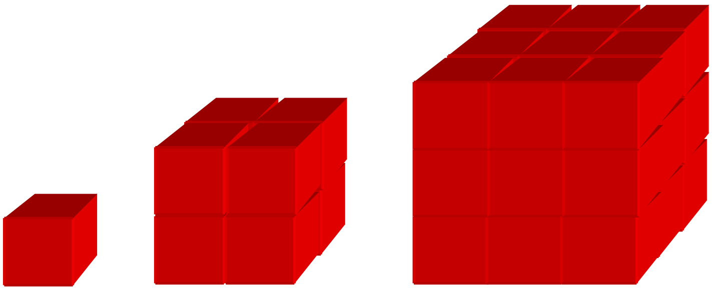
Exchange and Transport

2.1 Special Surfaces for Exchange

Surface area to volume ratio and the need for a specialised exchange surface in organisms

All animals need to maintain a supply of the materials they need (for example nutrients and oxygen, and for the removal of waste products of metabolism). In **single-celled organisms** (**unicellular**) these needs can be met purely by **diffusion**. This is because the distances are short, mere nanometres or millimetres in length. They have a relatively large surface area in comparison with their size, so exchange can happen across their cell surface.

However, larger **multicellular** organisms cannot rely upon diffusion. The distances that diffusion would have to take place over (the **diffusion paths**) are too great and the surface area is small in comparison to larger animals' sizes. Therefore, they need specialist exchange surfaces and a transport system to deliver materials to and from exchange surfaces and satisfy the demands created by high activity levels.



1cm	2cm	3cm
SA: $6cm^2$	SA: $24cm^2$	SA: $54cm^2$
Vol: $1cm^3$	Vol: $8cm^3$	Vol: $27cm^3$
SA:Vol = 6	SA:Vol = 3	SA:Vol = 2

The size of an animal is what affects its **surface-area-to-volume ratio** (**SA:Vol**). This is because as the size of an organism increases, its volume will increase at a much faster rate (cubic) than its surface area (squared). This means that as the size of the organism increases, the SA:Vol ratio decreases more and more.

The three cubes to the left are increasing in size from a length of 1cm, to 2cm, to 3cm. As you can see, the surface area does not increase as rapidly as volume, therefore the SA:Vol ratio quickly drops from 6 to 3 to 2, and would continue to.

Exchange Sufaces

All good exchange surfaces have certain features in common:

- a large surface area to provide more space for molecules to pass through (this is often achieved by folding the walls and membranes of the surface for exchange)
- a thin barrier to the surface to reduce the diffusion path
- a fresh supply of molecules on one side of the barrier to keep to the concentration high
- removal of required molecules on the other side to keep the concentration low

The latter three points above help to maintain a steep **concentration gradient**. Certain exchange surfaces also use an active transport mechanism to increase the rate of exchange or to allow exchange where not otherwise possible.

Examples of specialised exchange surfaces include the root hairs of plants, where long hair-like extensions increase the surface area, and they have specialised features to help with the absorption of water and minerals. However, not all exchange surfaces are present at the surface of a large organism, many are found in the organs where substances are removed from the transport system, for example, the alveoli in the lungs.