

Getting a “Bee” in Mathematics Class

In 2007, DreamWorks Animation released *Bee Movie*, an animated film cowritten and produced by comedian Jerry Seinfeld. In the film, honeybee Barry B. Benson is on a quest to change his predetermined career path, namely, a life of making honey. The filmmakers used various characteristics of honeybees to create an entertaining movie. Teachers can also use facts about honeybees to create interesting mathematics activities. This article describes two activities that combine the characteristics of honeybees with important mathematical concepts.

As an expectation for students in grades 6–8, *Principles and Standards for School Mathematics* states, “All students should represent, analyze, and generalize a variety of patterns with tables, graphs, words, and, when possible, symbolic rules” (NCTM 2000, p. 222). In activity 1, students analyze the family trees of honeybees and people. A goal of this activity is for students

to discover patterns related to the number of family members at various generational levels of a family tree. Students use a combination of graphs and tables to investigate these patterns. Some students may also be able to describe these patterns algebraically.

In activity 2, students calculate the surface area and volume of various prisms and make conjectures about which prism would be the best building block with which to construct a honeycomb. This activity relates to several geometry expectations for students in grades 6–8 (NCTM 2000, p. 232):

1. Use two-dimensional representations of three-dimensional objects to visualize and solve problems such as those involving surface area and volume
2. Recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life

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Edited by **Denisse R. Thompson**, Thompson@tempest.coedu.usf.edu, in mathematics education at the University of South Florida, Tampa, and **Gwen Johnson**, gjohnson@coedu.usf.edu, in secondary education at the University of South Florida. This department is designed to provide activities appropriate for students in grades 5–9. The material may be reproduced by classroom teachers for use in their classes. Readers who have developed successful classroom activities are encouraged to submit manuscripts in a format similar to this “Mathematics Exploration.” Of particular interest are activities focusing on the Council’s Content and Process Standards and Curriculum Focal Points. Send submissions by accessing mtms.msubmit.net.



THE BEE FAMILY TREE: RECOGNIZING PATTERNS

In the movie, Barry had two parents, Martin and Janet Benson. In reality, however, only female honeybees have both a mother and a father. Male honeybees, called *drones*, have only a mother. These fascinating facts about the ancestry of bees provide the basis for an interesting activity related to pattern recognition. Students construct a bee family tree for a female honeybee and a male honeybee and find patterns to help calculate the number of ancestors for a given generation.

To begin, teachers may want to discuss the first few generations of Betty Bee's family tree as shown on **activity sheet 1** before having students construct several more generations. After students add several generations

to the family tree, they can make conjectures about the number of bees in each older generation and record their data in the table on the sheet.

The numbers in the table are 1, 2, 3, 5, 8, . . . , which is a portion of the Fibonacci sequence. Hence, the number of bees in each older generation can be calculated by adding the number of bees in the two subsequent younger generations. For example, the number of great-grandparents that Betty has is equal to her number of grandparents plus her number of parents: the number of great-grandparents = the number of grandparents + the number of parents.

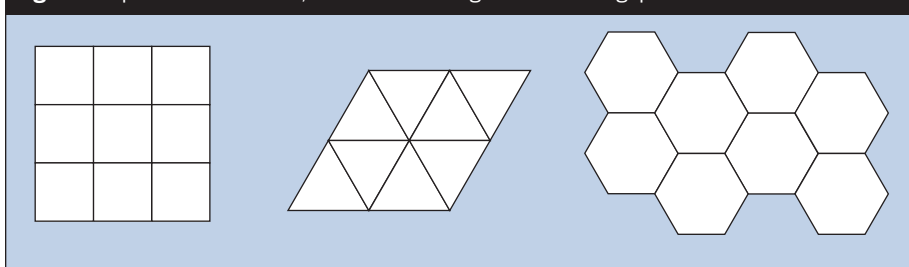
Once students have explored the activity for Betty, teachers can ask students to compare Bobby's family tree and look for similarities and dif-

According to the latest buzz, bees belong in mathematics class

ferences from Betty's family tree (see problem 7 on **activity sheet 1**). The bees in each generation of Bobby's tree number 1, 1, 2, 3, 5, 8, . . . , which, again, is the Fibonacci sequence.

