Size of an organism matters: *Understanding the Surface Area to Volume ratio*

Why does a small ice cube melt quicker than a large one?

Discuss this article read before class

- http://www.abc.net.au/science/articles/2012/01/18/3410634.htm

Learning Intention

- To understanding the relationship between surface area and volume and the role it plays in determining of size in living organisms

Questions to ask?

- What is the importance of the Surface Area : Volume ratio?
- How is surface area to volume ratio calculated?
- How does SA:Volume ratio change with changing size?
- What modifications do larger organisms exhibit to get round this problem?

What is the importance of the Surface Area : Volume ratio?

Examples….

1. Animals of the same species tend to be larger in areas that are colder. For example, the largest race of tigers (Siberian Tigers) are found in snow covered areas of Asia.

SA:Volume ratio of large animals is small. Means metabolism is low.

2. Babies left in a car on a hot day can dehydrate very quickly.

SA:Volume ratio of small animals is large. Means metabolism is high.

3. It's quicker to cook potatoes if they are cut up into smaller pieces.

4. A block of ice melts more slowly than crushed ice.

5. Mice have a much higher metabolic rate (for each gram of tissue) than elephants.

Importance

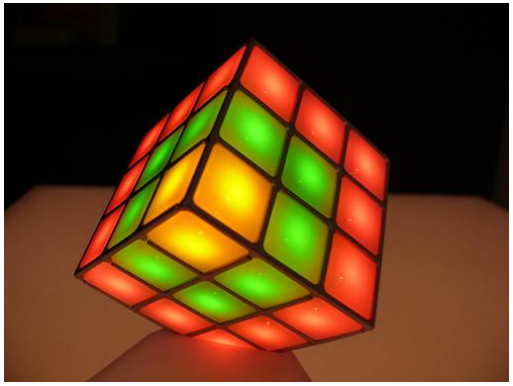
- Changes in the surface area to volume ratio have important implications or constraints on organisms size , and help explain some of the modifications seen in larger organism.

Question:

Why are penguins in Antartica so much bigger than those on Galapagos or in fact at Phillip Island?

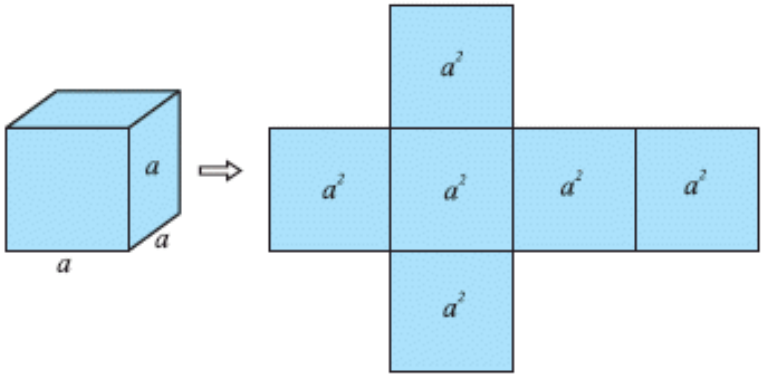
How is surface area to volume ratio calculated?

Formula for Surface Area

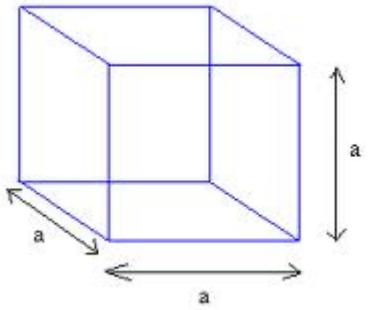


Surface Area of a Cube = $6a^2$

where a is the edge of the cube.



