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

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

Learning Intention

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

Discuss this article read before class

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

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

Examples….

1. It’s quicker to cook potatoes if they are cut up into smaller pieces.

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

3. 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.

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

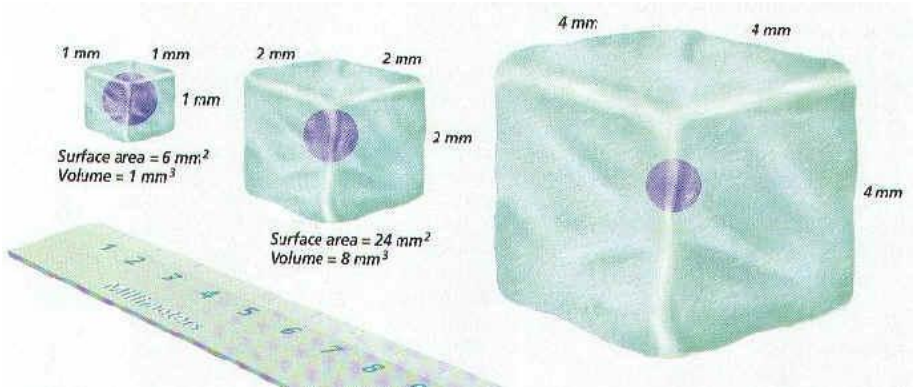
5. Mice have a much higher metabolic rates (for each gram of tissue) than elephants.

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?

Activity

- Diffusion and surface area to volume



Importance

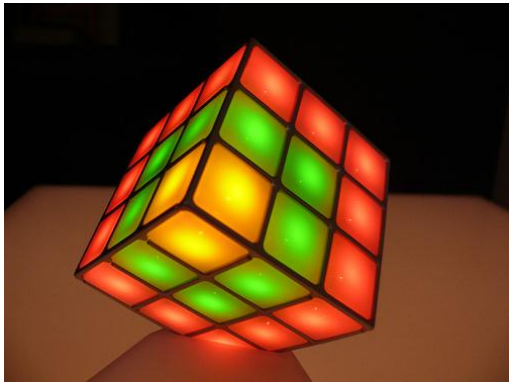
Changes in the surface area to volume ratio have important implications or constraints on organisms size , and help explain some of the modifications seen in larger organism.

Question:

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

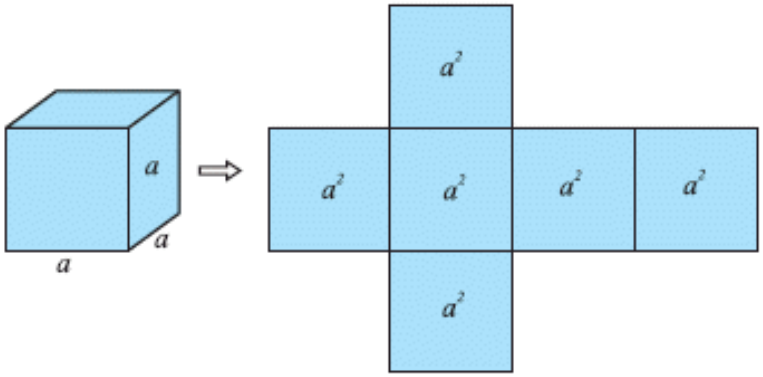
How is surface area to volume ratio calculated?

Formula for Surface Area

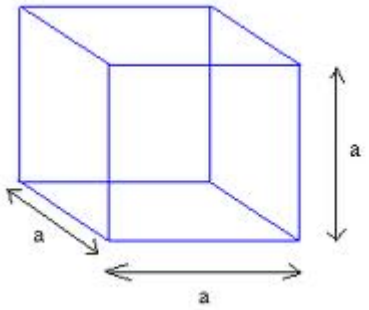


Surface Area of a Cube = $6a^2$

where a is the edge of the cube.