As an extension, teachers can have students compare the family tree of a bee with the family tree of a person, as indicated in problem 11 on **activity sheet 1**. The number of people in each generation of Tony's family tree is 1, 2, 4, 8, . . . , which generate powers of 2 ($2^0, 2^1, 2^2, 2^3, \dots$).

Fig. 1 Shapes that *tessellate*, or that can fit together with no gaps



MINDING YOUR OWN BEESWAX

In the movie, Barry is not excited with the prospect of spending his life making honey. However, the process that real honeybees use to make honey is enthralling. Especially interesting is the fact that honeybees build hexagonal honeycombs in which to store the honey. In this activity, students investigate properties of hexagons to learn why this shape is an efficient design for a honeycomb compared with other geometric shapes.

To begin the lesson, teachers can ask students, “If you were building a honeycomb, would you want it to have gaps? Why or why not?” Teachers may have to point out that a honeycomb with gaps wastes space; therefore, it would be best not to have any wasted space. Give students tracing paper or multiple copies of **activity sheet 2** so that the shapes can be cut apart. If students work in small groups, a large number of shapes can be cut out in a short amount of time.

Once students identify the triangle, square, and hexagon as shapes that fit together without leaving gaps, teachers can introduce the term *tessellation*. A tessellation is created when a shape is repeated to tile a plane, without gaps or overlaps. After discussing tessellations, teachers should ask students if the three prisms in problem 3 on **activity sheet 2** would tessellate (which they do). (See **fig. 1** for an illustration of tessellations.)

To help students understand why bees use a hexagonal honeycomb, have them explore the volume of prisms

that share the same perimeter for their base. Students must consider the amount of beeswax needed to construct the walls of each prism, as described in question 5. While working toward a correct conjecture, students should verify that the same amount of beeswax is used to build the walls of each prism. Remind students that to calculate this amount, the perimeter of the base is multiplied by the height (or depth) of the respective prism. For a comparison, assume that the height of each prism is one unit. Because each base has the same perimeter and the depth of each prism is one unit, bees need the same amount of beeswax to build each prism.

Depending on their prior experience, students may need to recall that the volume of each prism is equal to its height (or depth) multiplied by the area of its base, or

$$\text{volume} = \text{area-of-base} \times \text{height.}$$

Because the height of each prism is one unit, the problem simplifies to one of calculating the area of each base.

Students may use formulas to find the exact areas of the bases or estimate these areas by counting the number of squares in each base. The approximate areas of the triangular, square, and hexagonal bases are 27.71 square units, 36 square units, and 41.57 square units, respectively. Hence, the approximate volumes of the triangular, square, and hexagonal prisms are 27.71 cubic units, 36 cubic units, and 41.57 cubic units, respectively.

When students compare the volume of the prisms, they should notice that the hexagonal prism has the largest volume because its base has the largest area. For a given amount of beeswax for the walls, bees can store the most honey in a hexagonal honeycomb.

