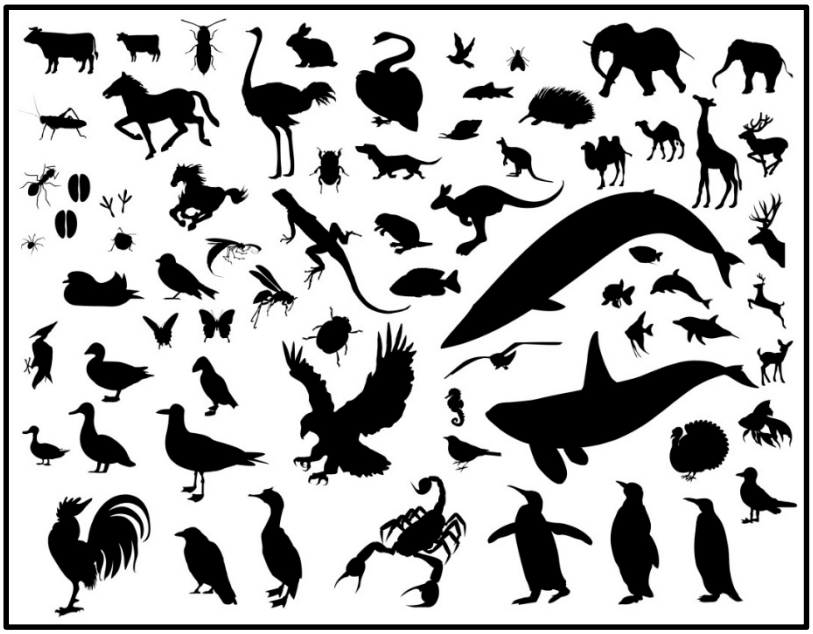
Animals Big and Small: Skin and Guts

What if elephants had small ears?

A VOLUME AND SURFACE AREA PROJECT



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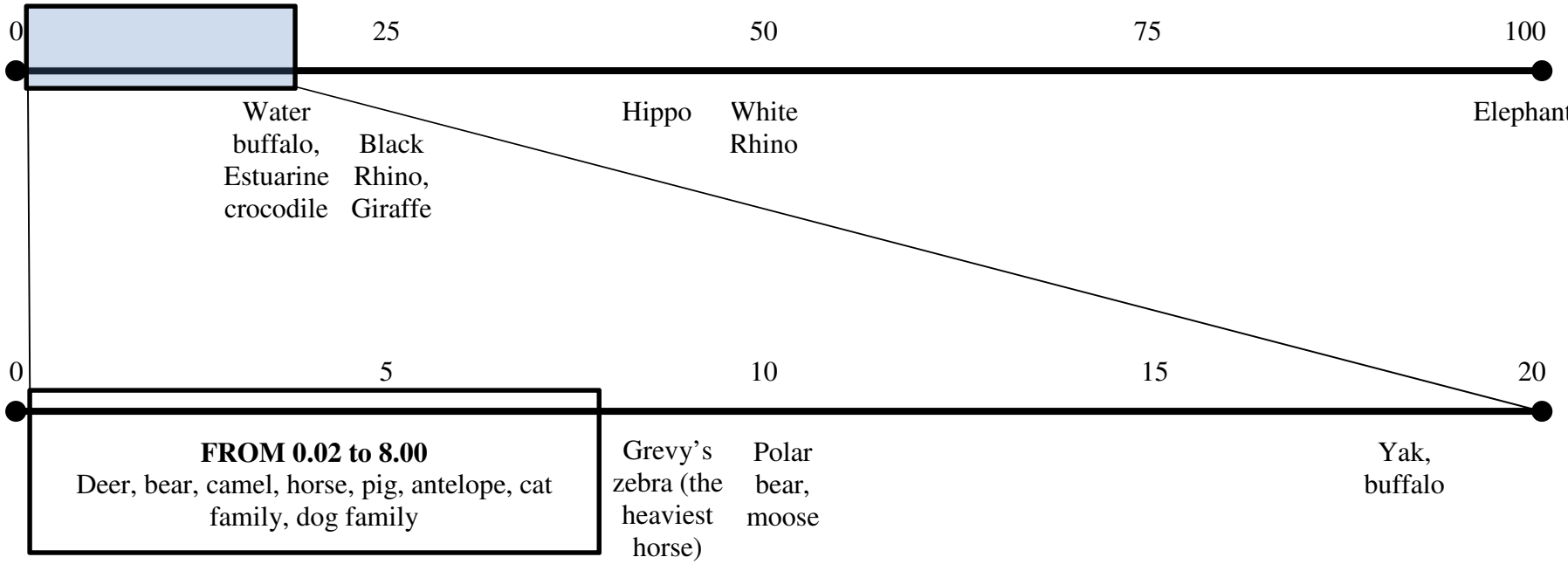
Animal Definitions

The following a definitions which fit the **vast majority** of animals. There are some exceptions to each of the rules.

