MO MATH
NATIONAL MUSEUM OF MATHEMATICS

MUTANT Creature Invasion

Minecraft Volume Investigation

Lesson Plan

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Overview

In this lesson, students investigate a fictional scenario to practice measuring volume by counting unit cubes.

Upon entering the classroom, students are asked to imagine they are entering into the world of Minecraft, where everything is made from cubes. The teacher tells the students that they are in a Minecraft blacksmith village, and mysterious creatures invaded the village last night. The villagers dismembered the creatures into a total of 100 cubes. The creatures also left footprints. It is up to the students to determine the volume of the creatures, and ultimately decide whether or not each poses a threat. The students' work determines which of the new creatures to welcome and which to destroy should they encounter them in the future. Students classify each creature as either "hostile" or "friendly", a determination made based on each creatures' volume compared to Steve's volume. In groups, students sketch the 2-dimensional footprints on grid paper and record the area of the base for each creature as left by the footprint. They then work together and reconstruct the corresponding 3-dimensional figures using 100 unit cubes.

Prerequisite Knowledge

- Students do not need an understanding of the game of Minecraft to participate in or understand this activity.
- Students should have a solid foundation in performing basic mathematical computations.
- Students should have a preliminary understanding of 2-dimensional and 3-dimensional figures.
- Prior activities with counting perimeter and area with 2-dimensional figures are beneficial.

Lesson Goals

- Collect information and problem solve.
- Use unit cubes to calculate volume.
- Define the formula for volume.

Assessment

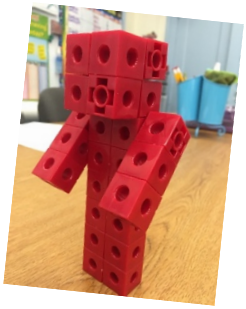
The attached handout is designed to allow students to demonstrate an understanding of the above goals. There are five checkpoints through the activity where the teacher checks students' work before they continue. A class exit slip with additional volume practice will be completed at the conclusion of the lesson

Common Core State Standards

5.MD.C.4: Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and improvised units.
6.G.A.2: Find the volume of a right rectangular prism with fractional edge lengths by packing it with unit cubes of the appropriate unit fraction edge lengths, and show that the volume is the same as would be found by multiplying the edge lengths of the prism. Apply the formulas $V = l\ w\ h$ and $V = b\ h$ to find volumes of right rectangular prisms with fractional edge lengths in the context of solving real-world and mathematical problems.

Setting up the Lesson

1. Before the students arrive, use painter's tape to create four figures on the floor. On a 12x12 tile floor, the tape should outline the squares on the floor to create figures (see visuals on following page). On a carpet or other flooring-type, you'll have to measure. The figures should have the following areas:
   - 7 ft.^{2}
   - 6 ft.^{2}
   - 9 ft.^{2}
   - 4 ft.^{2}



2. It will be helpful if students have a model version of Minecraft's Steve, the main character of the game. He can be assembled using 26 centimeter connector cubes. Eight assembled as 2 x 2 x 2 rectangular prism will make his head; 3 cubes for each arm, and 2 x 6 x 1 can create his body/legs. Although not realistic, this model would give him a **height of 8 feet tall, since the connector cubes represent cubic feet.**
3. **Decide how you will group students. If you will be grouping by level/ability, have groups determined before students arrive.**

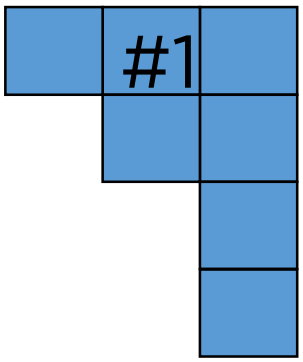
Length of Lesson:
1 class period
(45-60 minutes)

Length of Prep Time:
10-15 minutes

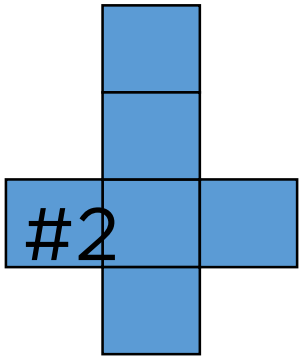
Materials:

- Writing utensils
- Student Handouts (pages 7-10 – one packet per student; 11 & 13 are optional and may be helpful for some students)
- Achievement certificates (page 14 – one per group)
- Exit Slips (page 15 – one per student)
- Connector cubes (100 per group)
- Painter's tape
- 4 index cards (optional – to create tent labels to number the figures)

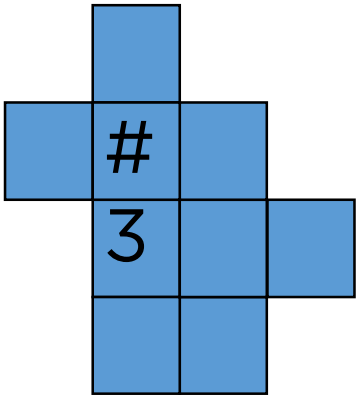
Examples of figures to create on the floor as the "creatures' footprints":



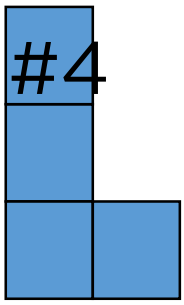
Example of a figure with an area of 7 square units.