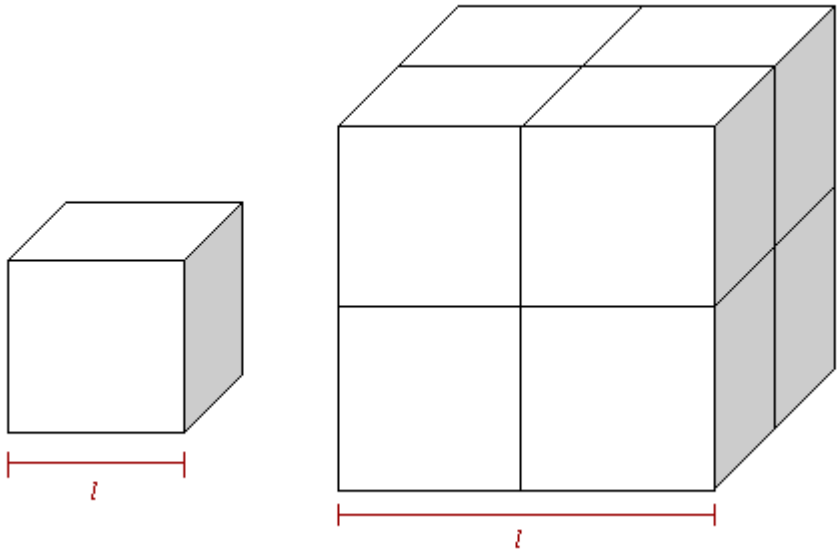
Formula for Volume



Volume = a^3

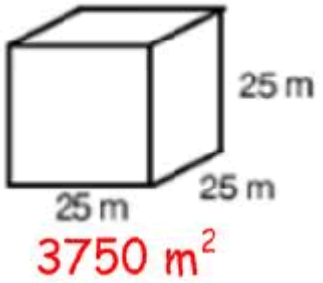
S= surface area
V= volume
A= length

Which has the bigger surface area?



SURFACE AREA TO VOLUME RATIO

- Surface area – the sum of the area of all surfaces of a 3d object



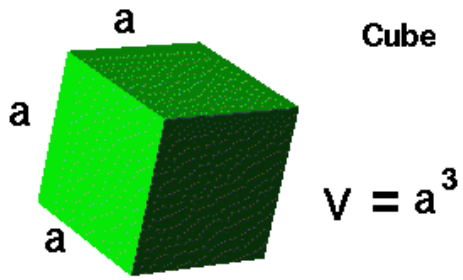
example

$SA=6a^2$

$SA = 6 \times (25 * 25)$

$= 3750\ m^3$

- Volume – the amount of space the object occupies



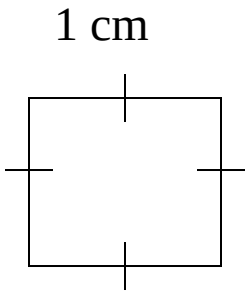
Example

$Volume= a^3$

$Volume= 25^3$

$= 15625\ m^3$

SMALL ANIMAL EXAMPLE:



SA = 6 X L ^{2}

= 6 X 1 X 1

= 6cm ^{2}

VOLUME = L^3

= 1 X 1 X 1

= **1 cm ^{3}**

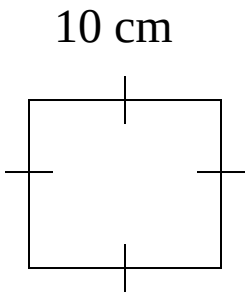
This is a small animal.

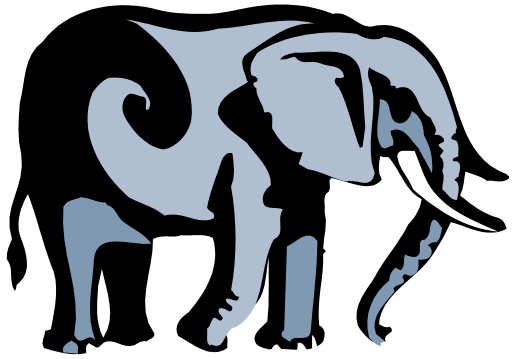
SA : V

6 : 1

6/1 = **6**

LARGE ANIMAL EXAMPLE





SA = 6 X L ^{2}

= 6 X 10 X 10

= 600cm ^{2}

VOLUME = L^3

= 10 X 10 X 10

= **1000 cm ^{3}**

This is a larger animal.

SA : V

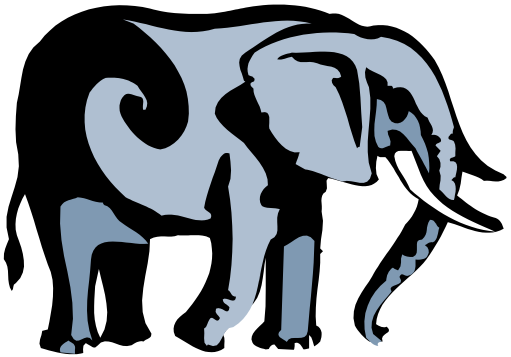
600 : 1000

600/1000 = **0.6**

How does SA:Volume ratio change with changing size?

