

Gas exchange Why does gas exchange become harder as organisms increase in size?	Gas exchange Four properties of a gas-exchange surface
Gas exchange Three ways animals maintain concentration gradients at exchange surfaces	Gas exchange Surfactant
Gas exchange How does the branched network of bronchioles help gas exchange?	Gas exchange Why are the alveoli covered in extensive capillary beds?
Gas exchange Muscle actions during inspiration	Gas exchange Muscle actions during forced expiration

Permeable, thin tissue layer, moist and large surface area.

Surface area-to-volume ratio decreases and the distance from the centre to the exterior increases.

Fluid lining the alveoli that reduces surface tension, so alveoli do not stick together and collapse when air is breathed out.

Dense networks of blood vessels, continuous blood flow, and ventilation with air (lungs) or water (gills).

Blood flows close to all of the surface, removing O_2 and bringing CO_2 to keep gradients steep.

It carries air to and from hundreds of millions of alveoli, giving a very large surface area.

Internal intercostals contract, ribs move down and in; abdominal muscles contract, pushing the diaphragm up. Thorax volume falls, pressure rises.

Diaphragm contracts and flattens; external intercostals contract, ribs move up and out; abdominal muscles relax. Thorax volume rises, pressure falls.

Gas exchange

Vital capacity

Gas exchange

Tidal volume

Gas exchange

**Role of the waxy cuticle and epidermis
in gas exchange**

Gas exchange

**Role of spongy mesophyll and air
spaces**

Gas exchange

Plan diagram

Gas exchange

Transpiration

Gas exchange

**Four factors that increase the rate of
transpiration**

Gas exchange

How is stomatal density calculated?

The volume of air breathed in or out in one normal breath.

Tidal volume + inspiratory reserve volume + expiratory reserve volume: the most air that can be breathed out after the deepest breath in.

Air spaces let gases diffuse through the leaf; moist spongy mesophyll walls give a large surface for gas exchange.

Reduce water loss by evaporation; the transparent epidermis protects the leaf and lets light through.

Loss of water vapour from the leaves and stems of plants, a consequence of opening stomata for gas exchange.

A diagram showing the distribution of tissues as outlined areas, with no individual cells drawn.

Number of stomata in the field of view $\div$ area of the field of view (πr^2), usually in stomata per mm^2 .

Higher light intensity, higher temperature, lower humidity and higher wind speed.

Gas exchange **HL only**

Cooperative binding

Gas exchange **HL only**

Foetal vs adult haemoglobin

Gas exchange **HL only**

Bohr shift

Gas exchange **HL only**

Why is the oxygen dissociation curve S-shaped?

Transport

Three adaptations of capillaries for exchange

Transport

Fenestrations

Transport

How to tell an artery from a vein in a micrograph

Transport

Role of elastic fibres in arteries

Foetal haemoglobin has a higher affinity for O_2 (curve to the left), so it loads O_2 from maternal blood in the placenta.

Binding of one O_2 to a haem group changes haemoglobin's shape, so the other haem groups bind O_2 more easily.

Cooperative binding: the first O_2 binds with difficulty, the next bind easily (steep part), then haemoglobin saturates (plateau).

Higher CO_2 lowers haemoglobin's affinity for O_2 , moving the curve right, so more O_2 is released in actively respiring tissues.

Pores in the walls of some capillaries, for example in the kidney glomerulus, that allow particularly rapid exchange.

Branching and narrow diameters (large surface area), thin walls one cell thick, and fenestrations where exchange must be rapid.

Stretch when blood is pumped in and recoil between beats, maintaining high pressure and pushing blood on.

Artery: thick wall compared with a narrow, round lumen. Vein: thin wall compared with a wide, often flattened lumen.

Transport

Role of smooth muscle in arteries

Transport

Two adaptations of veins for returning blood

Transport

Where can the pulse be felt?

Transport

Occlusion of a coronary artery

Transport

What does a correlation coefficient show?

Transport

Cohesion-tension mechanism

Transport

Four adaptations of xylem vessels

Transport

Arrangement of tissues in a dicotyledonous stem

Valves prevent backflow; thin, flexible walls are compressed by contracting skeletal muscles, pushing blood towards the heart.

Contracts to narrow the lumen, helping to maintain blood pressure; the thick wall withstands high pressure.

Blockage by fatty plaque (atherosclerosis) or a blood clot, cutting O₂ supply to cardiac muscle and causing a heart attack.

At the radial artery (inside of the wrist) or carotid artery (neck), using fingertips, not the thumb.

Transpiration draws water out of xylem by capillary action, creating tension that pulls water up; cohesion keeps the column continuous.

The strength of the correlation between two variables, from -1 to $+1$. A strong correlation does not prove causation.

Epidermis, cortex, ring of vascular bundles (phloem outside, xylem inside) and central pith.

