieces of paper. Demonstrate the technique: work together to trace the shape directly under the pipe cleaner (not tracing outside the pipe cleaner) to get an accurate representation of the perimeter-to-area ratio; make sure that for each repetition of the shape, at least one side of the polygon is lined up directly on top of an existing line; keep the repetitions clustered (rather than spreading out into a line); and number the repetitions 1-10 to make sure they have 10 repetitions for each shape.

For each shape, either provide students with the length of each side of the polygon, or ask them to do the calculations themselves. To find the length of each side, divide the total length of the pipe cleaner by the number of sides in the polygon (triangle: 3; square: 4; hexagon: 6). Measure with the ruler before bending the pipe cleaner, to make all sides of each shape equal.

Tell students to straighten and reuse the same pipe cleaner to make all three shapes. This ensures that the perimeter is the same across all of their tessellations, making it easy to compare the tessellations’ areas. Another way of thinking about this is that you are controlling the variable of the shapes’ perimeter.

After making 10 repetitions of each shape, each on its own piece of paper, ask students to layer their three papers on top of each other and hold them up to a window, moving the pages around so that the tessellations overlap as much as possible. Ask students to determine which shape’s tessellation covers the largest area. Gather the group’s attention and ask for a show of hands for which pairs thought hexagons made the largest overall shape, which pairs thought squares did, and which pairs though triangles did. (Hopefully hexagons are the clear winner.) Invite students to think back to their hypothesis, and then ask for a raise of hands for how many students were wrong in their initial guess. Encourage honesty -- a big part of science is recognizing when you were wrong, and using evidence to help change your mind! Reiterate that bees use hexagons to make the most efficient use of their wax, which is a very precious resource to them and also to humans.

Optional continuation: For a related art activity, students can make their own tessellations. Lesson plans abound online for this activity; check out The Exploratorium's resource here.

External Resources

Why do honeybees love hexagons? - This 4-minute video from TED-Ed explains the math behind the efficiency of honeybees' hexagons.

World's Weirdest: Honey Bee Dance Moves - This 90-second video from National Geographic shows the waggle dance that bees perform to communicate with each other about the location of food sources nearby the hive.

Image of honeybee with wax scales - This image shows a honeybee producing wax scales.

Creative tessellation - This lesson plan guides students through the process of making their own tessellation art pieces.

Vocabulary

Bee bread - a combination of pollen, nectar and honey that nurse bees eat in order to produce food (worker jelly) for the young larvae, also balled up and fed to older larvae

Beeswax - a solid compound produced by worker bees to make comb

Brood - immature honey bees: eggs, larva, pupa

Cell - the hexagonal compartment made of beeswax used to store honey, pollen, and nectar and to raise the brood

Comb - a mass of cells, usually formed in two layers with the cells fusing at the bases

Hive - the structure used by bees for a home

Honey - a dense and sugary enzyme-rich liquid compound made by bees from the nectar of flowers

Nectar - a sugary liquid secreted by plants to attract pollinators

Pollen - the vessel housing a plant's male gamete

Ratio - a relationship between two numbers showing how many times one value is contained within the other

Tessellation - shapes that can be arranged so that there are no gaps between them and that do not overlap

Worker bee - adult female bees who do not reproduce, usually over 99% of the colony's population

Further Study

Kids and Bees Handbook

Beeswax Facts for Kids

Why Are Honeycomb Cells Hexagonal?

Beeswax! What do the experts think? - This may be offered as a pre-lesson reading assignment for students.