Notes begin...

❑**Surface area available for gas exchange** – the greater this is, the greater the rate of diffusion (they are proportional)

-Some organisms require specialised absorptive surfaces to increase their surface area, that is if they are terrestrial (have an impermeable surface), large (small surface area to volume ratio) and have a high metabolic rate (cells require a large amount of metabolites e.g. O_2)

-Absorptive surface area can be increased by:

- **Evagination** (outfolding) of the surface
- **Invagination** (infolding) of the surface
- **Flattening** of the organism

Did you know?

The mouse and frog are similarly sized organisms BUT they each require different amounts of oxygen. This is because the mouse has a metabolic rate 10 times that of the frog and therefore where the frog has simple sacs for lungs, the mouse has spongy lungs consisting of millions of alveoli giving it a large surface area for gas exchange to meet its high metabolic rate

Would you rather be a mouse or a frog?

- **The difference in concentration** (concentration gradient) - the greater the gradient across the gas exchange surface, the higher the rate of diffusion, they are directly proportional. Concentration gradients are maintained by the use or excretion of the substances exchanged, or by their constant movement by a mass transport system e.g. with O_2 and CO_2 in the blood and the lungs

- **The length of the diffusion path** – the shorter this is, the greater the rate of diffusion i.e. They are **inversely** proportional e.g. distance from absorptive surface (or transport system) to the cells that require the metabolite

❑The presence of moisture on the exchange surface –

- The exchange of substances occurs only at **moist permeable surfaces**
- **Gases can first dissolve** into the liquid before diffusing across the membrane and this will increase the rate of diffusion
-Aquatic and soil organisms have moist and thus **permeable body surfaces**
-Most terrestrial organisms e.g. mammal and flowering plants have impermeable surfaces in order to prevent water loss by evaporation (either cornified oily skin or waxy cuticles)
- They therefore need **specialised** absorptive or exchange surfaces

Learning check; so we know this?

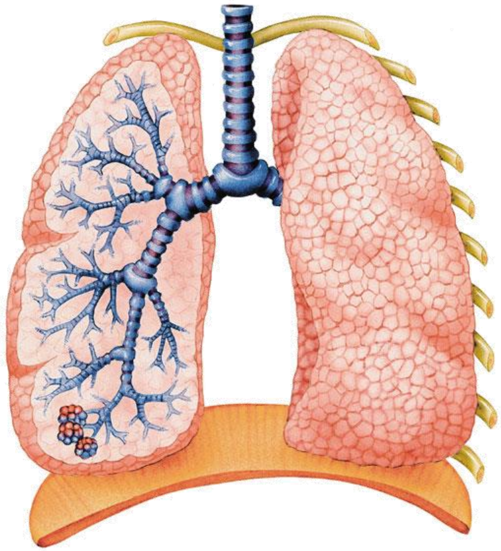
2.1.4 Understand factors affecting the rate of gas exchange:

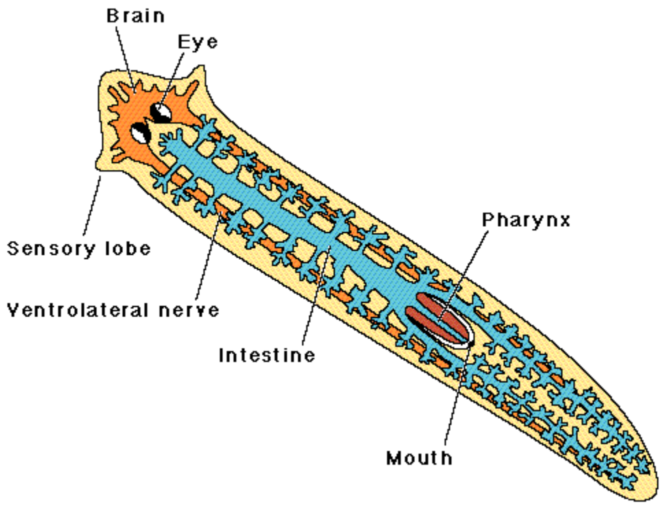
- large surface area for exchange;
- moist surface into which gases dissolve;
- diffusion gradients for O_2 and CO_2;
- diffusion path;
- appreciate the relationship between the factors shown in Fick's Law;

$$\text{Diffusion rate} \propto \frac{\text{Surface area of membrane} \times \text{Difference in concentration across the membrane}}{\text{thickness of membrane}}$$

Homework: research "surface area to volume ratio" and how it is linked to gas exchange

Surface area to volume ratio – this must be large enough to meet an organisms metabolic requirements





Surface area:

The total number of cells in direct contact with the surrounding environment

- It affects the rate of exchange of materials at exchange surfaces
- It influences the rate of supply of metabolites to tissues e.g. glucose to respiring cells
- *The absorptive surface area is "a measure of the rate of supply of metabolites to tissues"*

Volume:

The total three-dimensional space occupied by metabolically active tissues

- It influences the demand for metabolites (i.e. more volume means more demand)
- *The volume of an organism is "a measure of its demand for metabolites"*

Surface area to volume ratio is dictated by an organism's size and shape:

As an organism's size increases its surface area increases less than its volume does, as many cells are not in direct contact with the surrounding environment - therefore surface area to volume ratio decreases with increasing size of organism

large animals

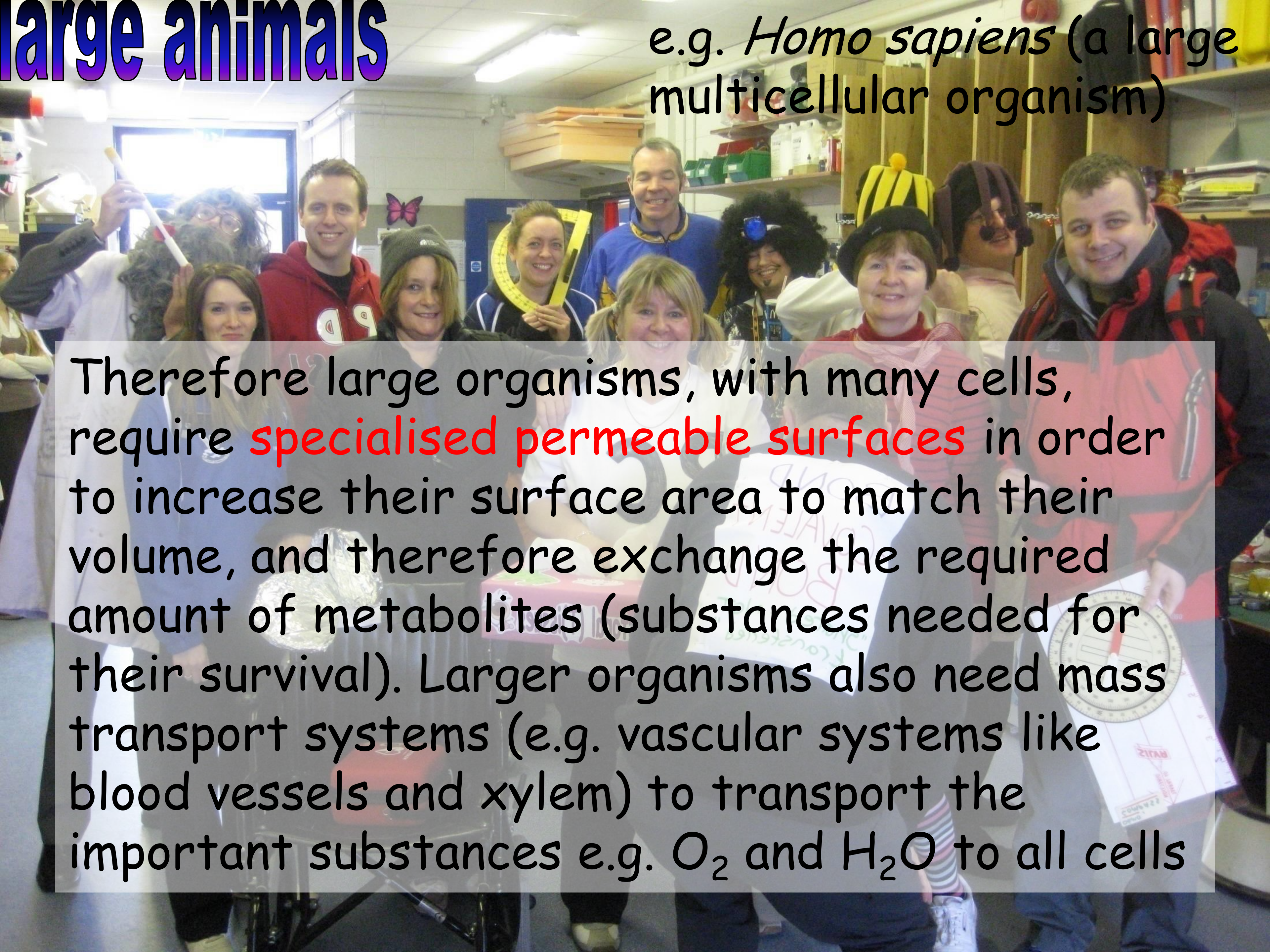
have a **small** surface area to volume ratio

Humpback whale

small animals

have a **large** surface area to volume ratio

Flatworm



large animals

e.g. *Homo sapiens* (a large multicellular organism)