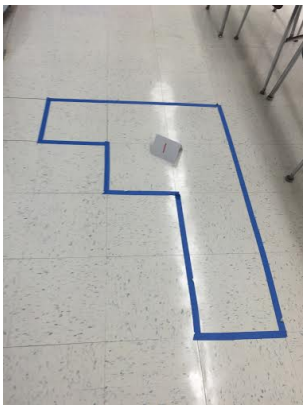
Example of a figure with an area of 6 square

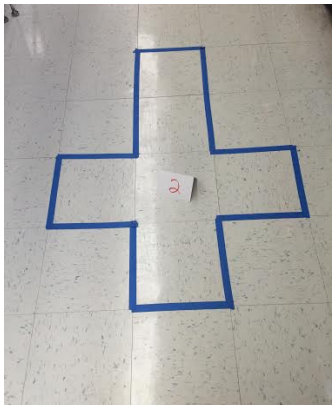


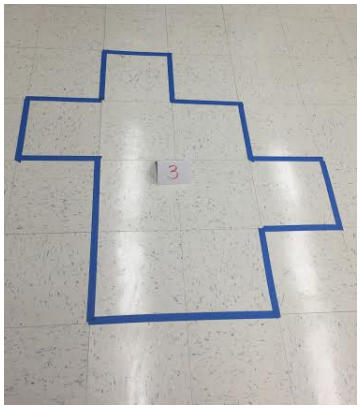
Example of a figure with an area of 9 square units.



Example of a figure with an area of 4







Teaching the Lesson:

1. Introduction: 5 minutes
    - Students will enter the classroom and be immediately intrigued by the figures on the floor. Explain that the students are investigating a mystery within the Minecraft world. It is okay if not all students have a background with Minecraft, they will catch on quickly to what they need to know for this activity.
    - Explain (or have a student volunteer to explain) that Minecraft is a block world of adventure in which you survive different terrain, explore various settings, and encounter all sorts of creatures – some friend and others foe.
    - In this particular adventure, students are in a blacksmith village investigating an incident involving new, never before-seen mutant creatures.

2. Explaining the Mission: 5-10 minutes
    - There were four mystery mutant creatures in the blacksmith village last night. The villagers didn't recognize the creatures, so they broke them apart. They later counted 100 total pieces from the four dismembered creatures.
    - The creatures left "footprints" on the ground. (If students are familiar with the game of Minecraft, they may recognize that the footprints look like they could belong to creatures that are similar to "Slimes", which are rectangular prisms with no appendages). Because it was dark, the villagers are unsure of the exact dimensions of the creatures, but they are able to recall their heights. Two were 3 feet tall, one was 4 feet tall, and one was 6 feet tall. However, it was difficult to tell which creature was each height.
    - No one knows for sure who they were or why they were here, so our task is to recreate the creatures and classify them as either "hostile" or "friendly".
    - Students work in groups and investigate the scene and recreate models of the creatures, determining their respective volumes using 100 unit cubes. Then, students compare their volumes to Steve's volume. If any creatures have a volume greater than Steve, they are considered "hostile" and potentially dangerous. Any creatures with a volume less than Steve's volume are considered non-threatening and "friendly".
    - In this activity, cubic feet will be modeled with cubic centimeters.
    - Review the definition of volume and the use of greater than/less than symbols, as these symbols will be used in data collection.
        - Volume: the amount of space, measured in cubic units, that an object or substance occupies. The basic formula for V = l w h. In this activity, the area of the base won't be rectangular, so it is more applicable to use the formula V = B x h
        - < less than
        - > greater than

3. Explaining the Procedure: 5-10 minutes
    - Assign students to groups and assign group roles.
        - Secretary: keeps track of problem solving methods and strategies used.
        - Data Control: ensures everyone has the correct information copied onto their data tables.
        - Supplies Manager: make sure the group begins and ends with 100 cubes total and everything is cleaned up.
        - Discussion Leader: develops and asks questions for the group to discuss after they finish the task.
    - Distribute handout and grid paper.
    - Have a class discussion to establish a procedure for collecting and labeling data. Each group member is responsible for individual data collection.

- Explain the procedure for sketching the footprints and including applicable units. The sketching portion of the lesson should be limited to 5 minutes.
- Explain that after data is collected, students should find a spot to work together to complete the data table.
- Groups have five opportunities to earn "achievements" (similar to the achievements earned in the game of Minecraft) throughout the lesson for correct work. When they reach the trophy symbol in the handout, they have the teacher check their work.
- Have students discuss how the connector cubes may help them determine the volume of the creatures.

4. Participate in the Activity: 25-30 minutes
    - Students should sketch the creatures' footprints to scale on the grid paper (1 foot = 1 centimeter).
    - Students should enter the collected data (i.e.: area of the base for each creature) into Chart A on the student handout.
    - Student groups should work together to use the evidence and employ various problem solving strategies to determine the creatures' volumes.
    - There are five checkpoints where the students earn "achievements" for accurate work. When students reach these checkpoints (indicated by a trophy), the teacher checks their work in exchange for a small achievement certificate.
    - The teacher addresses questions and concerns and provide feedback as students work. Here are some prompts:
        - Explain what you are currently doing.
        - Why are you using this approach?
        - Have you considered other methods?
        - Does the base have to be identical to the print on the floor or does it just need to have the same area? (This may guide students to create simpler rectangular bases which may be easier and more stable when working with the cubes.)

5. Closure: 5-10 minutes
    - Ensure that all students entered the information on their charts.
    - Discuss strategies that worked best.
    - Distribute exit slips.

Teacher Expectations

The teacher expects student engagement in this problem-solving lesson. Students actively participate in analyzing the creature footprints and attempting to create their 3-dimensional structures.

Student Outcomes

Students demonstrate an understanding of area, perimeter, and volume as it relates to 2-dimensional and 3-dimensional figures. Students demonstrate that volume can be determined by counting unit cubes or using the formula V = B x h.

