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.

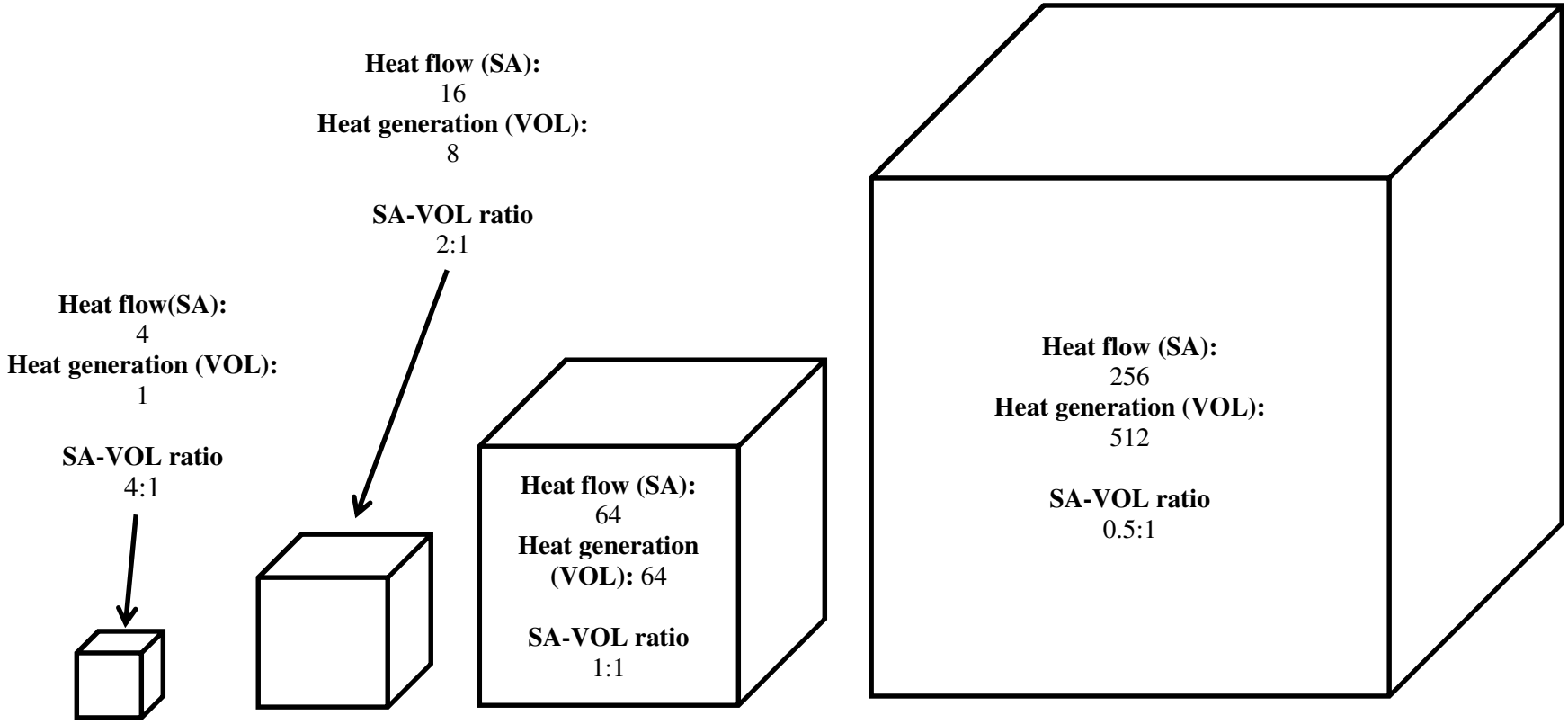
The greater the surface area-to-volume ratio of an animal, the more heat it loses relative to its volume.

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.**

Surface Area and Volume Comparison of Small and Large Animals

[The surface area and volume numbers are just for comparison purposes.]



We are small animals. We don't generate much heat and we don't have much heat flow. Compared to big animals, though, we can lose our heat much more easily and we can have a hard time staying warm.