Which has the largest SA: Volume ratio

- Mouse = 6

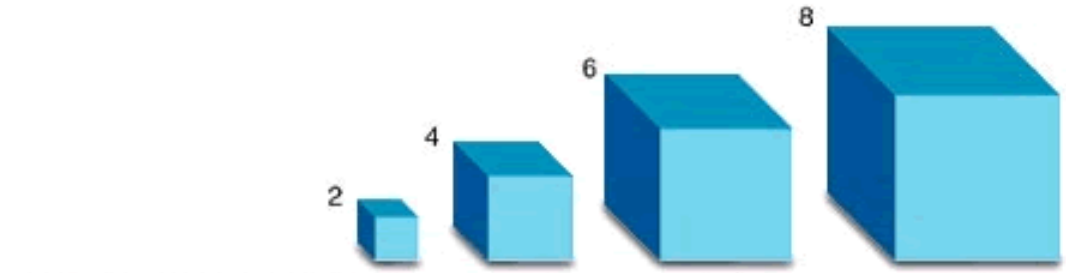


- Elephant = 0.6

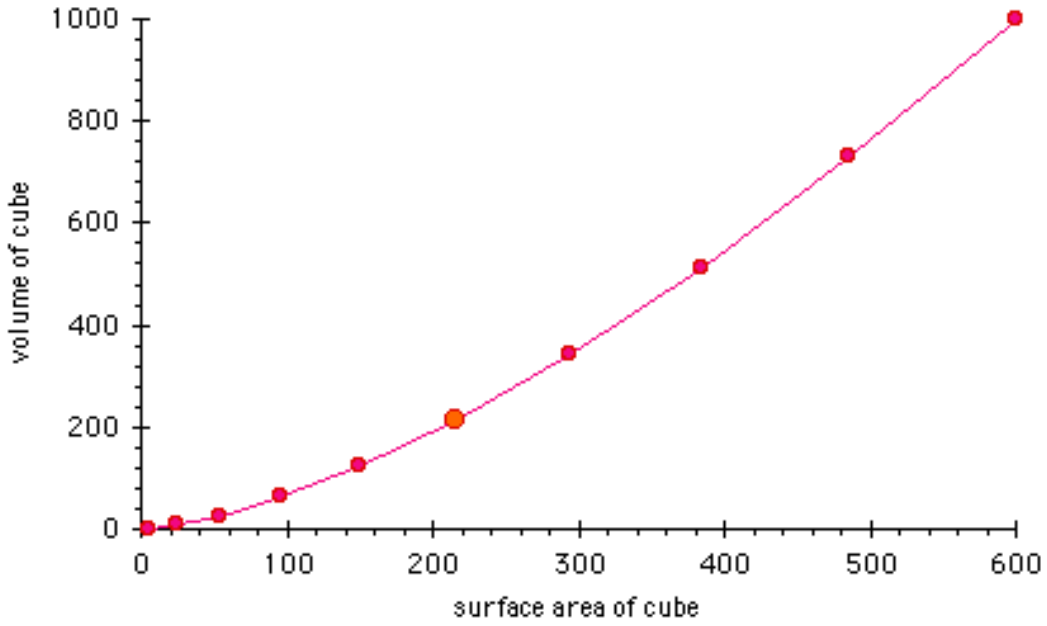
- Which would lose more heat?
- Which would need to eat more?
- Which organism has the higher metabolism?