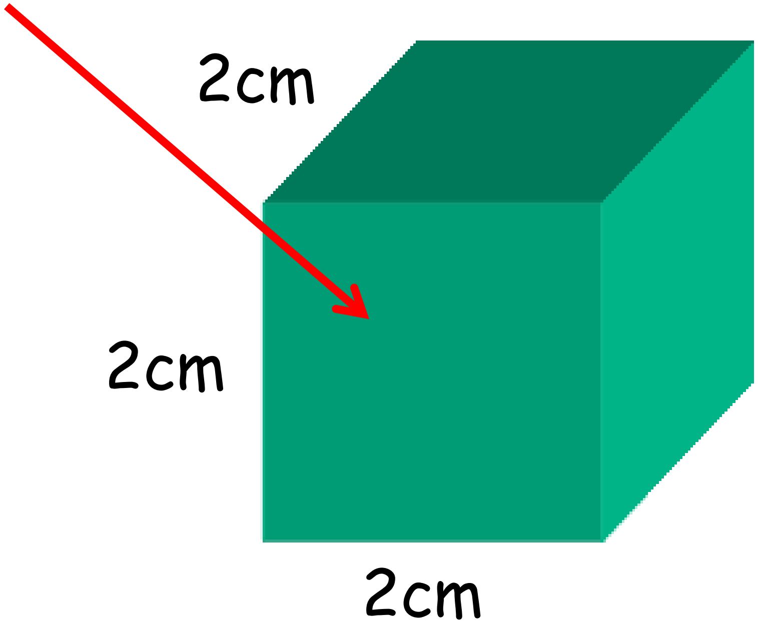
Therefore large organisms, with many cells, require specialised permeable surfaces in order to increase their surface area to match their volume, and therefore exchange the required amount of metabolites (substances needed for their survival). Larger organisms also need mass transport systems (e.g. vascular systems like blood vessels and xylem) to transport the important substances e.g. O_2 and H_2O to all cells

small animals

e.g. *Paramecium* (a single celled protoctistan)

Single celled organisms and those with small, flattened and tapering body plans have a large surface area to volume ratio and do not need specialised exchange structures and usually do not require mass transport systems, as the gases required can diffuse across their surface and to all cells that require them (short diffusion pathway)

- Some of these organisms that can perform gas exchange across their surface (have a large surface area to volume ratio) still need a mass transport system because the diffusion distance to all the cells is too great e.g. earth worm *e.g. Large organism*

