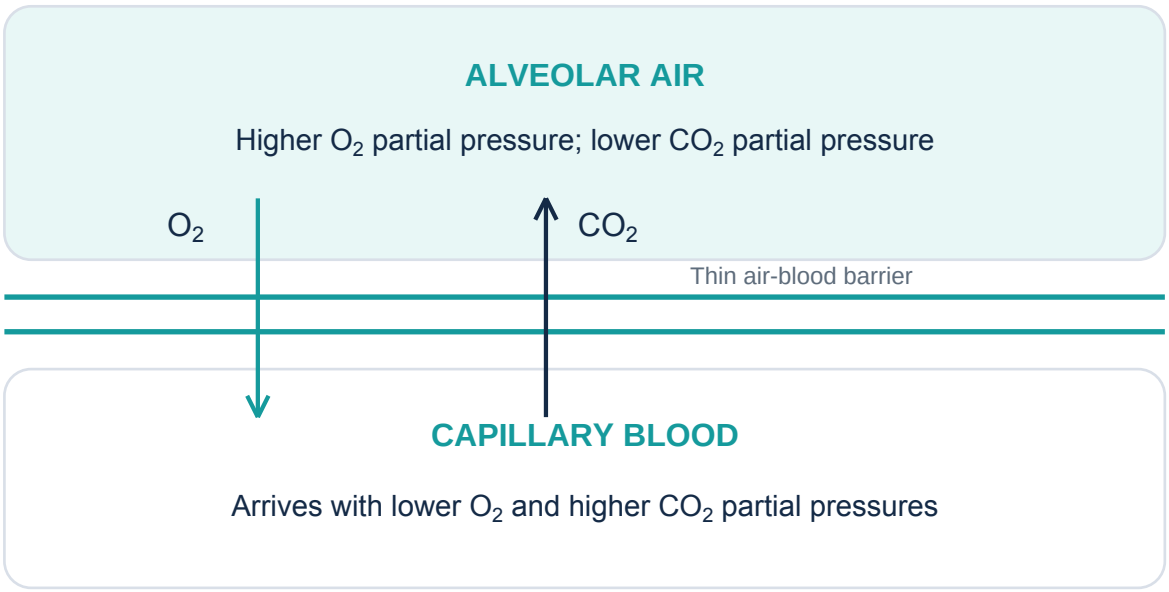
Two gases, opposite directions

At the alveoli, oxygen enters blood and carbon dioxide leaves it. Both cross the exchange surface by passive diffusion, down their own gradients.

1. FOLLOW THE NET MOVEMENT OF EACH GAS



2. OXYGEN: ALVEOLAR AIR TO BLOOD

Oxygen dissolves in the moist lining, then diffuses through the alveolar epithelium and capillary wall. It enters plasma and red blood cells, where much of it binds to haemoglobin. Blood carries this oxygen away for delivery to body cells.

3. CARBON DIOXIDE: BLOOD TO ALVEOLAR AIR

Carbon dioxide carried from respiring tissues diffuses in the opposite direction, from blood into the alveoli. It is then breathed out. Oxygen does not change into carbon dioxide in the alveolus: the two gases are exchanged independently.

Gas directions and transport to tissues: NHLBI, How the Lungs Work.
Diffusion and blood oxygenation: OpenStax Anatomy & Physiology 2e, section 22.4.

Scope: Cambridge Biology 9700 syllabus, section 9.1, outcome 7, p. 29.

A surface built for fast diffusion

The exchange surface combines a large area with a very short path. Each adaptation matters because it changes a specific factor affecting diffusion.

1. TRACE THE OXYGEN PATH THROUGH THE BARRIER

Alveolar air

↓

Thin moist lining

↓

Squamous alveolar epithelium

↓

Closely apposed basement membranes

↓

Capillary endothelium

↓

Plasma, then red blood cell

2. MANY ALVEOLI: LARGE TOTAL SURFACE AREA

The many small air sacs expose a large combined area to capillary blood. More surface is available for molecules to cross at the same time. This is an area advantage, not a claim that one alveolus has a thick wall.

3. THIN WALLS AND A MOIST LINING

Flattened alveolar cells and thin capillary endothelial cells keep the diffusion distance short. Basement membranes are closely apposed or fused in the thin exchange region. A thin liquid lining lets gases dissolve before crossing; the alveolus is not filled with blood or a deep pool of fluid.

Alveolar epithelium and respiratory membrane: OpenStax, section 22.1.
Surface area and diffusion distance: OpenStax Biology 2e, section 39.2.

Scope: Cambridge Biology 9700 syllabus, section 9.1, outcome 7, p. 29.

Keep the gradients in place

Diffusion would reduce a difference if air and blood were left unchanged. Ventilation refreshes the air, while circulation continually replaces the blood.

1. TWO FLOWS SUSTAIN ONE EXCHANGE SURFACE

Ventilation

Replenishes alveolar oxygen and removes carbon dioxide.

Blood flow

Brings oxygen-poor blood and carries oxygenated blood away.

Maintained diffusion gradients

Air stays separate from blood; only gases cross the barrier.

2. NAME THE GRADIENT PRECISELY

Each gas diffuses from higher to lower partial pressure. This compares the driving force across air and blood more precisely than comparing their total gas contents. In the lungs, the oxygen gradient points into blood; the carbon dioxide gradient points into alveolar air.

3. THREE PROCESSES, NOT ONE

Ventilation is bulk air movement. Gas exchange is diffusion across a surface. Cellular respiration is a set of metabolic reactions in cells. Diffusion itself does not require ATP, even though breathing muscles and the heart use energy to maintain air and blood flow.

Prediction: less exchange area, a thicker barrier or a smaller gradient slows diffusion when the other factors are unchanged.

Ventilation, perfusion and partial pressures: OpenStax, section 22.4.
Factors affecting diffusion: OpenStax Biology 2e, section 39.2.

Scope: Cambridge Biology 9700 syllabus, section 9.1, outcome 7, p. 29.