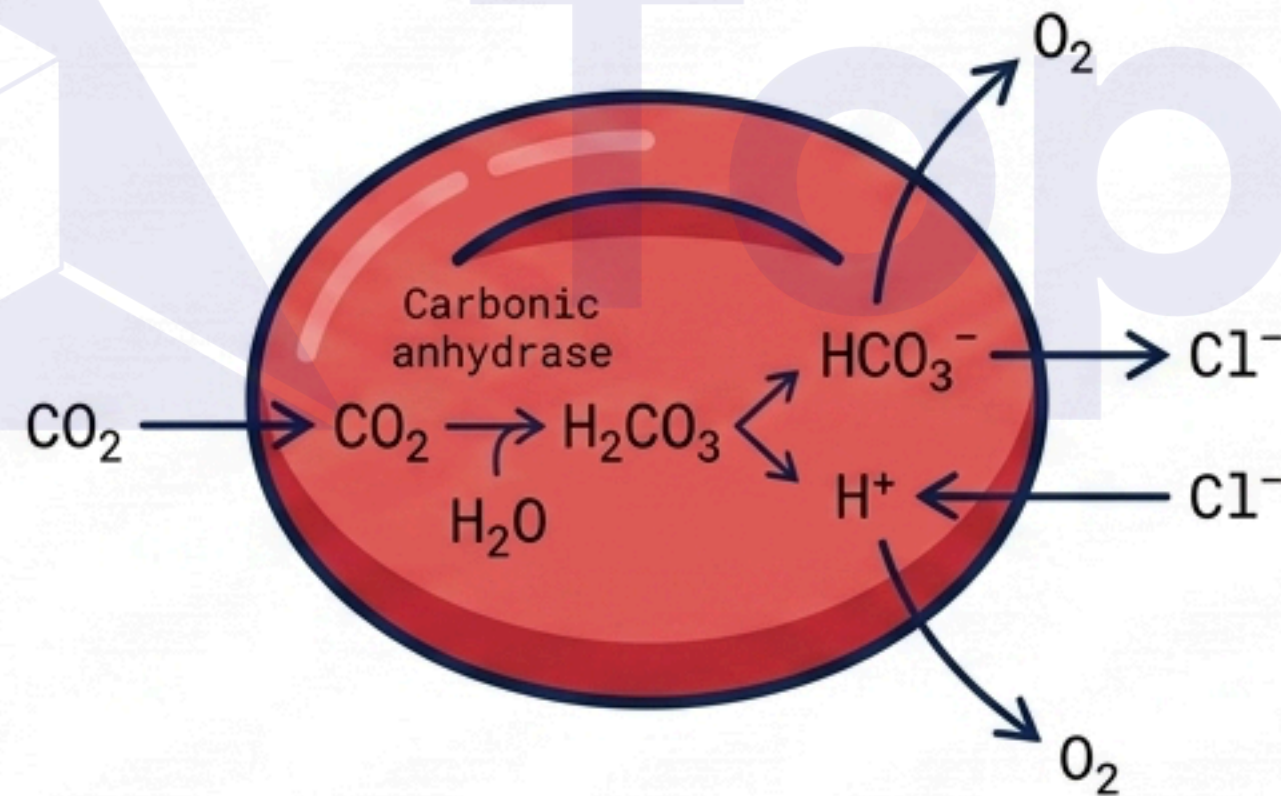


The Bicarbonate Route

Cellular Mechanisms of Carbon Dioxide Transport in Human Physiology



The Three Routes of CO₂ Transport

**Dissolved
in Plasma**

7%

Carried in a simple dissolved state through the blood plasma.

**Carbamino-
haemoglobin**

20-25%

Bound directly to haemoglobin inside Red Blood Cells.

