

Why O_2 Moves In and CO_2 Moves Out

The Physics and Physiology of Gas Exchange

Chapter 14.3 Explainer

01. THE ARENA

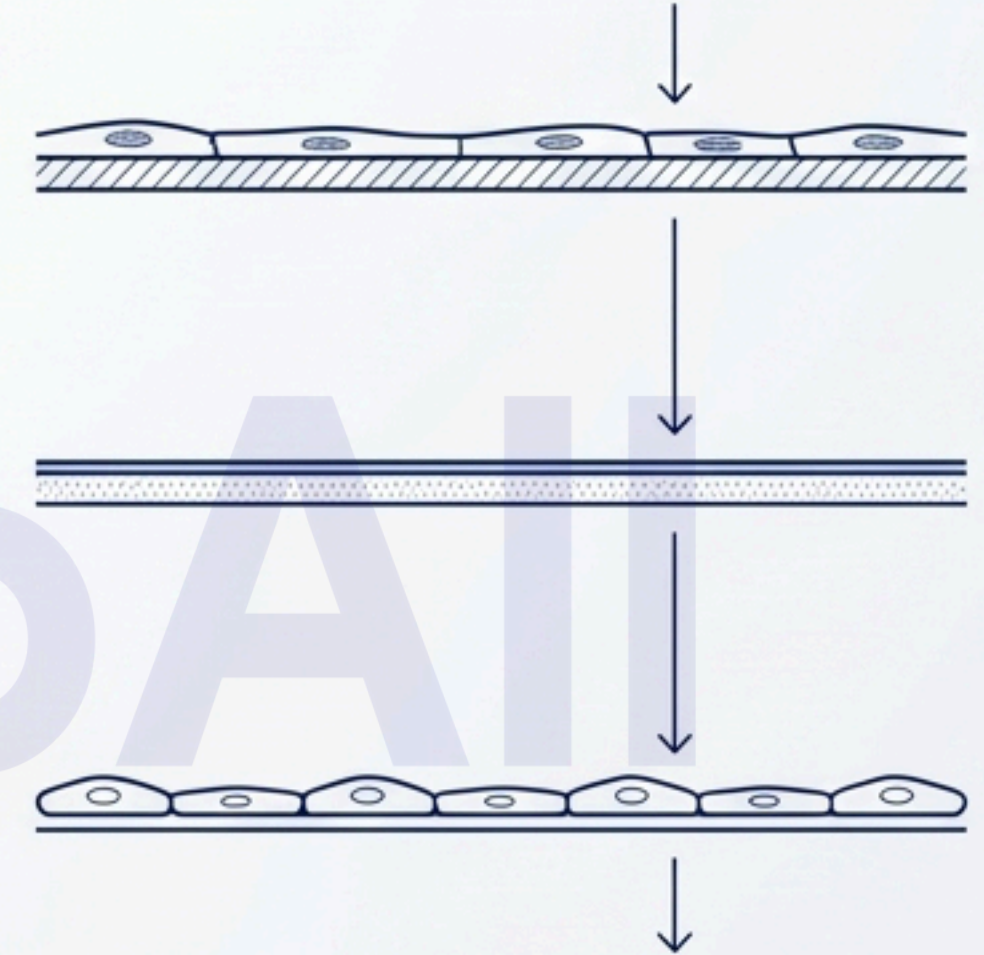
The Alveolar Exchange Hub

Gas exchange occurs primarily at the **alveoli**, and secondarily between blood and tissues. The structural setup is perfectly calibrated for rapid transfer.