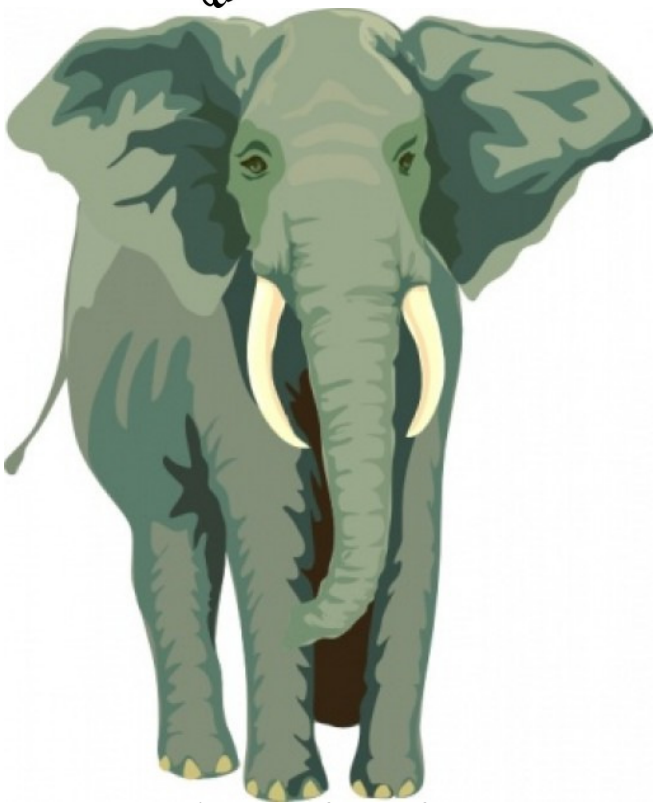
Smaller ↔ Bigger

We are big animals. We generate a lot of heat and we have a large flow of heat. Compared to small animals, though, we have a hard time losing heat which means we stay warm much more easily.

Created by Lance Mangham, 6th grade math, Carroll ISD

12. Determine the surface area-to-volume ratio of the animals listed below.

Animal	**Estimated surface area**	**Estimated volume**	**Estimated Surface Area-to-Volume Ratio (nearest hundredth)**
Mouse	6 square inches	1 cubic inches	to 1
Rat	24 square inches	8 cubic inches	to 1
Lemming	40 square inches	16 cubic inches	to 1
Labrador Retriever	3,532 square inches	13,824 cubic inches	to 1
Zebra	5,760 square inches	27,648 cubic inches	to 1
Polar Bear	14,400 square inches	96,768 cubic inches	to 1
Elephant	36,000 square inches	432,000 cubic inches	to 1
As the animal gets larger the surface area-to-volume ratio gets….			



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.

13.	Which animal in #12 will generate the most heat? least heat?		
14.	Which animal in #12 will lose the most heat? least heat?		

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.

15.	Which animal in #10 has the biggest SA-VOL ratio and thus will lose the most heat relative to its size?	
16.	Which animal in #10 has the smallest SA-VOL ratio and thus will lose the least heat relative to its size?	

17.	Which characteristic can animals change the easiest and fastest: their surface area or their volume? Explain.	

You will now use your surface area and volume knowledge and apply it to a wide variety of animals.

18.	Would you expect large desert animals to try to minimize or maximize their surface area-to-volume ratios? Why?	
19.	Would you expect large arctic animals to try to minimize or maximize their surface area-to-volume ratios? Why?	

ELEPHANTS

An elephant has a small surface area compared to its volume. Therefore, it has a very small surface area-to-volume ratio. Since elephants lose heat to their surroundings more slowly, they can overheat easily.

20.	**In terms of surface area and/or volume**, why do you think some elephants, like the African elephant, have extremely large ears (the largest earflap in history of any animal)?	

MICE

A mouse has a very large surface area-to-volume ratio. It loses heat to its surroundings very quickly and must eat a lot of food to replace the energy lost. That huge metabolic rate makes for a high heart rate, and because mammalian hearts are only good for about one billion beats, that heat-replacing pace is what gives mice a live fast, die young lifestyle.

21.	Who will lose more total heat in a given period, a mouse or an elephant? Why?	
22.	Who will lose more heat relative to its volume, a mouse or an elephant? Why?	
23.	Who will need to eat the most food, a mouse or an elephant? Why?	
24.	Who will need to eat the most food relative to size, a mouse or an elephant? Why?	

