Adaptations for gas exchange in animals

Gas exchange

How much oxygen an organism needs depends on its **volume**.
The rate that oxygen is absorbed at depends on the **surface area** available for gas exchange.
Therefore, the **surface area to volume ratio** of an organism affects:

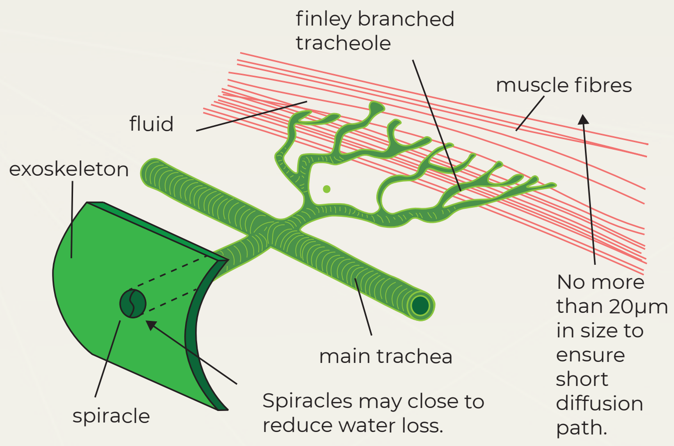
- the surface adapted for use for gas exchange
- the level of activity of the organism.

As organisms increase in size, their surface area to volume ratio decreases and so specialised respiratory surfaces are needed.

Gas exchange in insects

Insects cannot use their external surface for gas exchange as they are covered in an impermeable cuticle to reduce water loss by evaporation.

1. Pairs of spiracles on segments of the thorax and abdomen.
2. These holes lead to tubes called tracheae leading to tracheoles.
3. Tracheoles enter muscle cells directly. They have fluid at the end for dissolving and diffusion of oxygen.
4. During flight, when oxygen requirements increase, fluid in tracheoles decreases to shorten diffusion path and whole-body contractions ventilate by speeding up air flow through spiracles.



Gas exchange in fish

Fish require a specialised gas exchange surface as:

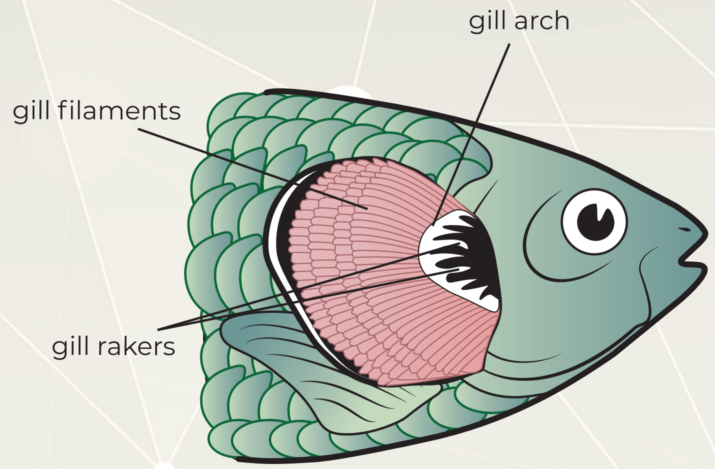
- they have a smaller surface area to volume ratio
- they are relatively active and so have high metabolic rates making oxygen requirements high
- they require a ventilation mechanism to maintain concentration gradients for gas exchange.

Ventilation in fish

Fish require a ventilation mechanism to push water, a dense medium with low oxygen content, over the high surface area gill filaments. Removal from water causes these gill filaments to collapse, stick together and the gas exchange surface becomes too small for survival.

1. Mouth opens, floor of buccal cavity lowers so volume increases, and pressure decreases and water rushes in.
2. Mouth closes, floor of buccal cavity raises, increasing pressure pushing water over the gills.
3. Pressure in gill cavity increases and water forces operculum open and leaves through it.

The gills have gill filaments made of gill plates/ lamellae, the gas exchange surface across which the water flows.
Gill rakers prevent large particulates entering and blocking the gills.

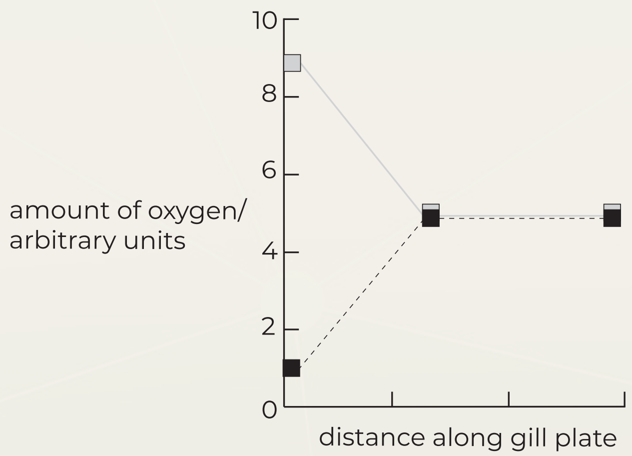


Gas exchange surfaces must:

- be moist
- be thin (short diffusion pathway)
- have a large surface area
- be permeable to gases
- in larger organisms they must have a good blood supply to maintain concentration gradients.