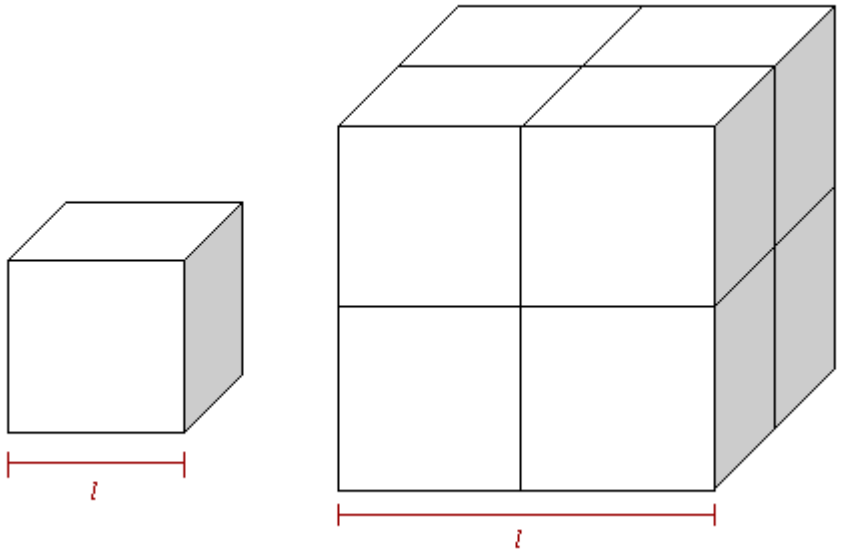
Formula for Volume



Volume = a^3

S= surface area
V= volume
A= length

Which has the bigger surface area?
Which has the bigger volume?



- The larger cube has the larger SA and also the the larger volume.

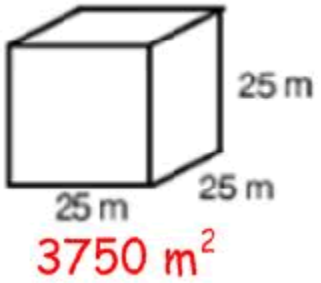
but

- What we want to compare is the SA:Volume ratio.

- Firstly we need to calculate this.

SURFACE AREA TO VOLUME RATIO

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



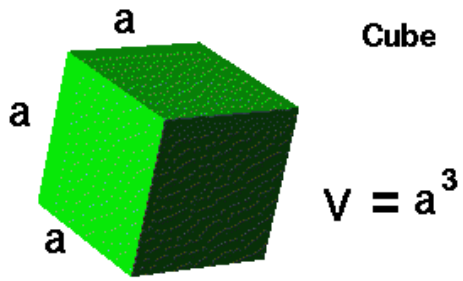
example

$SA=6a^2$

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

$= 3750\ m^3$

- Volume – the amount of space the object occupies



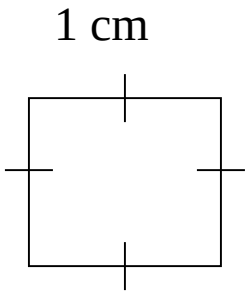
Example

$Volume= a^3$

$Volume= 25^3$

$= 15625\ m^3$

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}

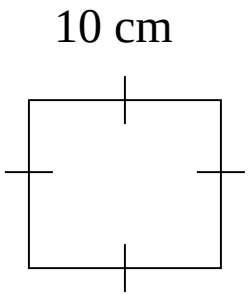
This is a small animal.

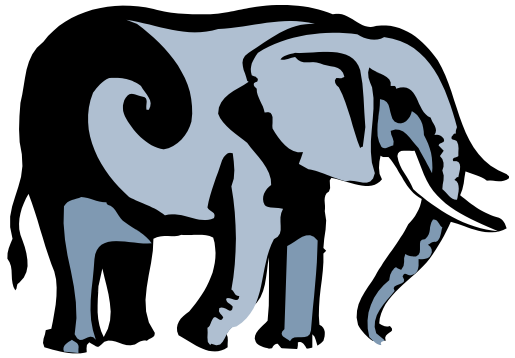
SA : V

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.

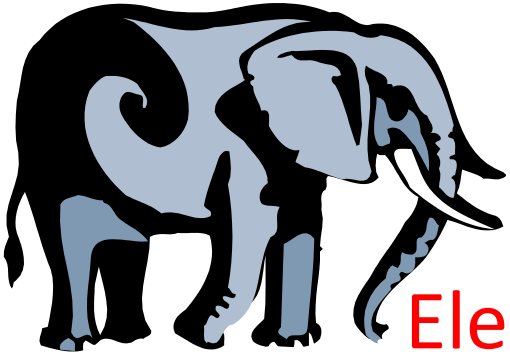
SA : V

600 : 1000

600/1000 = **0.6**

How does SA:Volume ratio change with changing size?