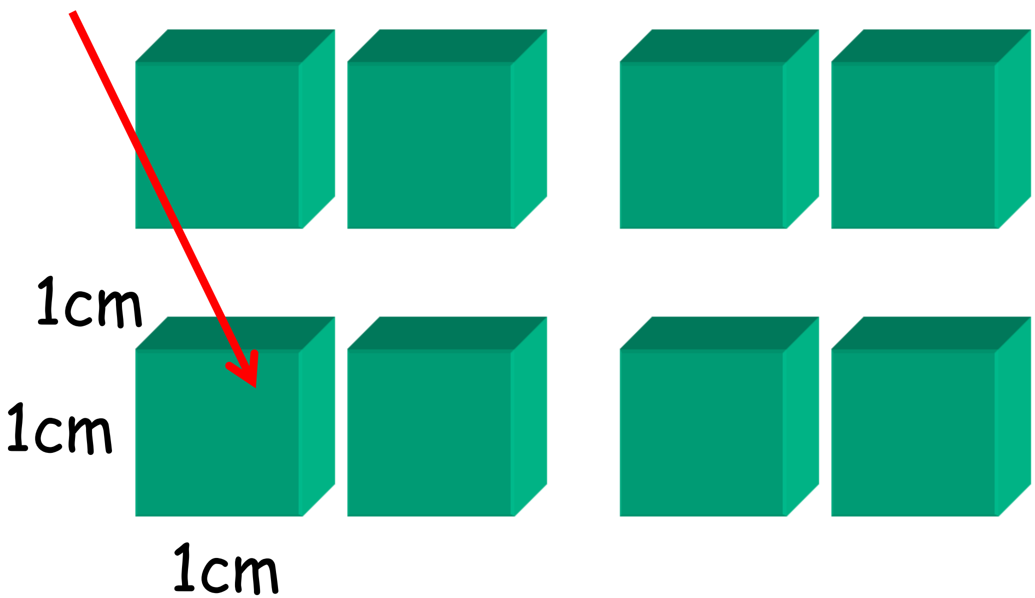


Surface area = 24 cm^2

Volume = 8 cm^3

SA : V ratio = 24:8 = 3:1

e.g. small organism



Surface area = 6 cm^2

Volume = 1 cm^3

SA : V ratio = 6:1

Complete the surface area to volume ratio questions for homework

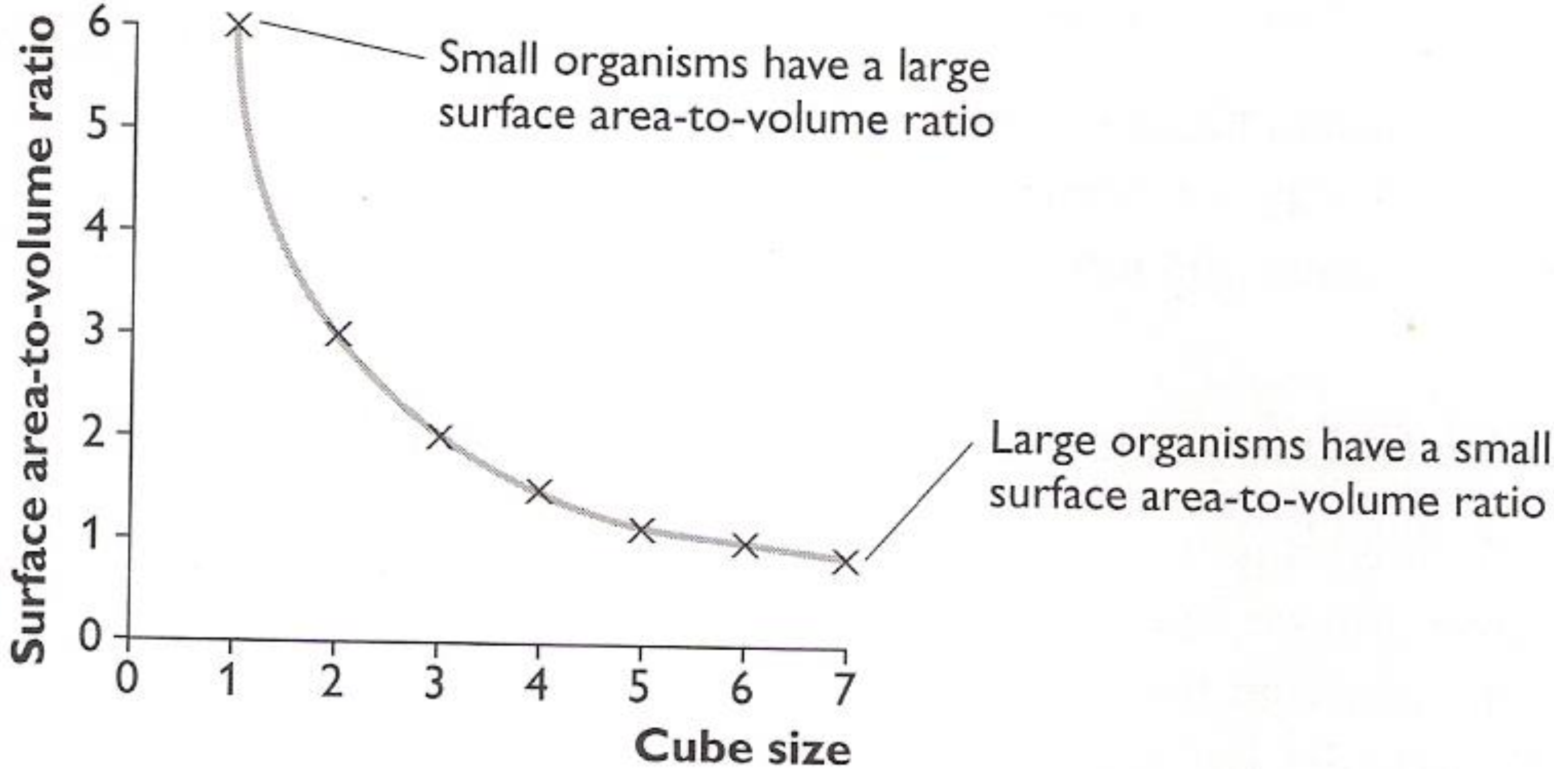


Figure 1 The relationship between size and surface area-to-volume ratio

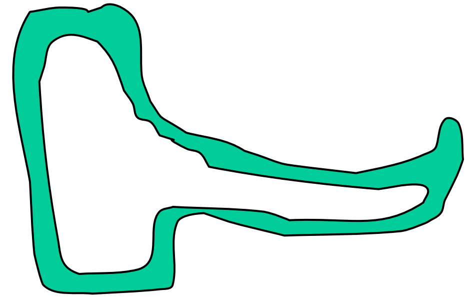
Qu: What features of exchange surfaces can aid passive and active transport?