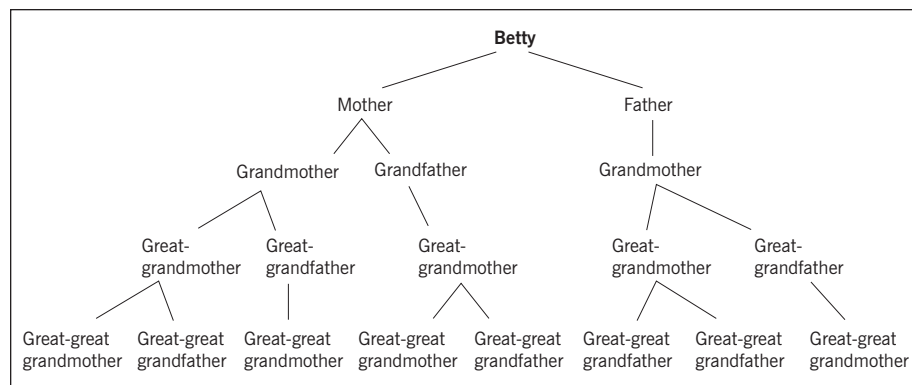
SUMMARY

Whether watched as an animated creature in a movie or studied as a real-life insect, bees are fascinating. In *Bee Movie*, Barry B. Benson was a smart bee that graduated from college and tried to change the paradigm of bee culture. In real life, bees are smart creatures that create complex geometric structures and have unusual ancestries. According to the latest buzz, bees belong in mathematics class.

SOLUTIONS

The Bee Family Tree: Recognizing Patterns

1. See below.

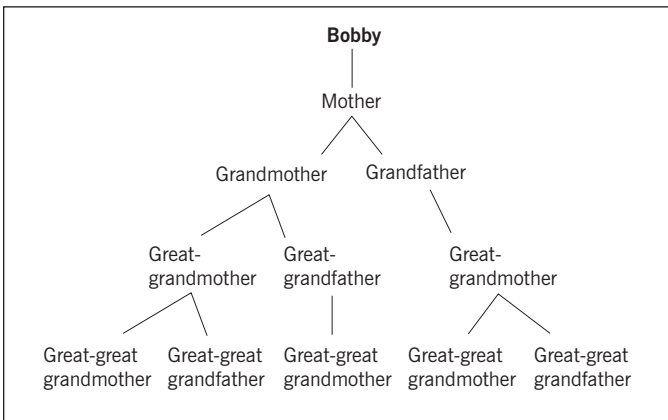


2.

Generation Level	Number of Bees at the Given Level
Betty	1
Parents	2
Grandparents	3
Great-grandparents	5
Great-great-grandparents	8

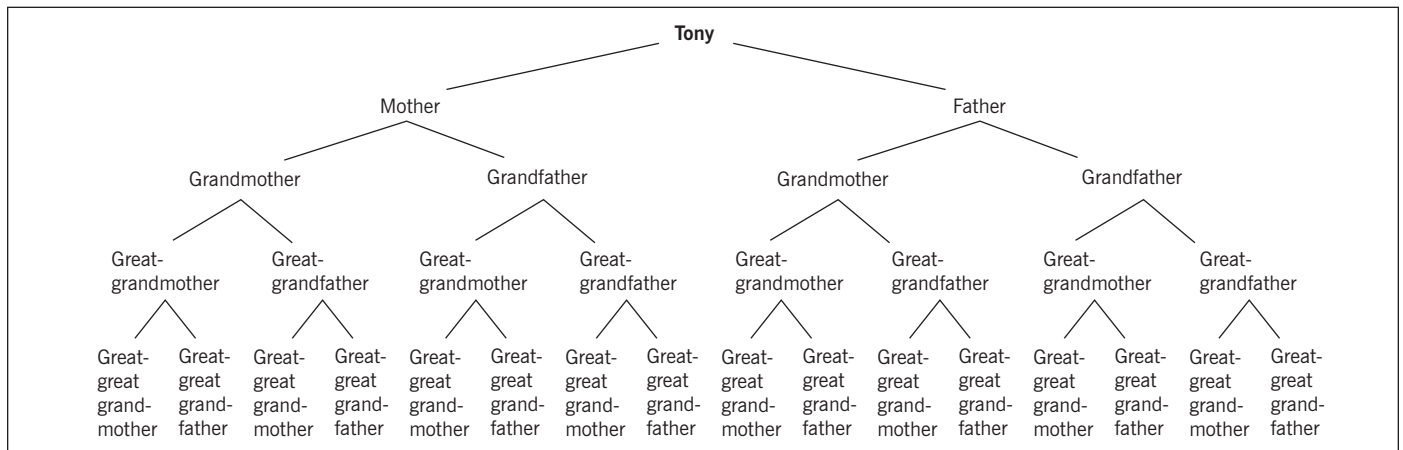
3. Answers will vary, but students should respond that the first row is 1, then 2, then all the following rows are the sum of the previous two rows.