Mouse = 6



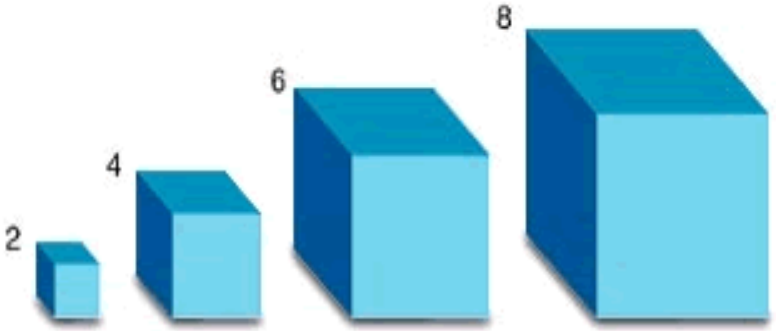
Elephant = 0.6

- The mouse has the smaller SA and the smaller volume

but

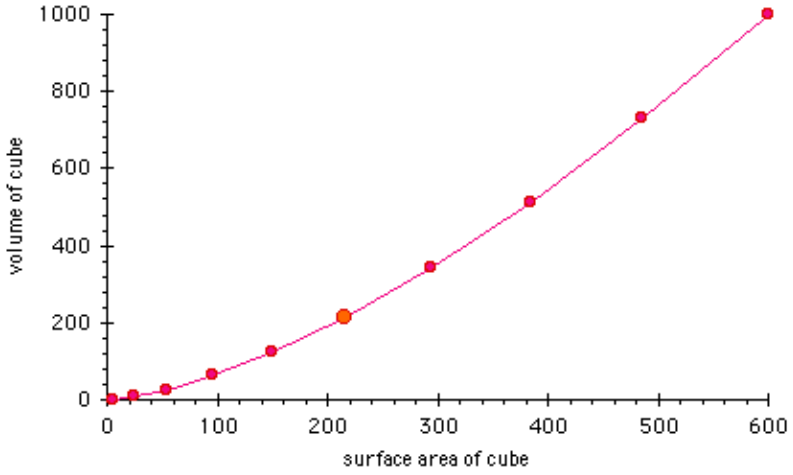
- The mouse has the larger SA: Volume Ratio

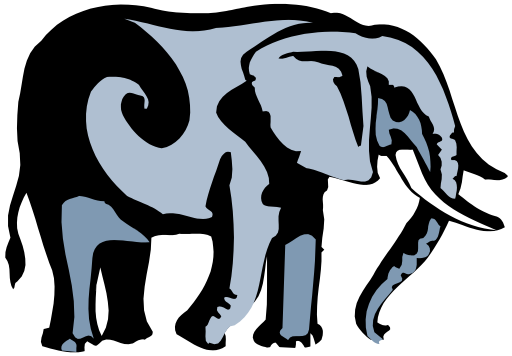
- A **small** animal/object has a **large SA:V ratio**
- A **large** animal/object has a **small SA:V ratio**



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

Basically this means that as things get bigger, their inside volume get more bigger than their outside (surface area).

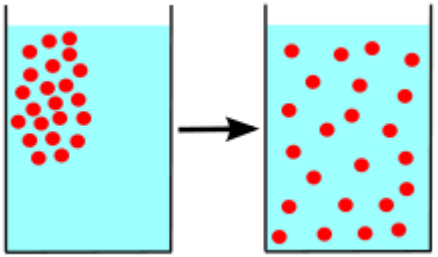


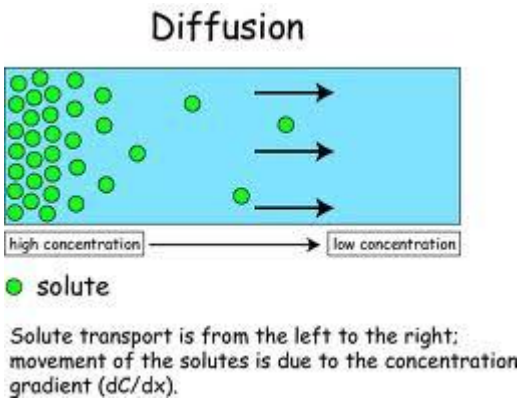


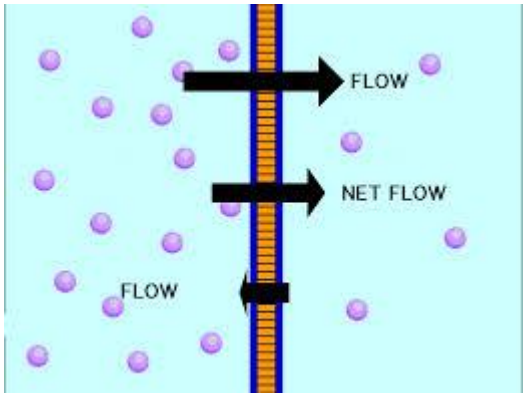
- Which would lose more heat?
- Which would need to eat more?
- Which organism has the higher metabolism?