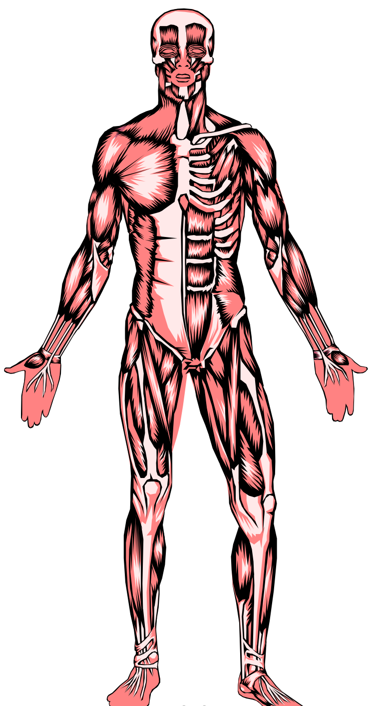
1. Methods of increasing surface area
2. Short diffusion gradient
3. Maintaining concentration gradients
4. Density of transport proteins

We will look at how these are displayed in the leaf mesophyll, root hairs, capillaries, erythrocytes and alveloi...

Leaf

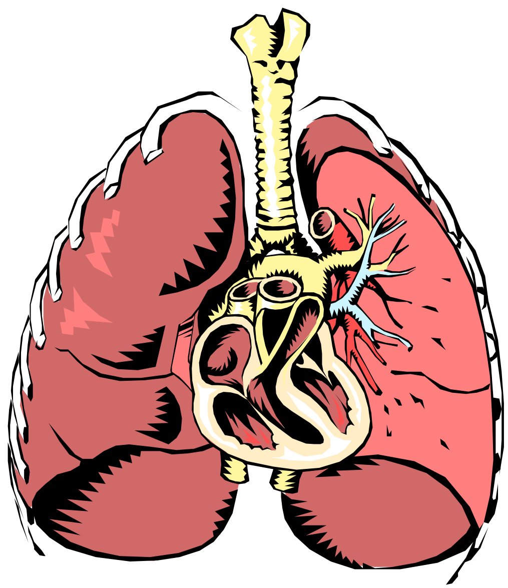
Root hair cell



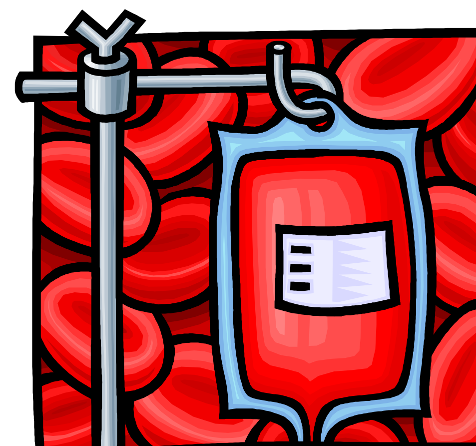


Capillaries

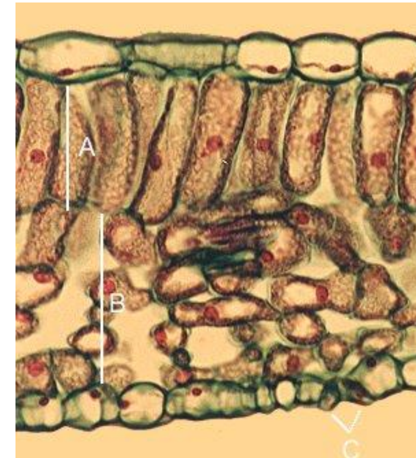
Alveoli



Erythrocytes



Mesophyll - Main site of photosynthesis



Palisade mesophyll

- tall & thin and arranged end on end
- less cell wall for light to cross
- large volume to contain chloroplasts