No cell contents, incomplete or absent end walls, lignified walls to withstand tension, and pits for water entry and exit.

Transport

Arrangement of tissues in a dicotyledonous root

Transport **HL only**

How is tissue fluid formed?

Transport **HL only**

Plasma vs tissue fluid

Transport **HL only**

Two features of lymph ducts

Transport **HL only**

Single vs double circulation

Transport **HL only**

Role of the atrioventricular and semilunar valves

Transport **HL only**

Why is the left ventricle wall thicker than the right?

Transport **HL only**

Order of events in the left side of the heart

Pressure filtration of plasma through capillary walls, promoted by high pressure of blood from arterioles.

Epidermis with root hairs, wide cortex, central vascular region with star-shaped xylem and phloem between its arms.

Valves for one-way flow and thin walls with gaps to let excess tissue fluid in; lymph returns to the blood in veins.

Similar water, ions, glucose and amino acids, but tissue fluid has very little protein, less O₂ and more CO₂ and wastes.

AV valves stop backflow into the atria when ventricles contract; semilunar valves stop backflow into the ventricles when they relax.

Fish: heart → gills → body, blood passes the heart once. Mammal: separate pulmonary and systemic circuits, heart twice.

SA node fires; atrial systole; ventricular systole (AV valve closes, semilunar valve opens); diastole (semilunar valve closes, AV valve opens).

It pumps blood at higher pressure around the whole body; the right only pumps to the lungs.

Transport **HL only**

Systolic and diastolic pressure

Transport **HL only**

Root pressure

Transport **HL only**

Adaptations of sieve tube elements

Transport **HL only**

Adaptations of companion cells

Muscle and motility **HL only**

Motile vs sessile

Muscle and motility **HL only**

Four reasons for locomotion

Muscle and motility **HL only**

An example of migration

Muscle and motility **HL only**

Sarcomere

Positive pressure potential in xylem caused by active transport of mineral ions into the xylem, so water enters by osmosis.

Systolic: highest arterial pressure, during ventricular systole. Diastolic: lowest, during diastole. Typical adult about 120/80 mm Hg.

Many mitochondria for ATP to load sugars actively, and plasmodesmata connecting them to sieve tube elements.

Sieve plates, reduced cytoplasm and organelles, and no nucleus, so sap flows easily.

Foraging for food, escaping from danger, searching for a mate and migration.

Motile organisms move from place to place (e.g. Atlantic salmon); sessile organisms are fixed but move parts (e.g. Venus flytrap closing its leaf).

The repeating unit of a myofibril between two Z lines, containing overlapping actin and myosin filaments.

Arctic terns fly between Arctic breeding grounds and the Antarctic each year.

Muscle and motility **HL only**

Sliding filament model

Muscle and motility **HL only**

Role of ATP in muscle contraction

Muscle and motility **HL only**

Titin

Muscle and motility **HL only**

Why are antagonistic muscles needed?

Muscle and motility **HL only**

Intercostal muscles as an antagonistic pair

Muscle and motility **HL only**

Motor unit

Muscle and motility **HL only**

What happens at a neuromuscular junction?

Muscle and motility **HL only**

Two roles of skeletons in movement

ATP binding detaches myosin from actin; its hydrolysis re-cocks the myosin head for the next power stroke.

Myosin heads bind actin, swivel and pull it towards the sarcomere centre using ATP; filaments slide, sarcomere shortens.

Muscle tissue can only exert force when it contracts, so a second muscle is needed to pull the body part back.

Immense spring-like sarcomere protein that helps sarcomeres recoil after stretching and prevents overstretching.

One motor neuron, all the muscle fibres it stimulates and the neuromuscular junctions that connect them.

Fibres in different orientations: external intercostals move ribs up and out, internal move them down and in; each stretches the other.

Anchorage for muscles and levers that pivot at joints.

Acetylcholine is released, binds to receptors on the muscle fibre and depolarises it, triggering contraction.

Muscle and motility **HL only**

Exoskeleton vs endoskeleton

Muscle and motility **HL only**

Ligament vs tendon

Muscle and motility **HL only**

Bones at the hip joint

Muscle and motility **HL only**

How is range of motion measured?

Muscle and motility **HL only**

Swimming adaptations of marine mammals

Muscle and motility **HL only**

How does a dolphin's tail movement differ from a fish's?

Ligament: bone to bone, stabilises the joint.
Tendon: muscle to bone, transmits force.

Exoskeleton (arthropods): outside, muscles on inner surface. Endoskeleton (vertebrates): inside, muscles attached outside by tendons.

As joint angles in degrees, using a goniometer or computer analysis of images, in each dimension of movement.

The head of the femur fits into a socket in the pelvis: a ball-and-socket synovial joint.

The dolphin's horizontal fluke moves up and down; a fish's tail moves from side to side.

Streamlining, forelimbs as flippers, tail as a fluke moved up and down, and a blowhole for breathing between dives.