

To Start:

- What are the basic requirements for sustaining life?
- How does the body ensure it gets these vital ingredients?

Learning Objectives



- Describe the changes in Surface Area : Volume ratio with increasing organism size
- Explain the need for an effective exchange mechanism within the body of multi-cellular organisms
- Identify the features of an effective exchange surface

The Need for an Exchange Surface

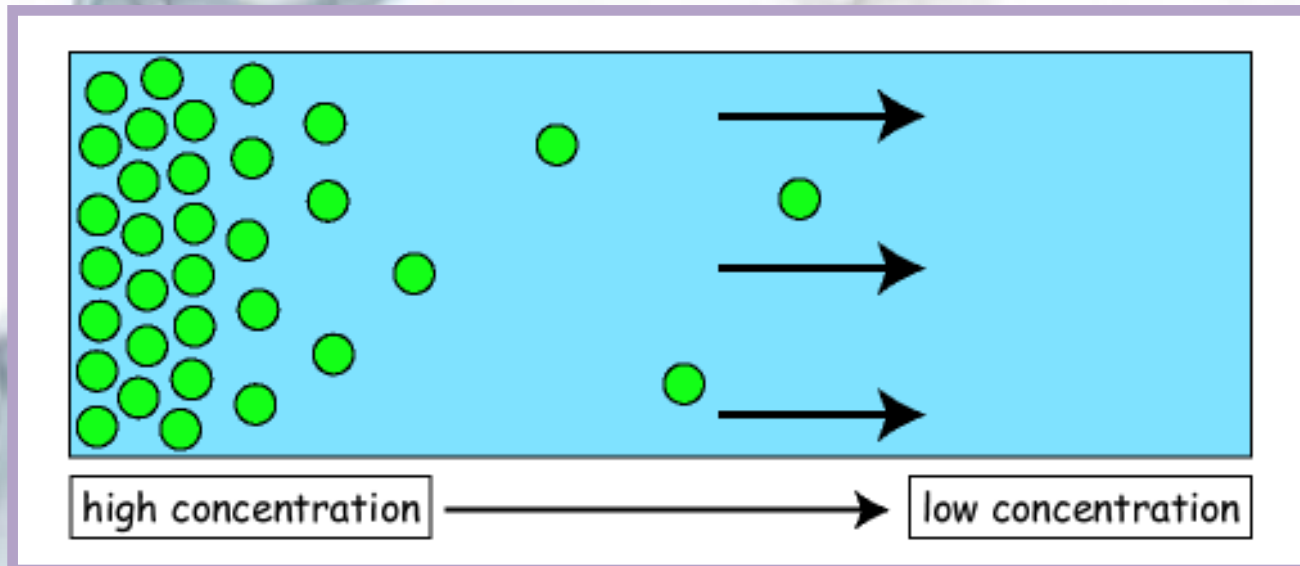


All animals must:

- **Maintain a supply of materials that they need for respiration and growth:**
 - nutrients
 - Oxygen
- **Remove the waste products of metabolism**
 - carbon dioxide
 - ammonium
 - urea

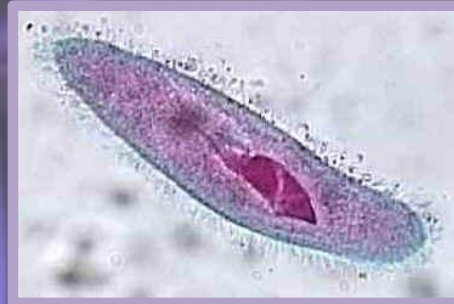
Diffusion as an Exchange Mechanism

The movement of molecules from an area of High Concentration to an area of Low Concentration



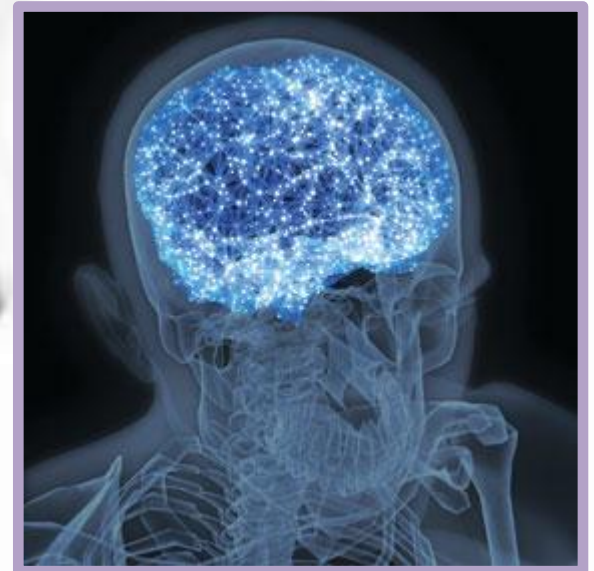
The Need for an Exchange Surface

- In small organisms diffusion across their body surface is sufficient:
 - distances are short (less than 0.5 mm)
 - **surface area is relatively large.**
- The body/cell surface acts as the exchange surface.



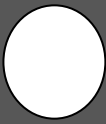
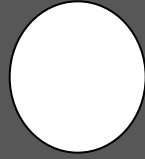
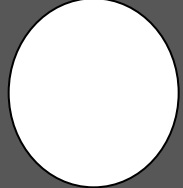


The Need for an Exchange Surface

- Large active organisms cannot rely upon their body surface:
 - surface area relative to volume is insufficient for exchange
 - distances are too great.





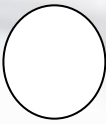

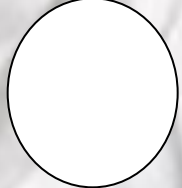
Imagine an animal composed of a ball of cells
What is the relationship between size, surface area, volume and s.a.:volume ratio?

Diameter / mm	1 	2 	3 	4 	5 
Surface area / mm ²					
Volume / mm ³					
s.a. : volume ratio					

Surface area sphere = $4\pi r^2$
Volume of sphere = $\frac{4}{3}\pi r^3$

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Diameter / mm	1 	2 	3 	4 	5 
Surface area / mm²	12.6	50.3	113.1	201.1	314.2
Volume / mm³	4.2	33.5	113.1	268.1	523.6
s.a. : volume ratio	3	1.5	1	0.75	0.60

Meeting the Demand

- Thus there is a need for the following:
 - Specialised **exchange surface** to meet the demands of high activity levels in multi-cellular organisms
 - Efficient **transport system** to deliver materials to and from the exchange surface



What Effect does an Increase in Size have on the need for a Specialist Exchange Surface in Larger Animals?

- As size increases, volume increases disproportionately compared to surface area.
- Demands of cells for nutrients and waste removal also increased disproportionately:
 - the surface does not increase sufficiently to accommodate these extra demands
 - must be met by a specialist exchange surface with enhanced surface area.



General Features of Exchange Surfaces

Large surface area relative to volume

The large surface can be provided by the body surface in small organisms or by folding of the exchange surface.

Permeable

This speaks for itself.

Thin

Diffusion is only efficient over short distances ($< 1\text{mm}$). Rate is inversely proportional to square of the distance.

Moist

O_2 , CO_2 and nutrients diffuse in solution.

Mechanism to maintain diffusion gradients

Transport system, ventilation mechanism or creation of currents across surface.

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