Lesson Notes and Suggestions

The visual differentiation handout is helpful for frustrated students. The combination scaffolding handout is helpful for students unable to develop or organize their own problem solving strategy. Teacher may provide clues such as the height of one creature to assist struggling students.

Common Student Missteps

Be sure students do not confuse height with volume. A creature could be taller than Steve, but would not be considered "hostile" if his volume was less than Steve's volume.

Extension Activities

- More Math: Create your own Minecraft creature. Determine the perimeter, area of the base, and volume. Draw the footprint on grid paper and exchange with a classmate to solve. Offer clues if needed.

- Technology: Students may use Minecraft to create the creatures described in this lesson. They may also use a web-based Isometric Drawing Tool created by the National Council of Teachers of Mathematics to create unique creatures using virtual manipulatives https://illuminations.nctm.org/Activity.aspx?id=4182

- Writing: Create a story about Steve's adventure helping the villagers solve the mystery of the mutant creatures.

Differentiation Options

- Accommodations for students with special needs:
  - A visual handout provides each possible 3-dimensional representation of the creatures.
  - A problem solving worksheet provides scaffolding for students to do the calculations for all possible combinations of creatures and heights.
- Accommodations for advanced students:
  - Use fractional lengths for the area of the base and height. The base could also be triangular. If the students will be using unit cubes, be sure the volume is a whole number. If they will be using a paper/pencil combination calculation method, the volume does not need to be a whole number.

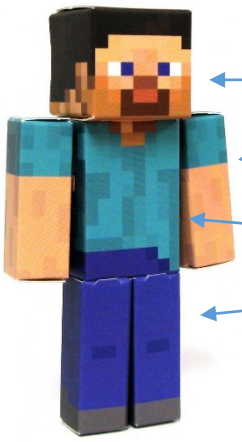
Name: _____ Date:_____

Mutant Creature Invasion:
Minecraft Volume Investigation

You are entering the world of Minecraft. In this dimension, you view the world from the perspective of a character named Steve. As you navigate and try to survive in this block world, you encounter all sorts of creatures, both hostile and friendly. Today, you come across a blacksmith village. The villagers offer to help you survive in exchange for your assistance in solving a mystery.

There were mystery mutant creatures in the village last night. The villagers didn't recognize them and since they couldn't identify them as hostile or friendly, they broke all of them apart. Afterward, they counted 100 total pieces between the four dismembered creatures. Because it was dark, the villagers were unsure of the exact dimensions of the creatures, but they were able to recall their heights. Two were 3 feet tall, one was 4 feet tall, and one was 6 feet tall and they had no arms or legs. However, it is difficult to tell which creature was which height. The creatures left "footprints" in the ground. Our job is to investigate the scene and recreate models of the creatures to determine their respective volumes using 100 cubes. Then, we will compare their volumes to Steve's volume. If any of the creatures have a volume greater than Steve, they will be considered "hostile" and potentially dangerous. Any creatures with a volume less than Steve's volume will be considered non-threatening and "friendly". Steve and the villagers would like to know which of the new creatures to welcome in the future, and which to destroy. They need your help!

Steve



Head: 2 x 2 x 2

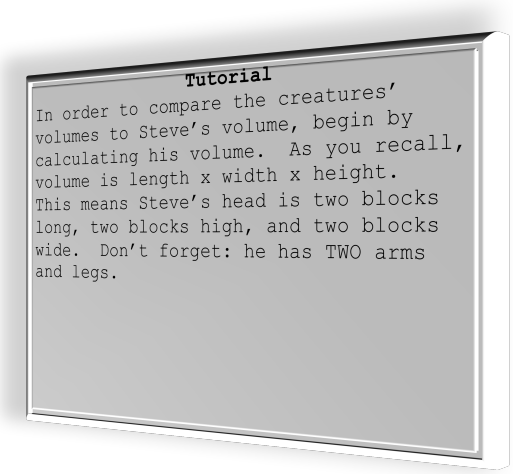
Each arm: 3 x 1 x 1

Torso: 3 x 2 x 1

Each leg: 3 x 1 x 1

Steve's Total Volume:

_____



Investigation Procedure

Step 1: Collect the evidence**.** Using grid paper, sketch the creatures' footprints. Be sure to label the lengths of the sides and label each footprint so you know which creature it belongs to.

Step 2: Record the area of the base for each creature in Chart A.

Step 3: Analyze the clues. In Chart A, use the formula for volume (area of the base x height) to determine the possible volume of each creature.

Tutorial
Multiply the area of the base for each creature by each possible height to determine the possible volumes for each creature.

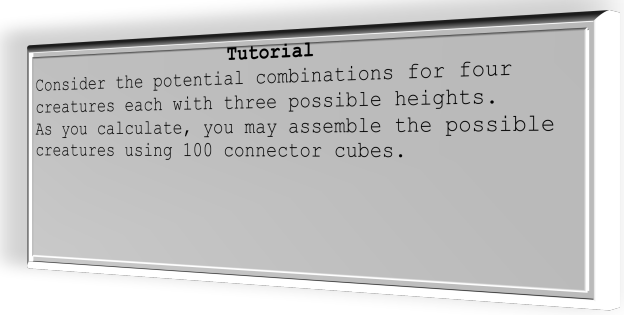
Chart A

Creature	Area of the Base	Possible Height	Possible Volume
		3 feet	
		3 feet	
		4 feet	
		6 feet	
Creature 2		3 feet	
		3 feet	
		4 feet	
		6 feet	
Creature 3		3 feet	
		3 feet	
		4 feet	
		6 feet	
Creature 4		3 feet	
		3 feet	
		4 feet	
		6 feet	

Tutorial
Don't forget to include unit labels! Area of the base is two-dimensional and measured in square units (in this case, $feet^2$). Volume is three-dimensional and measured in cubic units (in this case, $feet^3$).