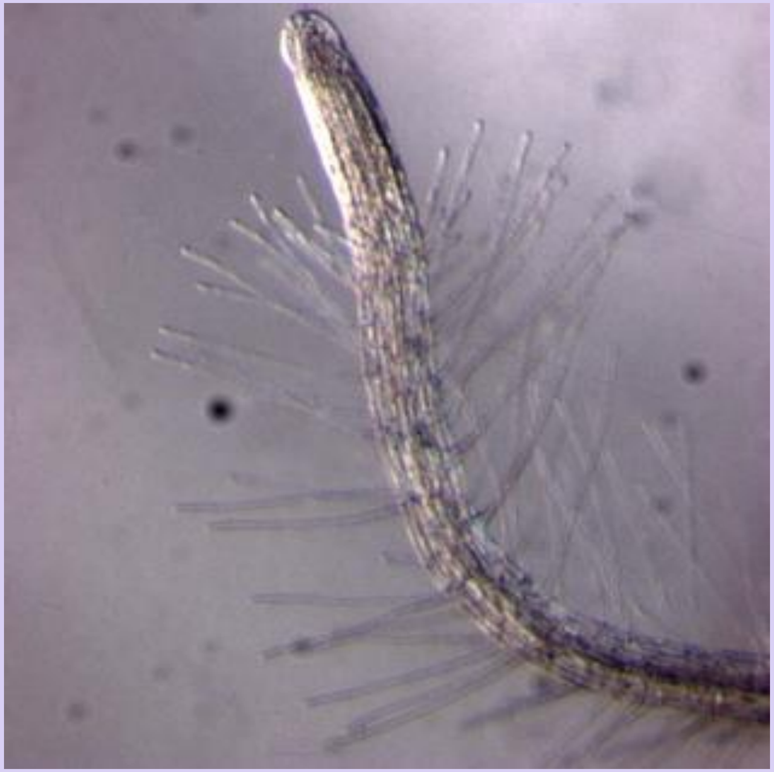
Spongy mesophyll

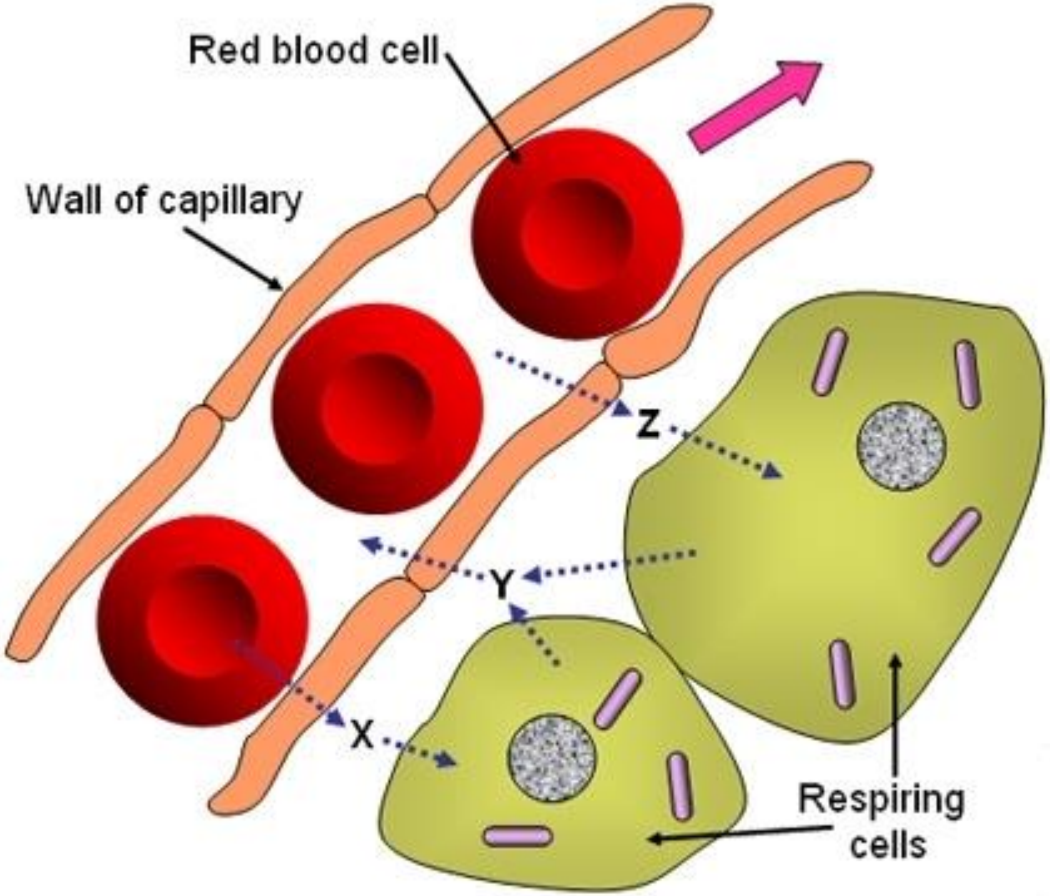
- Lots of air spaces, providing a large surface area
- Allow diffusion of CO_2 to palisade cells

As cells photosynthesise they use CO_2, maintaining a high concentration gradient for CO_2 uptake