		Species	**Examples**
Mammals	Air-breathing animals, produce their own internal heat (warm-blooded), mothers nurse young with milk, have teeth, give birth to live young, has hair/fur	4,000	humans, dogs, cats, cows, elephants, pigs, whales, dolphins, horses
Amphibians	Lay eggs, do not produce their own internal heat (cold-blooded), lives on land, breeds in the water, smooth and moist skin	4,325	Frogs, toads, salamanders
Reptiles	Do not produce their own heat (cold-blooded), have scales	6,900	snakes, alligators, crocodiles, turtles, lizards
Birds	Have feathers, have wings, produce their own heat (warm-blooded), egg-laying, have beak, no teeth	9,700	Pigeons, hummingbirds, flamingos, parrots, bluejay, dove, duck
Fish	Lives wholly in the water, Gills and fins, do not produce their own heat (cold-blooded), scales	45,000	Salmon, bass, perch, cod, goldfish, tuna
Tetrapods	Reptiles, birds, amphibians, and mammals		

THE RELATIVE SIZE OF ANIMALS



0.002 to 0.06	most birds, lizards, frogs, toads, snakes
0.004 to 0.002	rats and mice
0.0004	hummingbirds
0.0003	bats and shrews
0 to 0.00004	***99.9% of all animals*** – insects, arachnids, worms, crustaceans, etc.

NOTE: If the blue whales were placed on the number line, they would be at 2000.

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PART 1: Learning About Surface Area and Volume

You may use centimeter cubes and a calculator for this project.

1. Create two figures for each number of cubes indicated. Make one figure represent the maximum surface area for that number of cubes and the second figure represent the minimum surface area.

Number of cubes	Maximum Surface Area (square units)	Minimum Surface Area (square units)
6		
7		
8		
9		
10		
n		no pattern

Think about what kind of shapes make the most and least surface area.

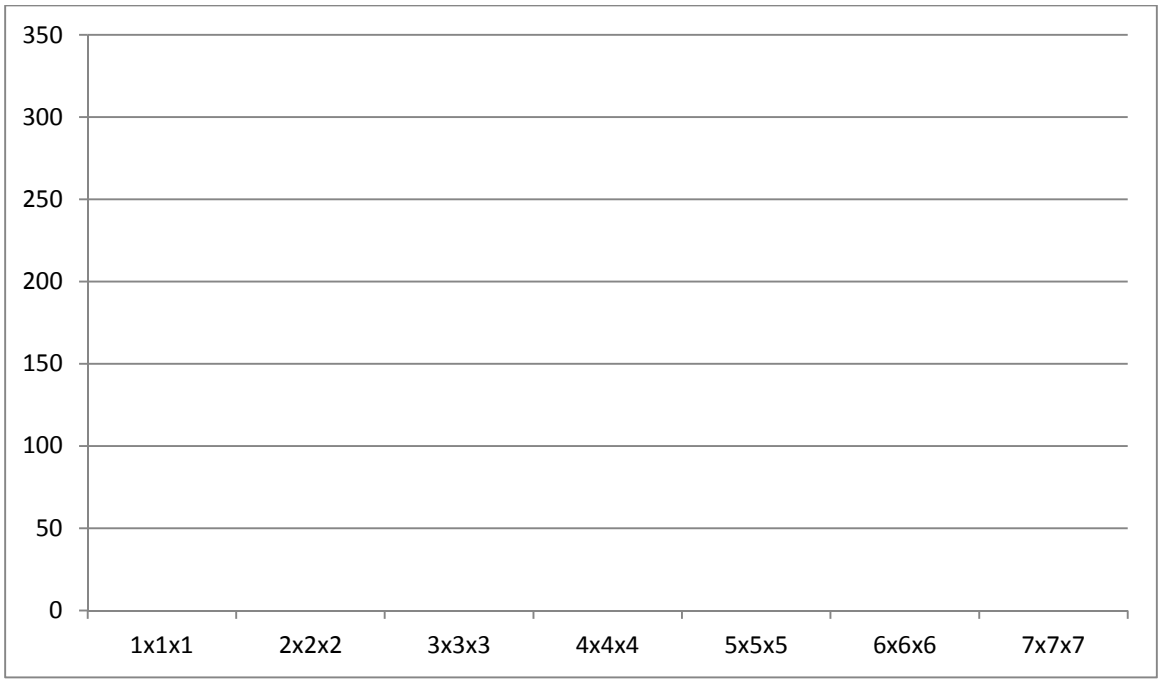
2. Complete the following table. Record the surface area and volume of each cube or shape.