Squamous Epithelium
(Alveolar wall)

Basement Substance
(Supporting matrix)

Endothelium
(Alveolar capillary wall)

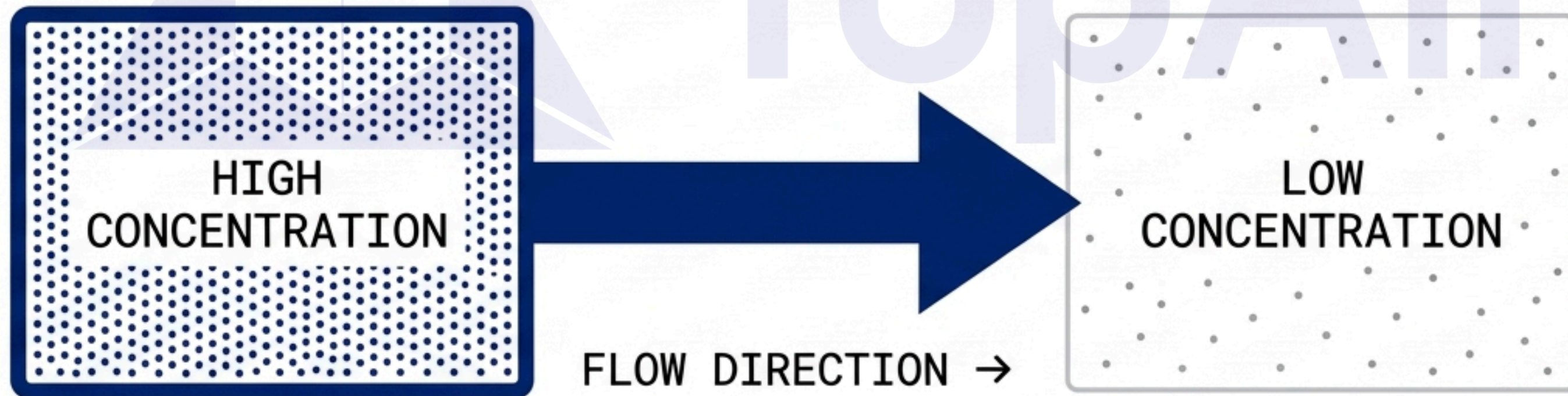


Amber Note: The total thickness of these three combined layers is much less than a single millimetre, providing minimal physical resistance to gas flow.

02. THE MECHANISM

Simple Diffusion & Gradients

Gases do not require active pumping to cross the alveolar membrane. They move entirely via passive simple diffusion, driven by two structural factors: the solubility of the specific gases and the thickness of the diffusion membrane.





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$$E=mc^2$$



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MEASURING THE GRADIENT

Understanding Partial Pressure

In a mixture of atmospheric gases, each individual gas exerts its own independent pressure. This specific, isolated force is known as its partial pressure.

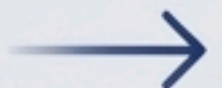
Amber Note: Gases always diffuse from a region of higher partial pressure to a region of lower partial pressure.