4.



5.

Generation Level	Number of Bees at the Given Level
Bobby	1
Parents	1
Grandparents	2
Great-grandparents	3
Great-great-grandparents	5



6. Answers will vary, but students should note that the first two rows are each 1, then all following rows are the sum of the previous two rows.

7. The two patterns use almost the same numbers, except that Bobby has an additional row of 1 before the summing pattern starts.

8. (See the family tree at the bottom of the page.)

9.

Generation Level	Number of People at the Given Level
Tony	1
Parents	2
Grandparents	4
Great-grandparents	8
Great-great-grandparents	16

10. Answers will vary, but students should explain that every row is twice the previous row.

11. Answers may vary.

Minding Your Own Beeswax

1. (b); (c); (e)

2. Answers will vary.

3. (c)

4. Answers will vary.

5. (a) 63.44 square units; (b) 96 square units; (c) 83.14 square units

6. (a) 21.22 cubic units; (b) 36 cubic units; (c) 31.18 cubic units. (Teachers may want to tell students that the area of the hexagon is 31.18 square units for both 5c and 6c.)

7. Shape (c) will hold the most honey.

REFERENCES

Bee Movie. Directed by Stephen Hickner and Simon J. Smith.

Glendale, CA: DreamWorks Animation, 2007.

National Council of Teachers of Mathematics (NCTM). *Principles and Standards for School Mathematics*. Reston, VA: NCTM, 2000. ●

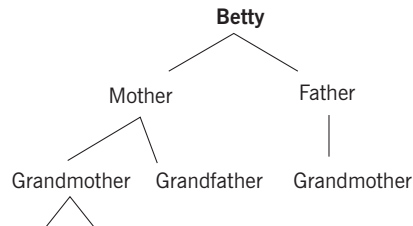
activity sheet 1

Name _____

The Bee Family Tree: Recognizing Patterns

Female honeybees have both a mother and father. Male honeybees have only a mother. Use this information to complete the following problems.

1. Continue the diagram for two more generations for Betty, a female honeybee.

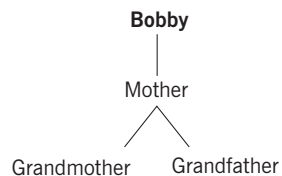


2. Use your diagram to show the number of bees at each level. Record your data in the table.

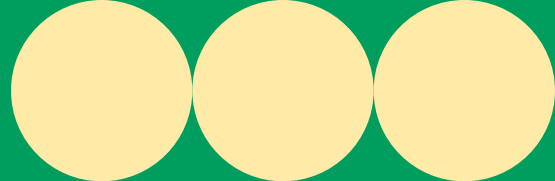
Generation Level	Number of Bees at the Given Level
Betty	
Parents	
Grandparents	
Great-grandparents	
Great-great-grandparents	

3. What patterns, if any, do you notice in the table?

4. Continue the diagram for two more generations for Bobby, a male honeybee.



activity sheet 1 (continued)



5. Use your diagram to show the number of bees at each level. Record your data in the table.

Generation Level	Number of Bees at the Given Level
Bobby	
Parents	
Grandparents	
Great-grandparents	
Great-great-grandparents	

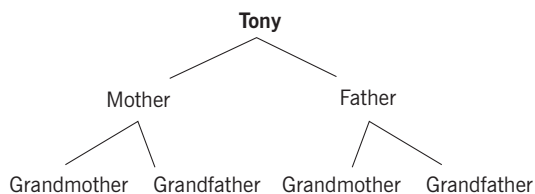
6. What patterns, if any, do you notice in the table?