Step 4: Do the math to identify the combination of creatures' volumes that total 100 cubes. Remember to make sure you have two that are 3 feet tall, one that is 4 feet tall, and one that is 6 feet tall.

Show your work:



Step 5: Record the creature volumes that total 100 units^3 on Chart B and identify each as hostile or friendly.

Chart B

	Volume *Area of the Base x Height*	Is the volume of the creature greater than or less than Steve? *Fill in < or >.*	Hostile or Friendly? *Write 'H' or 'F'*
Creature 1	_____ ft.^{3}		
Creature 2	_____ ft.^{3}		
Creature 3	_____ ft.^{3}		
Creature 4	_____ ft.^{3}		

Tutorial
Double Check: Do the creatures' combined volumes total 100 cubic feet?

Step 6: Recreate the four creatures using connector cubes.

Step 7: Destroy the models of the hostile creatures, so that only the friendly creatures remain. Be sure to clean up when you're done.

Investigation Follow Up

1. What is the formula for calculating volume? _____

2. Explain the problem solving strategy you used to determine the creatures' volumes.

_____

_____

_____

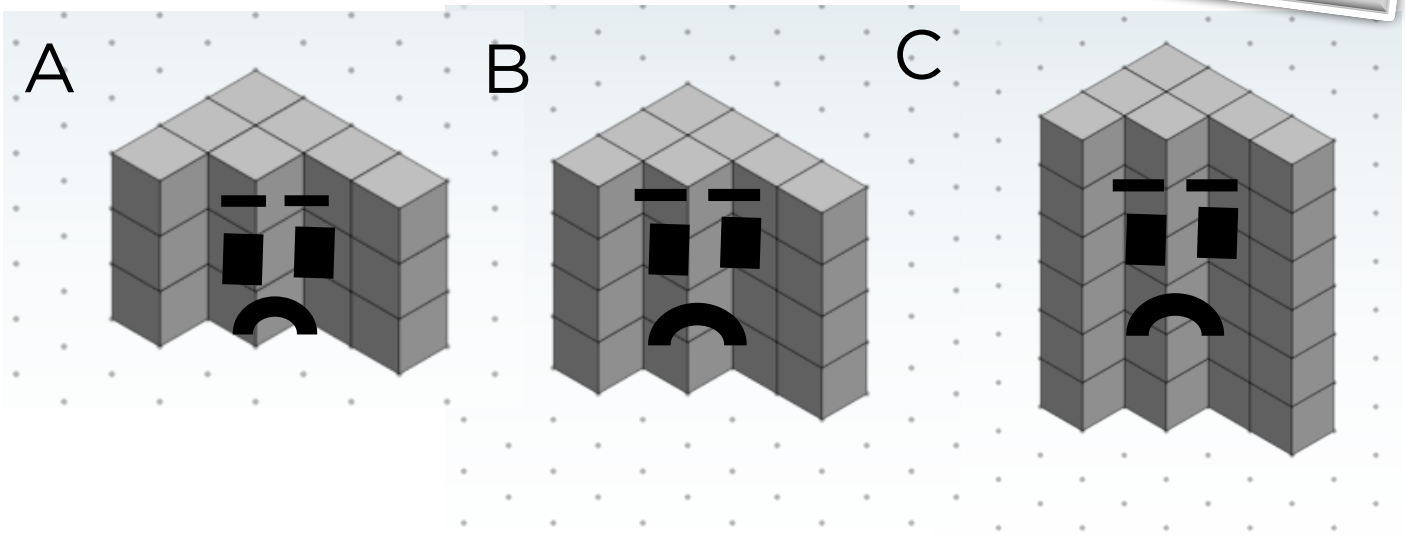
_____

Tutorial

The following figures represent the 3-dimensional figures possible based on the information presented. Your task is to identify the ones that match the volumes of the creatures in the village.

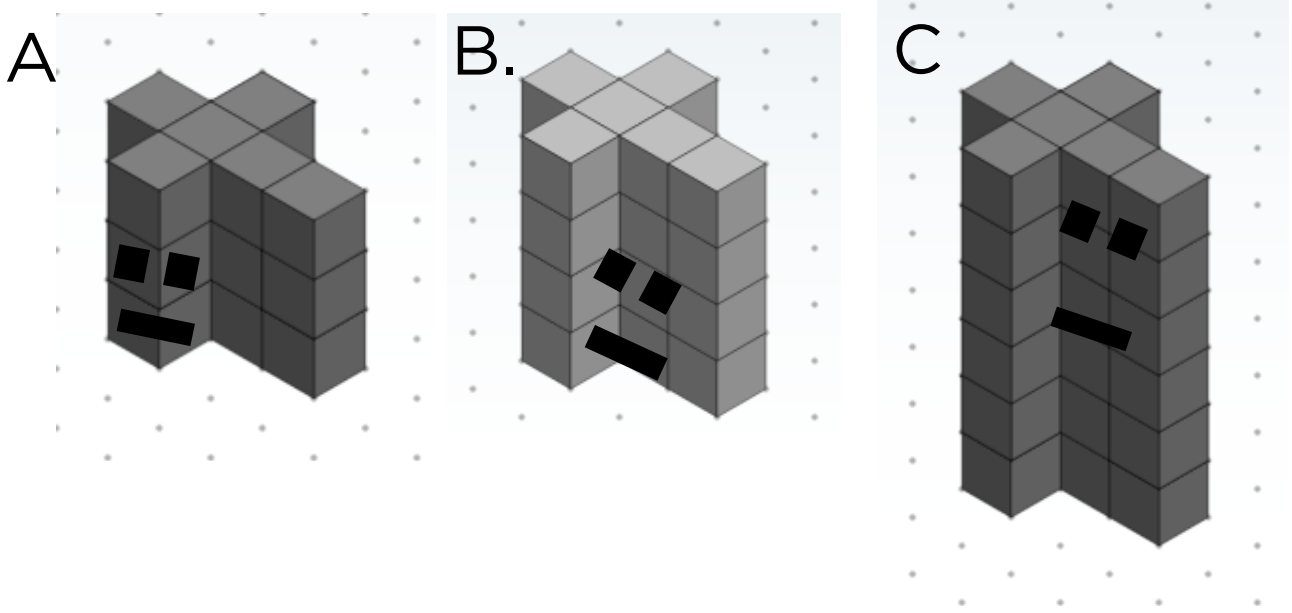
Differentiation Option 1: Provide a Visual (may be used in place of Chart A)