Root hair cell

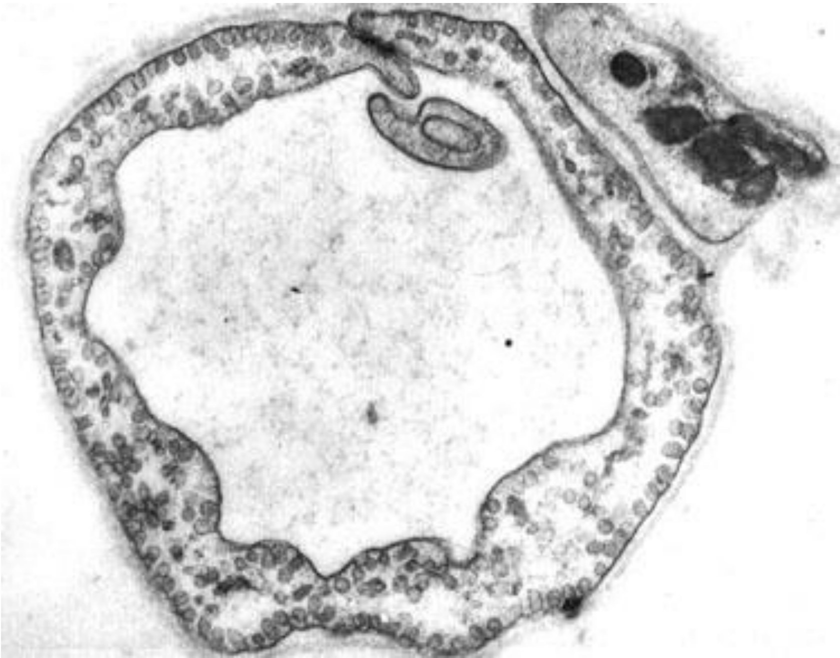
- Uptake water by osmosis; concentration gradient maintained by water moving to rest of plant
- Uptake mineral ions by active transport
- Long thin cytoplasmic extension creates large surface area to volume ratio



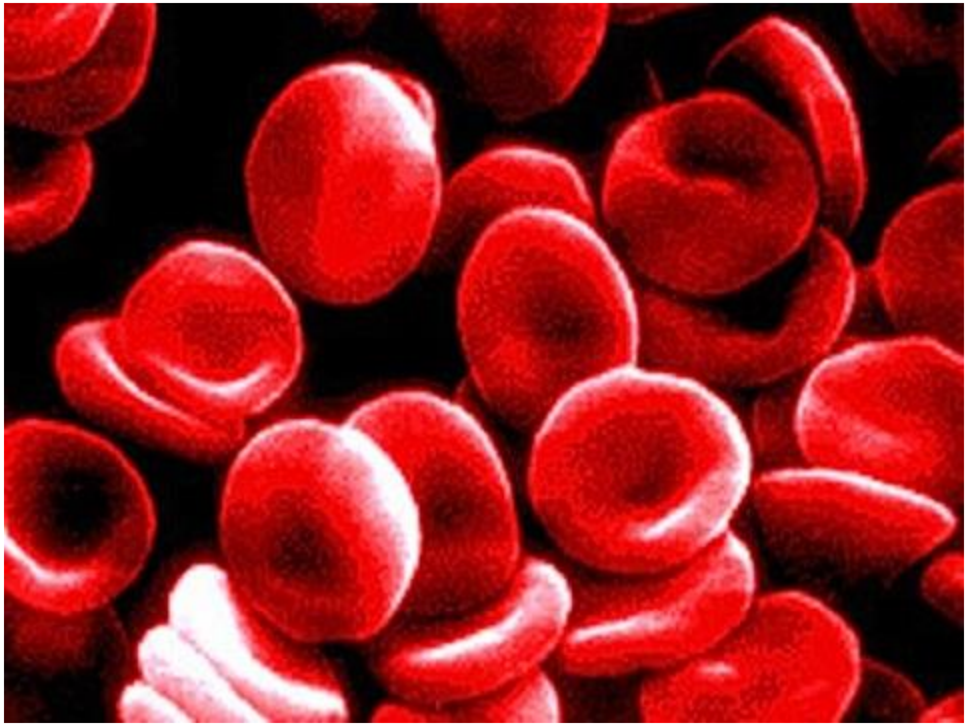


Capillaries

- Site of gas and nutrient exchange with all cells in body
- Walls one cell thick, reduces diffusion distance