pO_2

Partial
pressure of
Oxygen

pCO_2

Partial
pressure of
Carbon
Dioxide



THE DATA MATRIX

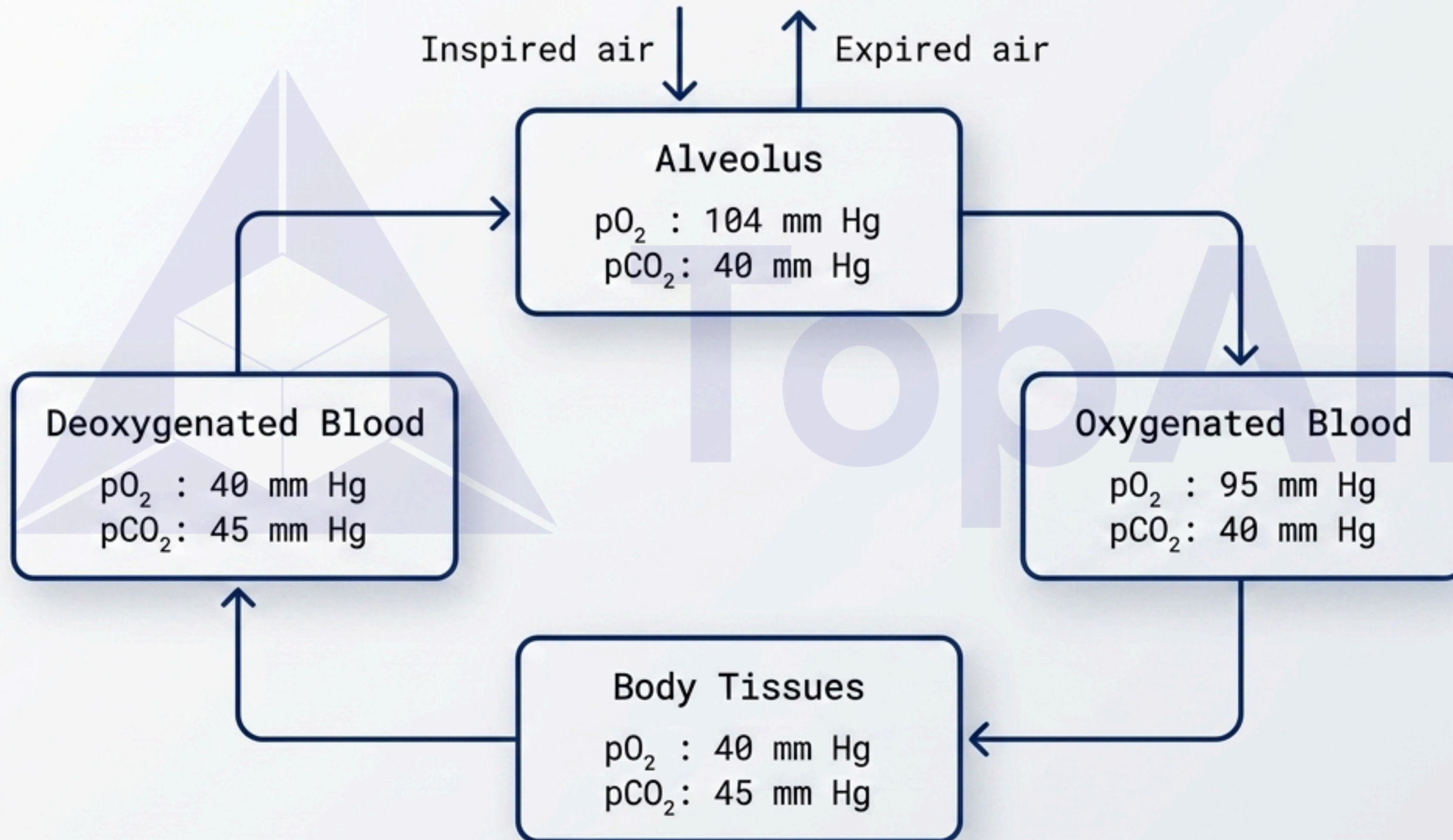
Partial Pressures at Exchange Sites

The continuous concentration gradients that drive oxygen from the atmosphere deep into tissues, while pulling carbon dioxide out.

Respiratory Gas	Atmospheric Air	Alveoli	Blood (Deox)	Blood (Ox)	Tissues
O ₂	159	104	40	95	40
CO ₂	0.3	40	45	40	45

VALUES EXPRESSED IN MM HG. FLOW FOLLOWS THE PRESSURE GRADIENT.

The Gas Exchange Circuit



The Solubility Multiplier

The pressure gradient driving CO₂ out is significantly smaller than the gradient pulling O₂ in. How does enough CO₂ escape the blood?

$$\Delta pO_2 = \sim 64 \text{ mm Hg } (104 \rightarrow 40)$$



Oxygen relies on a massive pressure difference to forcibly drive diffusion into the blood.

$$\Delta pCO_2 = 5 \text{ mm Hg } (45 \rightarrow 40)$$



20-25x

Carbon dioxide relies on a tiny pressure difference, BUT its solubility is 20-25 times higher than oxygen.

Because of this extreme solubility, the volume of CO₂ that diffuses per unit of pressure difference perfectly matches the high-pressure diffusion of O₂.

The Perfect Favorable Setup



Anatomy meets Physics

Every factor in the human body is perfectly aligned for rapid, continuous, and passive gas exchange.

1. The Membrane

An incredibly thin (<1mm) barrier provides minimal physical resistance.

2. The Physics

Continuous, opposing partial pressure gradients act as an invisible → biological conveyor belt.

3. The Chemistry

The 20-25x higher solubility of CO₂ perfectly compensates for its → narrower pressure gradient.

SYSTEM STATUS: OPTIMAL EXCHANGE



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