Edge of cube (units)	Dimensions (units)	Surface Area (square units)	Volume (cubic units)	Surface Area-to-Volume Ratio (simplified per unit)
1	1 x 1 x 1			6 to 1
2	2 x 2 x 2			to 1
3	3 x 3 x 3			to 1
4	4 x 4 x 4			to 1
5	5 x 5 x 5			to 1
6	6 x 6 x 6			to 1
7	7 x 7 x 7			to 1

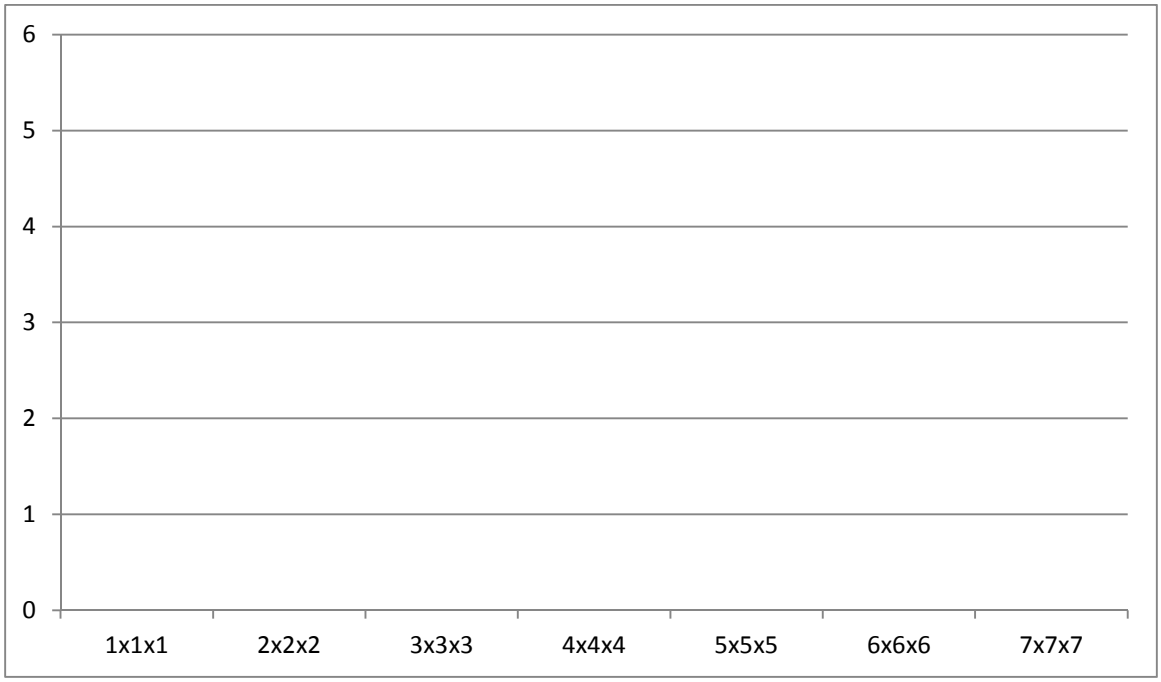
3.	As you continue to increase the edge size of the cube, which will grow faster: surface area or volume?	
4.	What happens to the surface area-to-volume ratio as the cubes get larger?	
5.	When the edge of the cube doubles what happens to the surface area?	
6.	When the edge of the cube doubles what happens to the volume?	

7. On the graph below first plot the surface area for each of the seven cubes you examined in question 2 on the previous page. Create a line graph. Note that your graph will not be proportional or linear.

8. Then on the same graph plot the volume for each of the seven cubes you examined in question 2 on the previous page. Create a second line graph. Note that your graph will not be proportional or linear.



9. On the graph below plot the surface area-to-volume ratio for each of the seven cubes you examined in question 2 on the previous page. Create a line graph.



10. Using what you learned in the previous problems, complete the table below.

When the edge of the cube…	The surface area gets multiplied by...	And the volume gets multiplied by…
doubles (x2)		
triples (x3)		
quadruples (x4)		
goes up *m* times		

11.	You have 3x3x3 cube and a 7x7x7 cube. What is the ratio of their surface areas? Use your tables above to help.	

PART 2: Applying the Surface Area-to-Volume Ratio to Animals

Why are flying squirrels in the Arctic more than 50% larger than those in Central America?

Animals adapt to their environment. Part of this adaptation involves both an animal's surface area and an animal's volume. How the surface area and volume compare can tell us a lot about the different places where animals live.

The surface-area-to-volume ratio is also called the surface-to-volume ratio.

Animals generate heat internally in proportion to their volume.
The larger the volume of the animal the more heat it can produce.
Animals lose heat externally in proportion to their surface area.
The larger the surface area of the animal the more heat it can lose.

Body temperatures of animals are usually greater than the outside temperature meaning that frequently the direction of heat 'flow' is from the animal to the outside, i.e. heat is lost from the animal. For a mammal heat lost to the outside, via the surface, must be replaced by heat obtained from the breakdown of food.

The greater the surface area-to-volume ratio of an animal, the more heat it loses relative to its volume.

As animals grow in size their inside (volume) gets "more bigger" than their outside (surface area). You proved this in part one when you completed table number two. As you increased the side length, the volume started growing much faster than the surface area.

The larger the animal, the smaller the surface area-to-volume ratio and so the less relative area there is to lose heat. This means that for identically shaped animals of different sizes, the large one will keep its temperature more easily. **Being bigger means being warmer.**