Creature 1



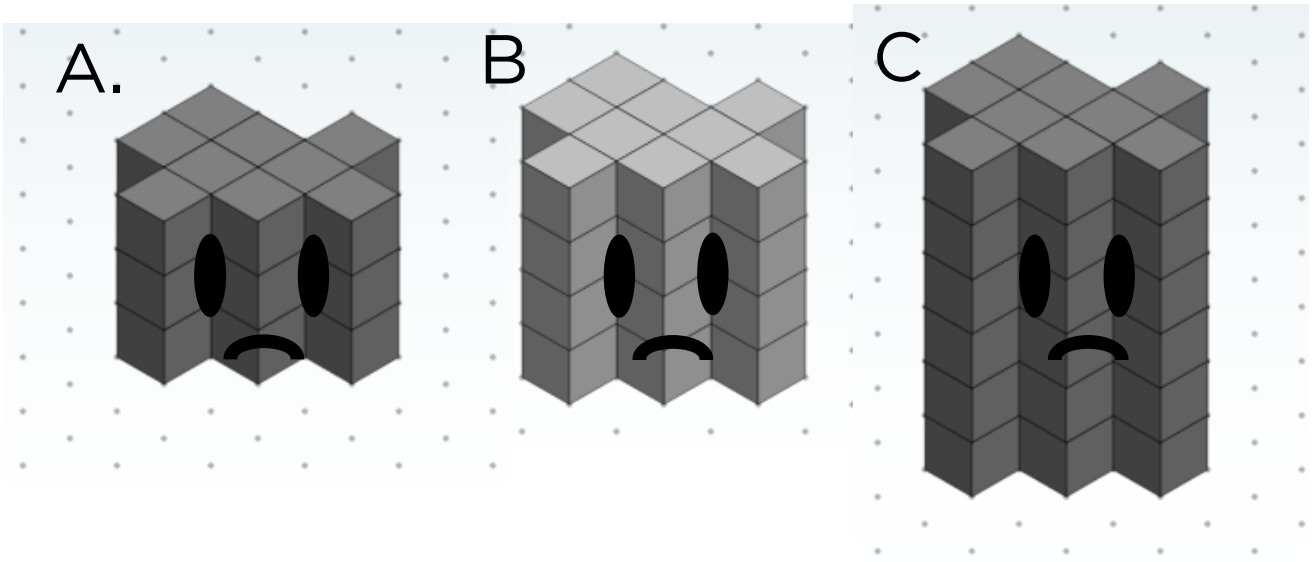
Volume: _____ Volume: _____ Volume: _____

Creature 2



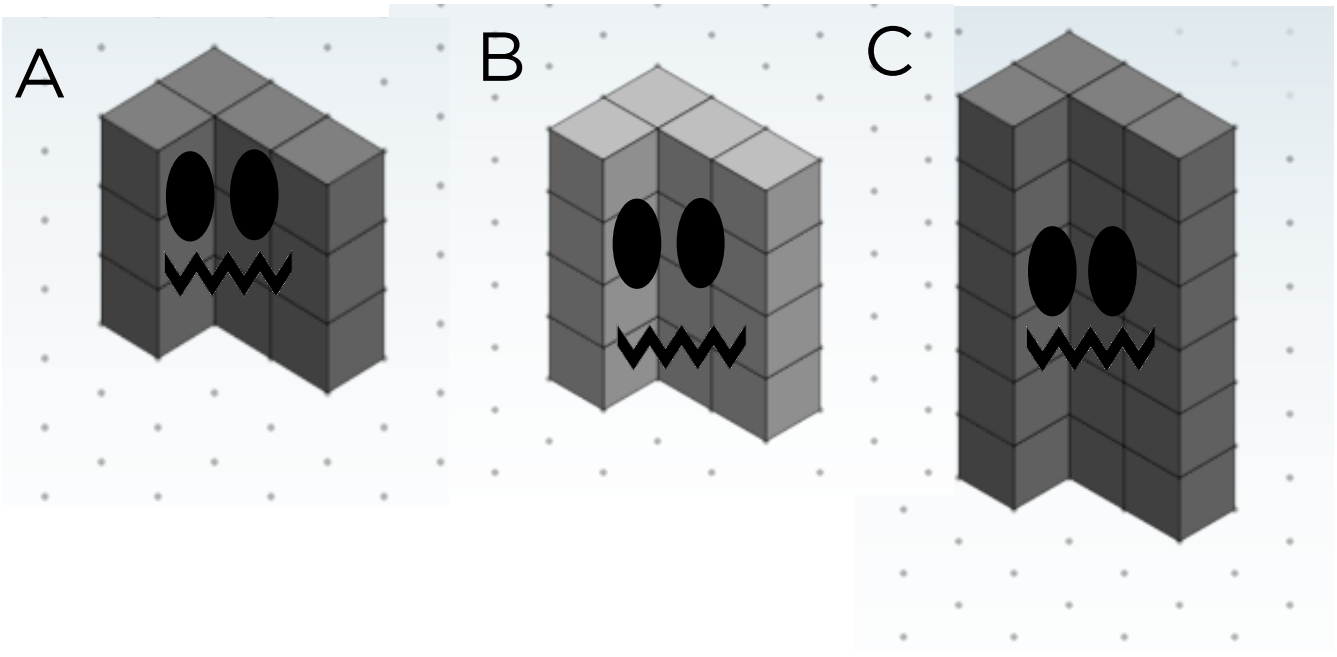
Volume: _____ Volume: _____ Volume: _____