FOXES

In general, similar animals have different ear sizes depending on the climate in which they live.

25.	The arctic fox has much smaller ears than the fennec fox, which lives in the desert. **In terms of SA-VOL ratio**, why?	

BEARS/POLAR BEARS

Some bears can almost become spherical. A sphere has the smallest surface area-to-volume ratio of any shape. While a one unit cube has a ratio of 6:1, a one unit diameter sphere has a ratio of only 4.84:1. The polar bear has stocky limbs and very short ears.

26.	**In terms of SA-VOL ratio**, why would a bear want to curl up into a ball (sphere)?	
27.	Polar bears and camels are both very large animals. Why does a polar bear have short, stumpy legs while a camel has tall gangly legs?	
28.	A lemming (a small mouse-sized mammal of the tundra, related to a mole) is much smaller than a polar bear. **In terms of SA-VOL ratio**, which species loses body heat more easily?	
29.	**In terms of surface area and/or volume**, why does a polar bear have very short ears?	

PENGUINS

30.	**In terms of surface area and/or volume**, why do penguins tuck in their flippers close to their bodies to help stay warm?	

PEOPLE

31.	**In terms of surface area and/or volume**, why do people fold their arms over their chest or even sit hugging their knees to their chin when they are cold?	
32.	Who will lose more total heat in a given period, an infant or an adult?	
33.	Who will lose more heat relative to its volume, an infant or an adult?	
34.	Who will need to eat the most food, an infant or an adult?	
35.	Who will need to eat the most food relative to size, an infant or an adult?	

BIRDS

36.	**In terms of SA-VOL ratio**, why are birds in the Antarctic (the Emperor penguin, for example) very large compared to many birds found other places?	

SMALLER and LARGER

White-tailed deer are larger in Canada than in the Florida Keys. The common wolf is 20% larger in northern Canada than in northern Mexico. Mountain lions are smaller closer to the equator. Flying squirrels in the Arctic are more than 50% larger than those in Central America.

37.	**In terms of SA-VOL ratio**, why are all these animals larger in some places and smaller in other places?	

WARM-BLOODED and COLD-BLOODED

Warm-blooded animals try to maintain a constant body temperature. They generate their own heat and they cool themselves. Warm-blooded animals can shiver, which is the most effective way of producing heat.

Cold-blooded animals take on the temperature of their surroundings. They are more active in warm environments and sluggish in cold environments. Cold-blooded animals cannot shiver.

38.	Small warm-blooded animals have a large surface area-to-volume ratio. What does this tell you about the amount of food they will need to eat?	
39.	Where would you expect warm-blooded animals to have a slender body design? Where would you expect warm-blooded animals to have a chubby body design?	
40.	Why does having a large surface area-to-volume ratio help small cold-blooded creatures warm up when they need to?	

LIZARDS/REPTILES

Just about all reptiles are cold-blooded. Lizards are cold-blooded.

41.	**In terms of surface area and/or volume**, why does a lizard stretch out to bask in the sun in the morning?	
42.	**In terms of surface area and/or volume**, why are most reptiles long and slender?	
43.	Why do most reptiles only need to eat sparingly?	
44.	**In terms of SA-VOL ratio**, why do most land mammals, lizards, and snakes curl up in a cold environment?	

45.	An animal has a volume of 720 cubic inches. A smaller animal has dimensions that are half the size of the larger animal. What is the volume, in cubic inches, of the smaller animal?	
46.	An animal has a volume of 64 cubic centimeters. A smaller animal has dimensions that are three-fourths the size of the larger animal. What is the volume of the smaller animal?	
47.	How many 2 by 2 by 2 inch animals could fit inside a 4 by 4 by 4 inch box?	
48.	An animal in the general shape of a prism has volume of 1000 cm^3. What is the smallest surface area possible for this animal? What is the smallest SA-VOL ratio possible for this animal?	
49.	You have two dogs, one that weighs 30 pounds and one that weighs 60 pounds. How much does the big dog eat compared to the small dog? a) it eats the same amount b) it eats less c) it eats more, but not twice as much d) it eats twice as much e) it eats more than twice as much	