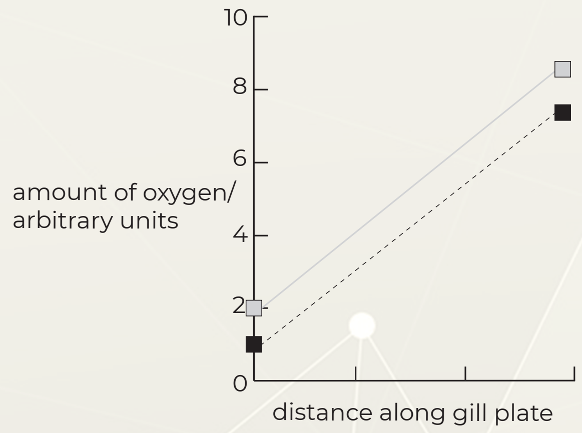
Continuous flow

If water and blood flow in the same direction equilibrium is reached and oxygen diffusion stops halfway across the gill plate.



Counter current flow

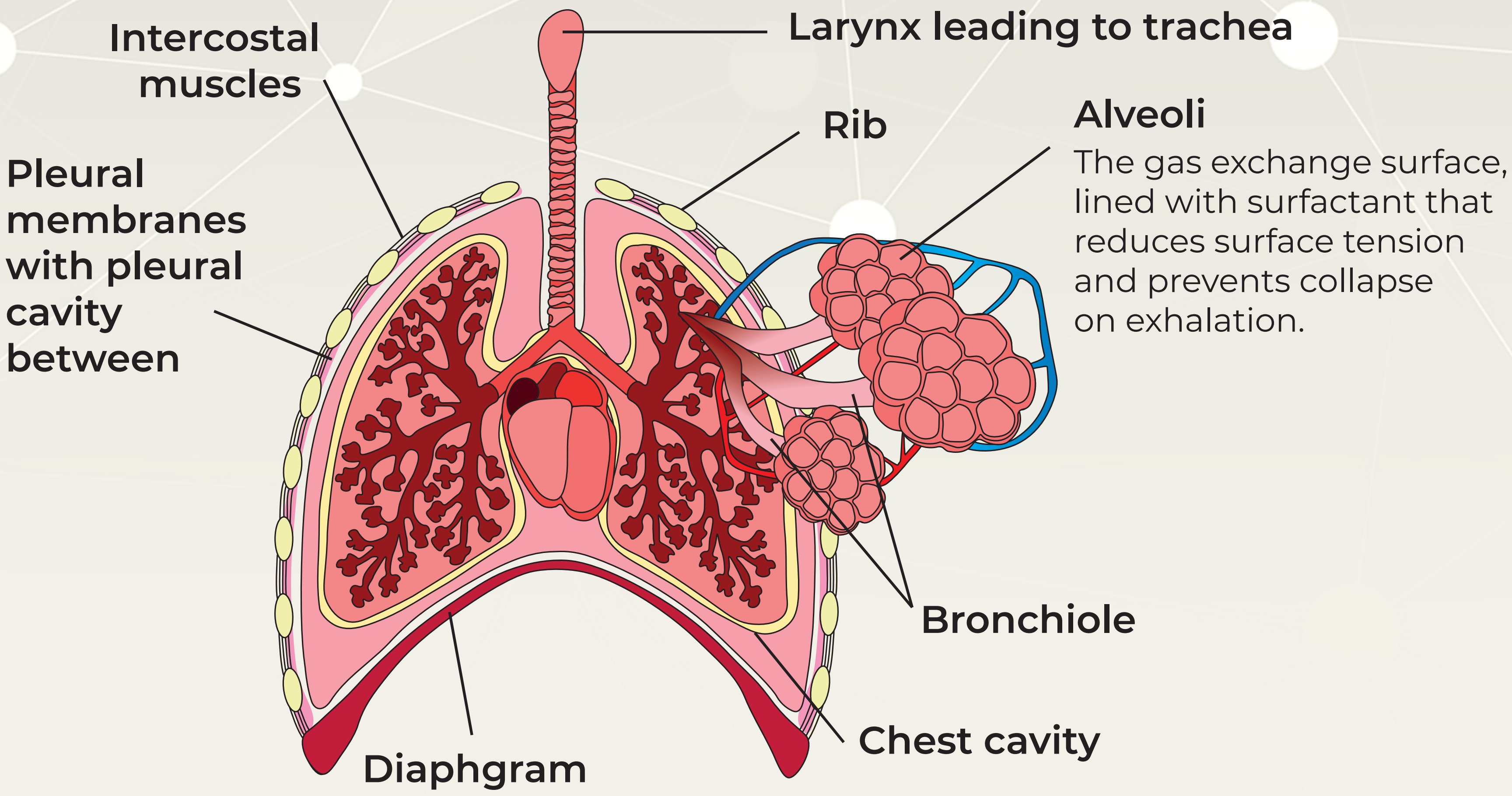
If water and blood flow in opposite directions across the gill plate the concentration gradient is maintained, and oxygen diffuses into the blood across the entire gill plate.



How some organisms adapt to the challenge of gas exchange:

Amoeba	Flatworm	Earthworm
*Single cell *Large surface area to volume ratio *Rate of oxygen diffusion through cell membrane meets demand.	*Multicellular *Smaller surface area to volume ratio *Flattened body to reduce diffusion distance so rate of oxygen diffusion through body surface meets demand.	* Multicellular, even smaller surface area to volume ratio. * Body surface still used for gas exchange, but circulatory system needed to distribute oxygen, mucus secreted to moisten surface and slow moving to reduce oxygen demand.

Gas exchange in humans



Ventilation in humans - Inspiration

1. External intercostal muscles contract and pull the rib cage up and out.
2. Outer pleural membrane is pulled out. This reduces pressure in the pleural cavity and the inner pleural membrane is pulled outward.
3. This pulls on the surface of the lungs and causes an increase in the volume of the alveoli.
4. Alveolar pressure decreases to below atmospheric pressure and air is drawn into the lungs.