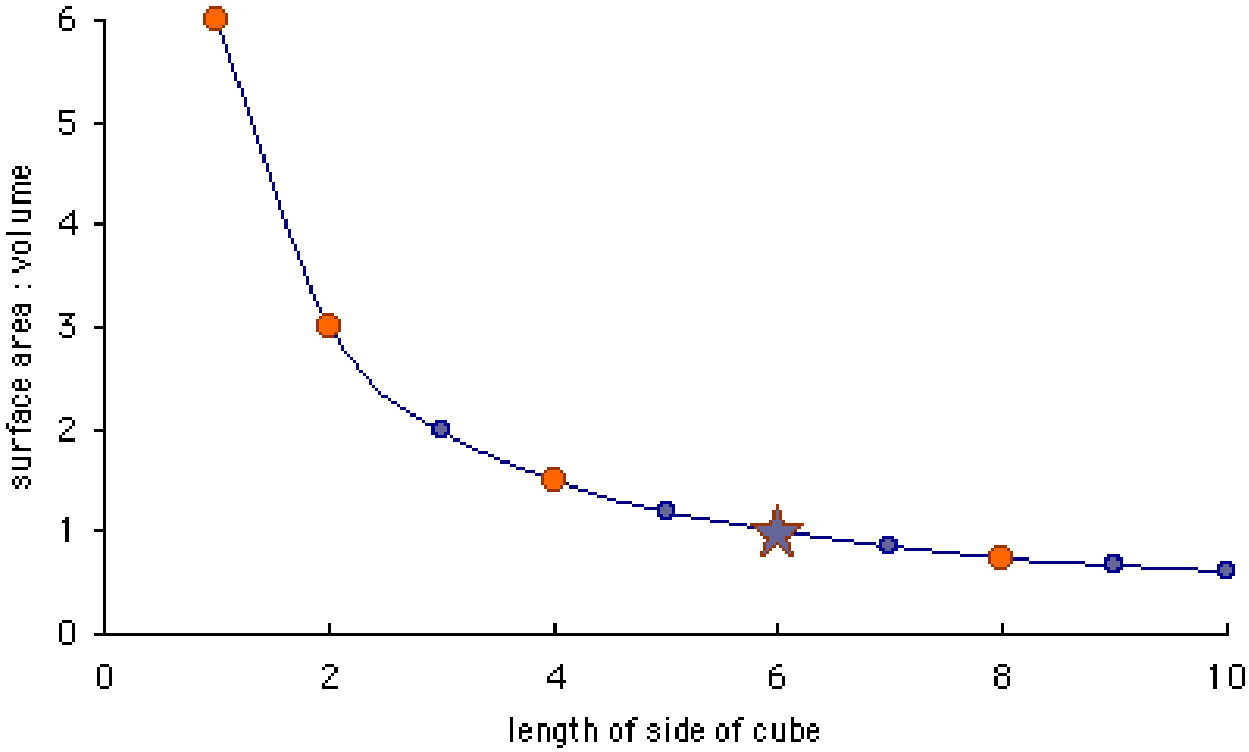
Therefore mathematically:

- A **small** animal/object has a **large SA:V ratio**
- A **large** animal/object has a **small SA:V ratio**



Surface area (square inches)	24	96	216	384
Volume (cubic inches)	8	64	216	512
Surface area/volume	3.0	1.5	1.0	0.75


1000
800
600
400
200
0
volume of cube
0
100
200
300
400
500
600
surface area of cube

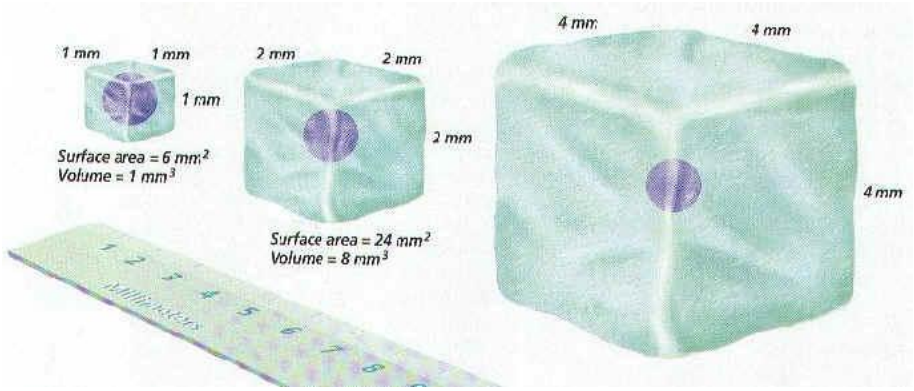

surface area : volume
length of side of cube
0
1
2
3
4
5
6
0
2
4
6
8
10

What modifications do larger organisms exhibit to get round this problem?

Answer this yourself do
Biozone
Limitations to Cell Size page 71-72

Activity

- Diffusion and surface area to volume



How Surface Area to Volume Ratio Limits Cell Size

1. A cell is a metabolic compartment where a multitude of chemical reactions occur.
2. The number of reactions increase as the volume of metabolic volume within a cell increases. (The larger the volume the larger the number of reactions).
3. All raw materials necessary for metabolism can enter the cell only through its cell membrane.
4. The greater the surface area the larger the amount of raw materials that can enter at only one time.
5. Each unit of volume requires a specific amount of surface area to supply its metabolism with raw materials. The amount of surface area available to each unit of volume varies with the size of a cell.
6. As a cell grows its SA/V decreases.
7. At some point in its growth its SA/V becomes so small that its surface area is too small to supply its raw materials to its volume. At this point the cell cannot get larger.