Creature 3



Volume: _____ Volume: _____ Volume: _____

Creature 4



Volume: _____ Volume: _____ Volume: _____

Tutorial

Which combination of figures totals $100ft^3$? Remember, you need to have two that are 3 feet fall, one that is 4 feet tall, and one that is 6 feet tall.

Differentiation Option 2: Provide Scaffolding

Combo #1: Example	Combo #2	Combo #3
Creature 1: 7 ft^2 x 3 ft = 21 ft^3	Creature 1: 7 ft^2 x 6 ft = ____	Creature 1: 7 ft^2 x 4 ft = ____
Creature 2: 6 ft^2 x 3 ft = 18 ft^3	Creature 2: 6 ft^2 x 3 ft = ____	Creature 2: 6 ft^2 x 6 ft = ____
Creature 3: 9 ft^2 x 4 ft = 36 ft^3	Creature 3: 9 ft^2 x 3 ft = ____	Creature 3: 9 ft^2 x 3 ft = ____
Creature 4: 4 ft^2 x 6 ft = 24 ft^3	Creature 4: 4 ft^2 x 4 ft = ____	Creature 4: 4 ft^2 x 3 ft = ____
Total Volume: 99 ft^3	Total Volume: ____	Total Volume: ____
Combo # 4	**Combo # 5**	**Combo # 6**
Creature 1: 7 ft^2 x 3 ft = ____	Creature 1: 7 ft^2 x 3 ft = ____	Creature 1: 7 ft^2 x 6 ft = ____
Creature 2: 6 ft^2 x 6 ft = ____	Creature 2: 6 ft^2 x 3 ft = ____	Creature 2: 6 t^2 x 4 ft = ____
Creature 3: 9 ft^2 x 4 ft = ____	Creature 3: 9 ft^2 x 6 ft = ____	Creature 3: 9 ft^2 x 3 ft = ____
Creature 4: 4 ft^2 x 3 ft = ____	Creature 4: 4 ft^2 x 4 ft = ____	Creature 4: 4 ft^2 x 3 ft = ____
Total Volume: ____	Total Volume: ____	Total Volume: ____
Combo # 7	**Combo # 8**	**Combo # 9**
Creature 1: 7 ft^2 x 3 ft = ____	Creature 1: 7 ft^2 x 4 ft = ____	Creature 1: 7 ft^2 x 4 ft = ____
Creature 2: 6 ft^2 x 4 ft = ____	Creature 2: 6 ft^2 x 3 ft = ____	Creature 2: 6 ft^2 x 3 ft = ____
Creature 3: 9 ft^2 x 3 ft = ____	Creature 3: 9 ft^2 x 6 ft = ____	Creature 3: 9 ft^2 x 3 ft = ____
Creature 4: 4 ft^2 x 6 ft = ____	Creature 4: 4 ft^2 x 3 ft = ____	Creature 4: 4 ft^2 x 6 ft = ____
Total Volume: ____	Total Volume: ____	Total Volume: ____
Combo # 10	**Combo # 11**	**Combo # 12**
Creature 1: 7 ft^2 x 3 ft = ____	Creature 1: 7 ft^2 x 6 ft = ____	Creature 1: 7 ft^2 x 3 ft = ____
Creature 2: 6 ft^2 x 4 ft = ____	Creature 2: 6 ft^2 x 3 ft= ____	Creature 2: 6 ft^2 x 6 ft = ____
Creature 3: 9 ft^2 x 6 ft = ____	Creature 3: 9 ft^2 x 4 ft = ____	Creature 3: 9 ft^2 x 3 ft = ____
Creature 4: 4 ft^2 x 3 ft = ____	Creature 4: 4 ft^2 x 3 ft = ____	Creature 4: 4 ft^2 x 4 ft = ____
Total Volume: ____	Total Volume: ____	Total Volume: ____

Tutorial

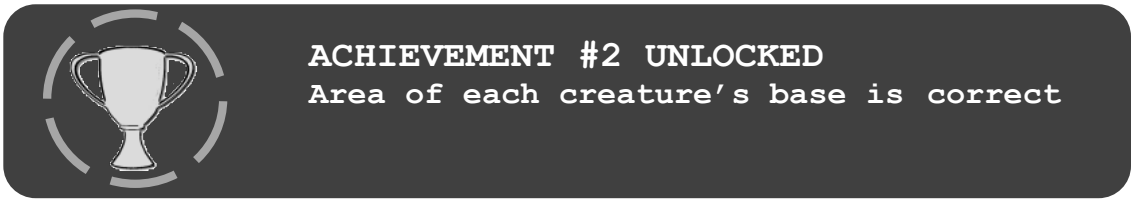
One strategy for solving the mystery is to check every possible combination of creatures and heights. If there are 4 creatures and 3 possible heights, there are 12 possible combinations. Which combination totals 100 ft^3?