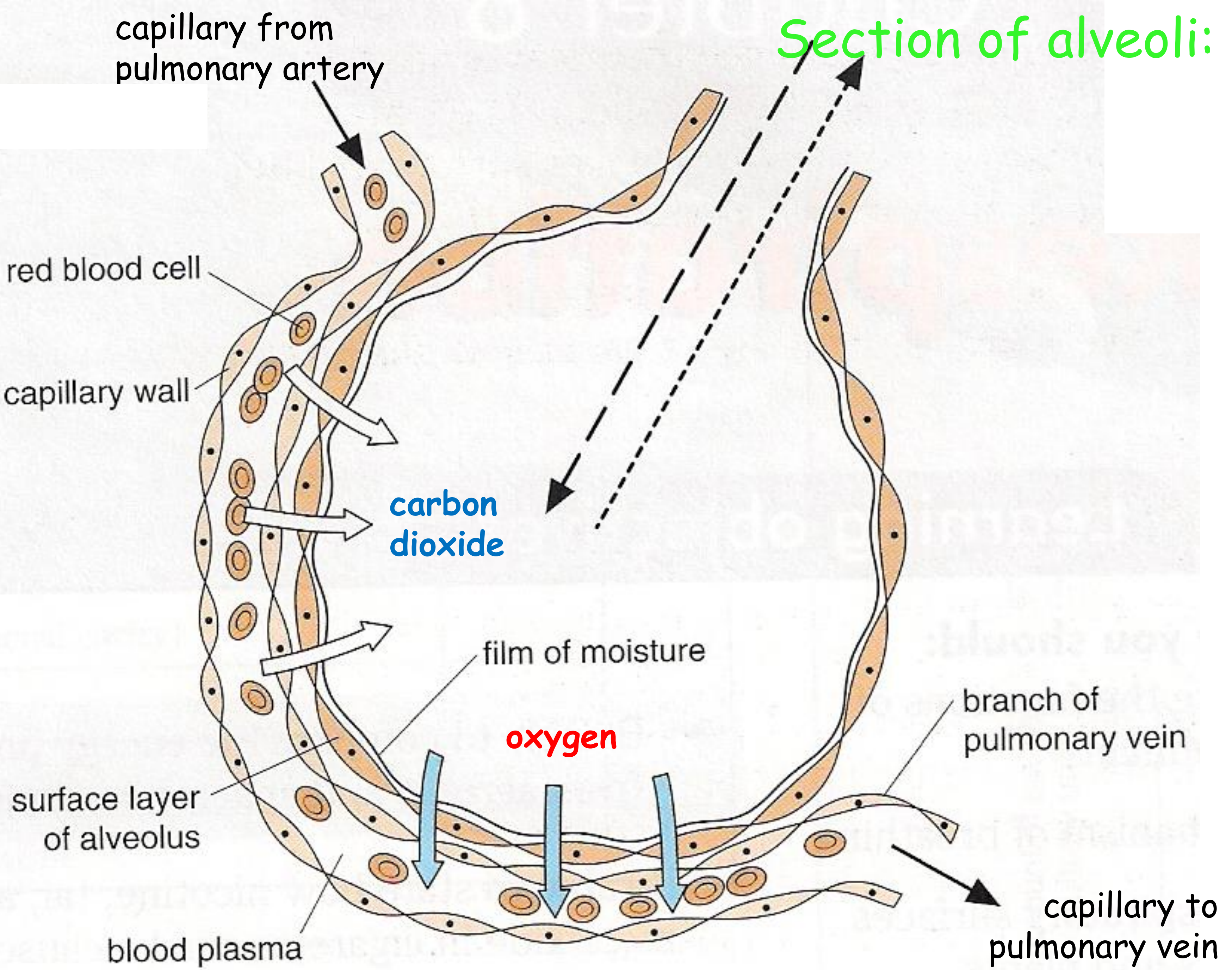
- Cells flattened (have squamous/pavement epithelium)



Erythrocytes

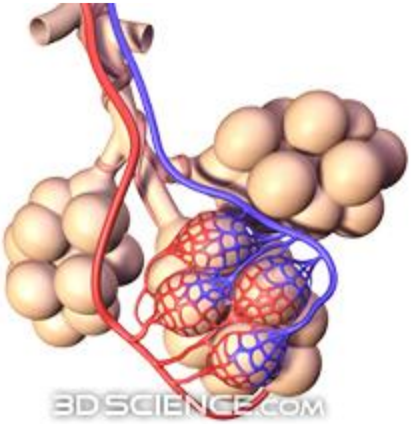
- Biconcave shape maximises SA:Vol for oxygen exchange
- No nucleus to maximise volume to carry haemoglobin

Section of alveoli:



Alveoli

- Site of gas exchange in lungs
- Walls one cell thick, reduces diffusion distance
- Squamous epithelial cells lining the alveoli
- Breathing movements and constant blood flow maintain concentration gradients
- Carbon dioxide conc always higher in blood
- Oxygen conc always higher in alveolus



The absorptive surfaces in flowering plants and animals – cut and stick summary!

leaf mesophyll

root hairs

capillaries

erythrocytes

ALVEOLI

Complete cut and stick!