7. Compare any patterns that you see in the number of bees in each generation for Betty and Bobby.
- How are the number patterns alike?

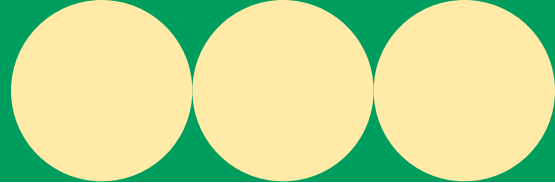
- How are the number patterns different?

Extension: Recognizing Patterns

8. Continue the diagram for two more generations for Tony, a middle school student.



activity sheet 1 (continued)



9. Use your diagram to show the number of people at each level. Record your data in the table.

Generation Level	Number of People at the Given Level
Tony	
Parents	
Grandparents	
Great-grandparents	
Great-great-grandparents	

10. What patterns, if any, do you notice in the table?

11. Compare the patterns and the number of members in a family tree for bees and for people. What do you find?

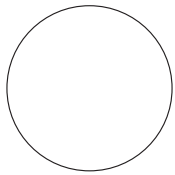
Challenge: Construct an algebraic expression that models the sequences of numbers in each table.
(Hint: Some sequences may be easier to model recursively.)

activity sheet 2

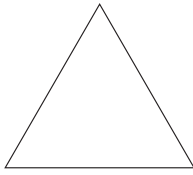
Name _____

Minding Your Own Beeswax

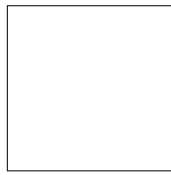
1. Consider the six shapes below. Which shapes can fit together without leaving any gaps? Trace copies of the shapes onto paper to investigate. Use enough copies to be sure that there would be no gaps.



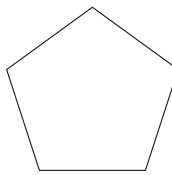
(a)



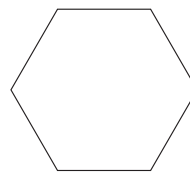
(b)



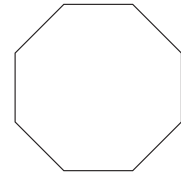
(c)



(d)



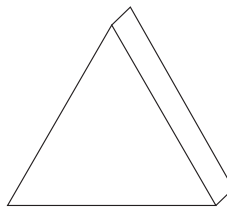
(e)



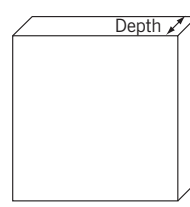
(f)

2. If you were building a honeycomb, would you want it to have gaps? Why, or why not?

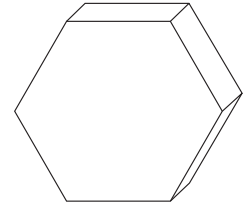
3. Consider the three prisms at right. The base of (a) is an equilateral triangle; (b) has a square base; and (c) is a regular hexagon. If each has the same depth, which prism will hold the most honey? _____



(a)



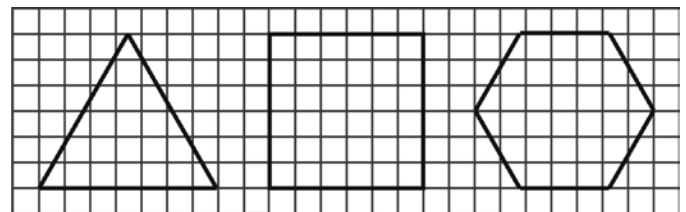
(b)



(c)

4. Make a conjecture and provide a rationale, explaining why your choice of shape would hold the most honey.

5. For each prism, find the amount of beeswax that would be needed to make the walls of the prism. The grid at right shows each base placed on a grid. Assume that the depth of each prism is 1 unit.



(a)

(b)

(c)

6. Find the volume of each prism. (Remember that the depth is 1 unit.)

7. Which shape would hold the most honey for a given perimeter for the base?