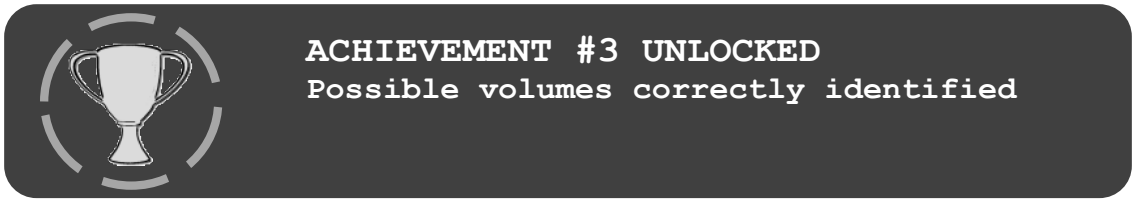
Achievements

To be distributed to groups as they reach checkpoints throughout the handout.

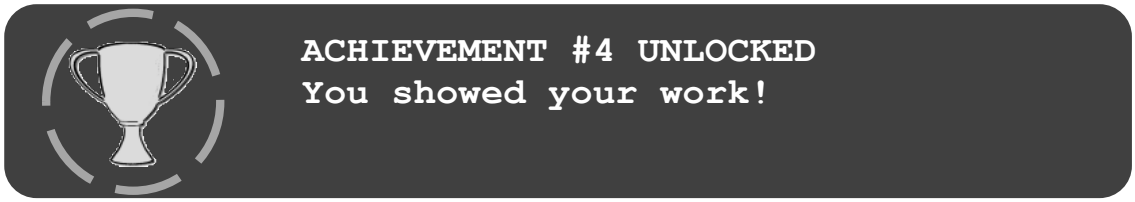
Checkpoints are indicated by this symbol:  on pages 7 – 10.

Page 7

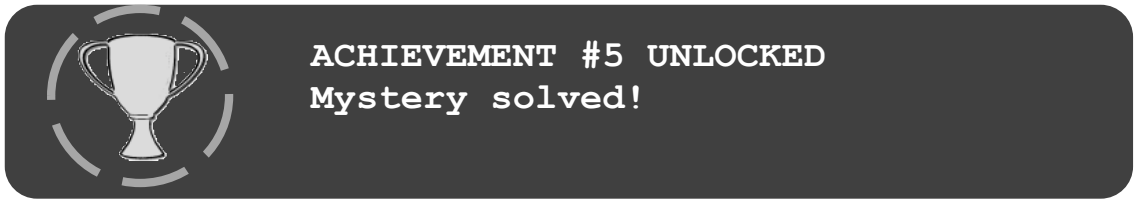




Page 8



Page 9



Exit Slips

Exit Slip Fill in the missing values Name: _____	Area of the Base (The total square units outlined)	Height	Volume (Area of the Base * Height)
	_____ $ft.^2$	3 ft.	45 $ft.^3$
	12 $ft.^2$	_____ ft.	72 $ft.^3$
	5 $ft.^2$	17 ft.	_____ $ft.^3$

Exit Slip Fill in the missing values Name: _____	Area of the Base (The total square units outlined)	Height	Volume (Area of the Base * Height)
	____ $ft.^2$	3 ft.	45 $ft.^3$
	12 $ft.^2$	_____ ft.	72 $ft.^3$
	5 $ft.^2$	17 ft.	_____ $ft.^3$

Exit Slip Fill in the missing values Name: _____	Area of the Base (The total square units outlined)	Height	Volume (Area of the Base *Height)
	_____$ft.^2$	3 ft.	45 $ft.^3$
	12 $ft.^2$	_____ ft.	72 $ft.^3$
	5 $ft.^2$	17 ft.	____ $ft.^3$

Answer Keys

Page 7: Steve's Total Volume: 26 units^3

Pages 8-10: Student problem solving strategies will vary.

Creature	Area of the Base	Possible Height	Possible Volume
	7 feet^2	3 feet	21 feet^3
	7 feet^2	3 feet	21 feet^3
	7 feet^2	4 feet	28 feet^3
	7 feet^2	6 feet	42 feet^3
Creature 2	6 feet^2	3 feet	18 feet^3
	6 feet^2	3 feet	18 feet^3
	6 feet^2	4 feet	24 feet^3
	6 feet^2	6 feet	36 feet^3
Creature 3	9 feet^2	3 feet	27 feet^3
	9 feet^2	3 feet	27 feet^3
	9 feet^2	4 feet	36 feet^3
	9 feet^2	6 feet	54 feet^3
Creature 4	4 feet^2	3 feet	12 feet^3
	4 feet^2	3 feet	12 feet^3
	4 feet^2	4 feet	16 feet^3
	4 feet^2	6 feet	24 feet^3

	Volume Area of the Base x Height	Is the volume of the creature greater than or less than Steve? *Fill in < or >.*	Hostile or Friendly? *Write 'H' or 'F'*
Creature 1	21 ft.^{3}	<	F
Creature 2	36 ft.^{3}	>	H
Creature 3	27 ft.^{3}	>	H
Creature 4	16 ft.^{3}	<	F

Page 13: Combination #12 is the correct solution.