Diffusion

- Movement(or spreading out) of particles .
- Diffusion happens across a concentration gradient i.e. from on area of more particles to an area of less particles.
- It can also happen through barriers such as cell membrane as particles are small and can pass through.

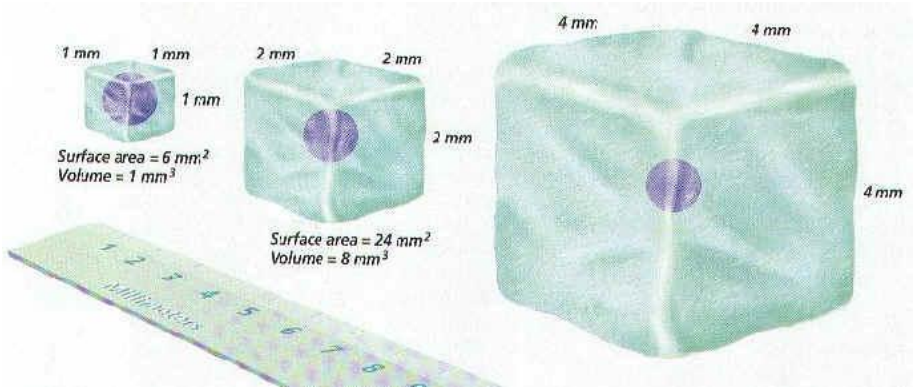






Activity

- Diffusion and surface area to volume



Rate of diffusion

- Is how quickly over time does a substance diffuse in another substance.

- In this prac we are looking at rate of diffusion of sulphuric into cubes. This can be calculated by

Effective Rate of diffusion = Volume of uncoloured/Volume of coloured

- In which of the 3 cubes was the rate of diffusion most effective

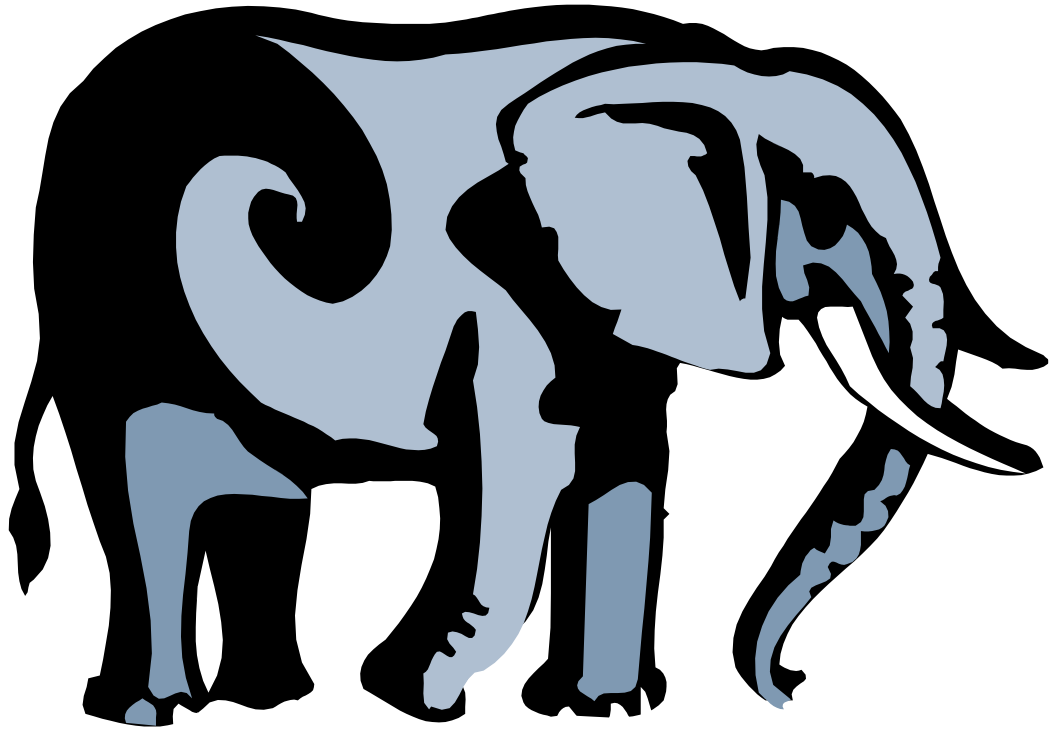
- Answer - The smaller cube

- Therefore small organisms have a big SA compared to their size.

- Smaller organisms with smaller SA: Volume Ratio more effectively.

- ***Therefore cells need to be small to be able to carry out their functions more effectively.***

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



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.

- **Biozone** Limitations to Cell Size page 71-72
- **Heinemann Text** : Chapter 4.3