Page 14:

Exit Slip Fill in the missing values Name: _____	Area of the Base *The total square units outlined*	Height	Volume *Area of the Base x Height*
	15 ft.^{2}	3 ft.	45 ft.^{3}
	12 ft.^{2}	*6* ft.	72 ft.^{3}
	5 ft.^{2}	17 ft.	*85* ft.^{3}

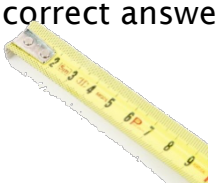
Group Member Task Cards

Secretary

Your job: keep track of problem solving methods and strategies used.
Think: Did your group draw pictures? Use manipulatives? Use paper/pencil calculations?

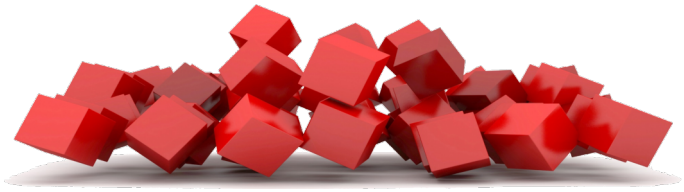
Data Control

Your job: ensure that everyone in your group has the correction information recorded on their data tables.
Check: Is everyone keeping up? Do your answers match? If not, lead a discussion about what the correct answer is.



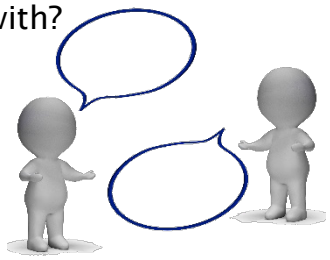
Supplies Manager

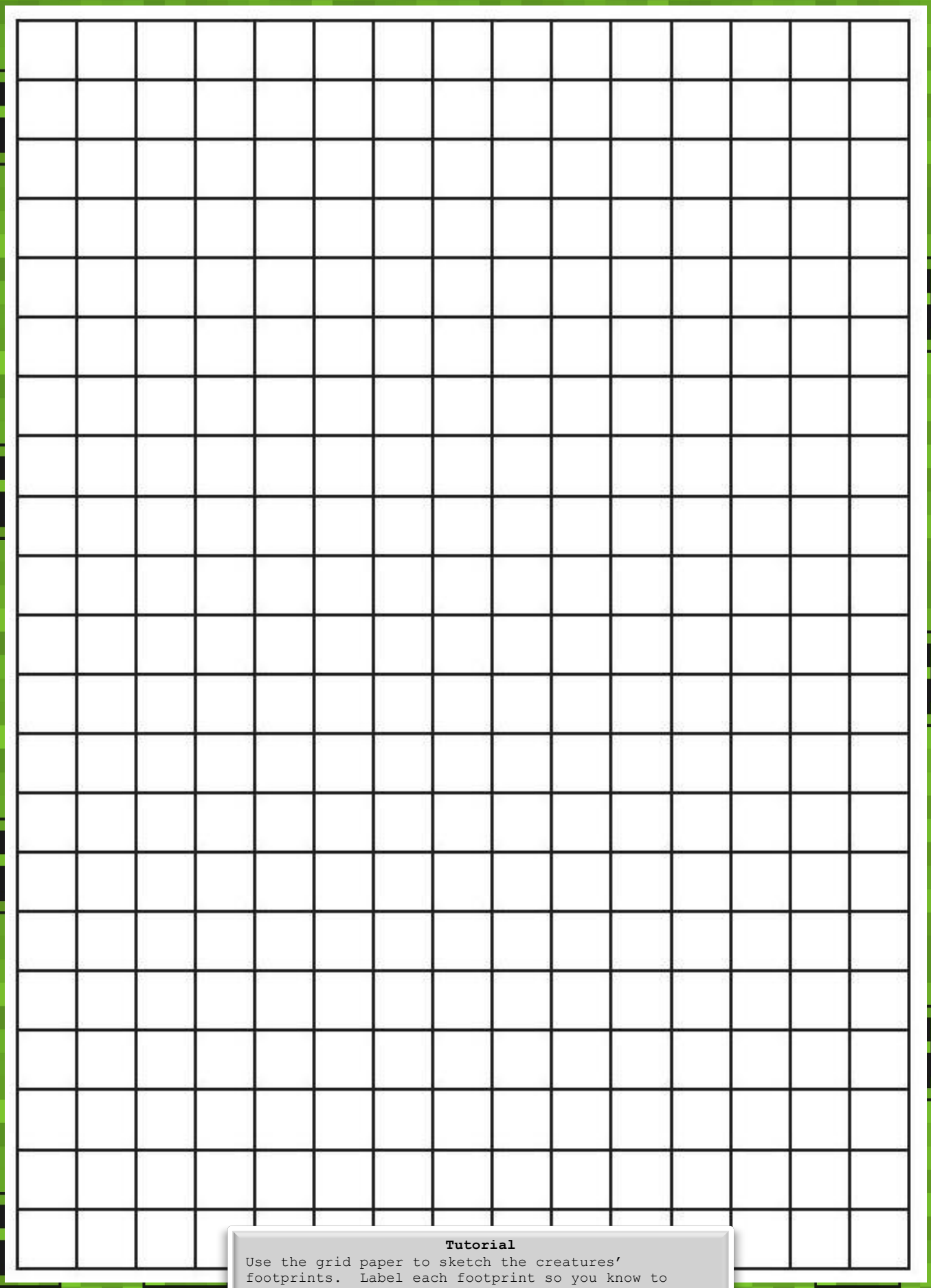
Your job: make sure the group begins and ends with 100 cubes total and everything is cleaned up.



Discussion Leader

Your job: develop and ask questions for the group to discuss after they finish the task.
Example: What did we do well? What did we struggle with?





Tutorial

Use the grid paper to sketch the creatures' footprints. Label each footprint so you know to which creature it belongs, and label the area of the base.

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