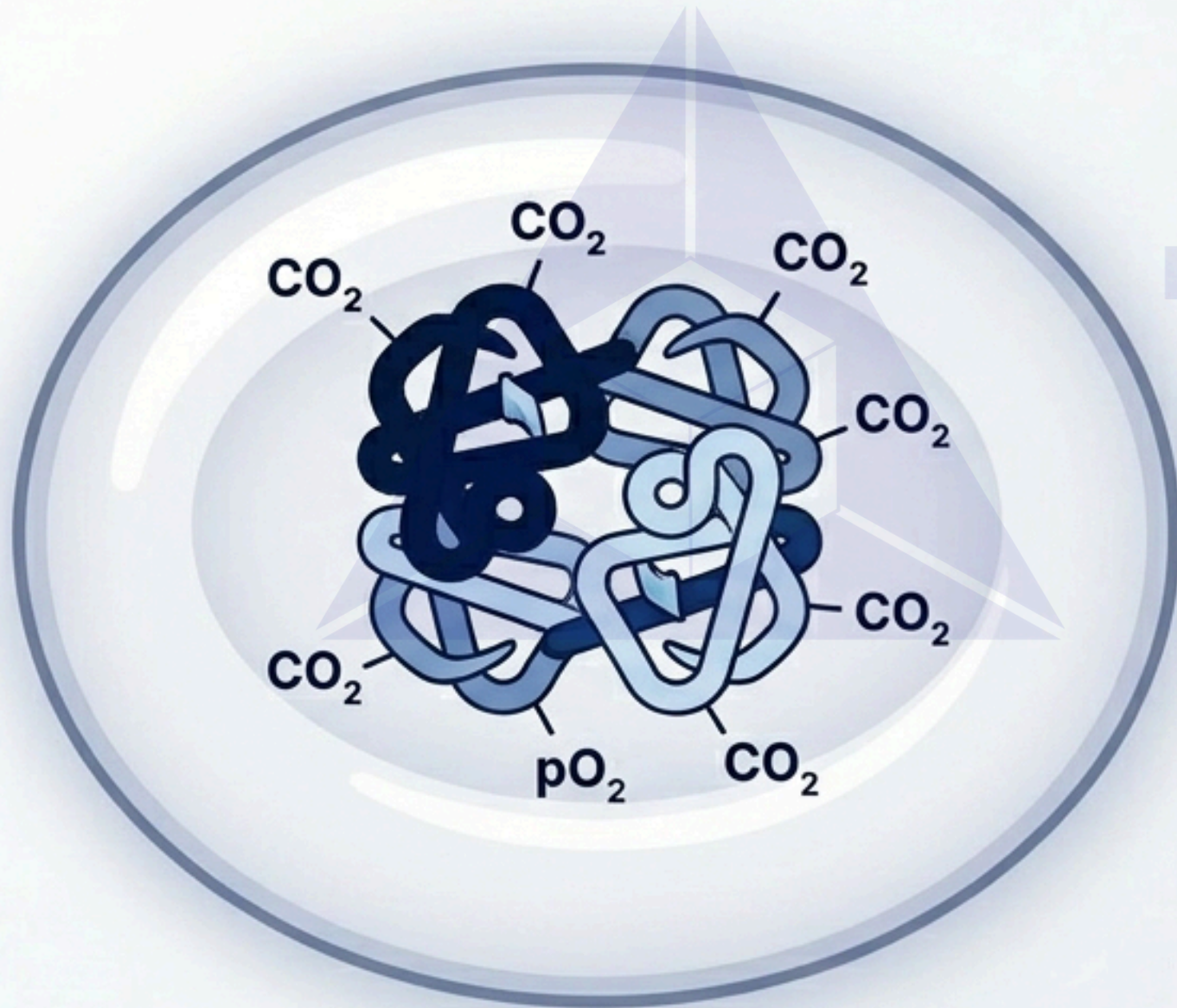
**Bicarbonate
(HCO₃⁻)**

70%

The primary transport mechanism, driven by enzymatic reactions within the RBC.

The Alternative Route: Carbamino-haemoglobin

Approximately 20-25% of CO_2 binds directly to haemoglobin.



The pO_2 Dependency

The partial pressure of Oxygen (pO_2) is the major factor dictating this binding.

- High pCO_2 + Low pO_2 (Tissues) = Binding of CO_2 .
- Low pCO_2 + High pO_2 (Alveoli) = Dissociation of CO_2 .



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$$E=mc^2$$



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The Engine: Carbonic Anhydrase

The Catalyst

Present in very high concentrations inside RBCs (and minute quantities in plasma).

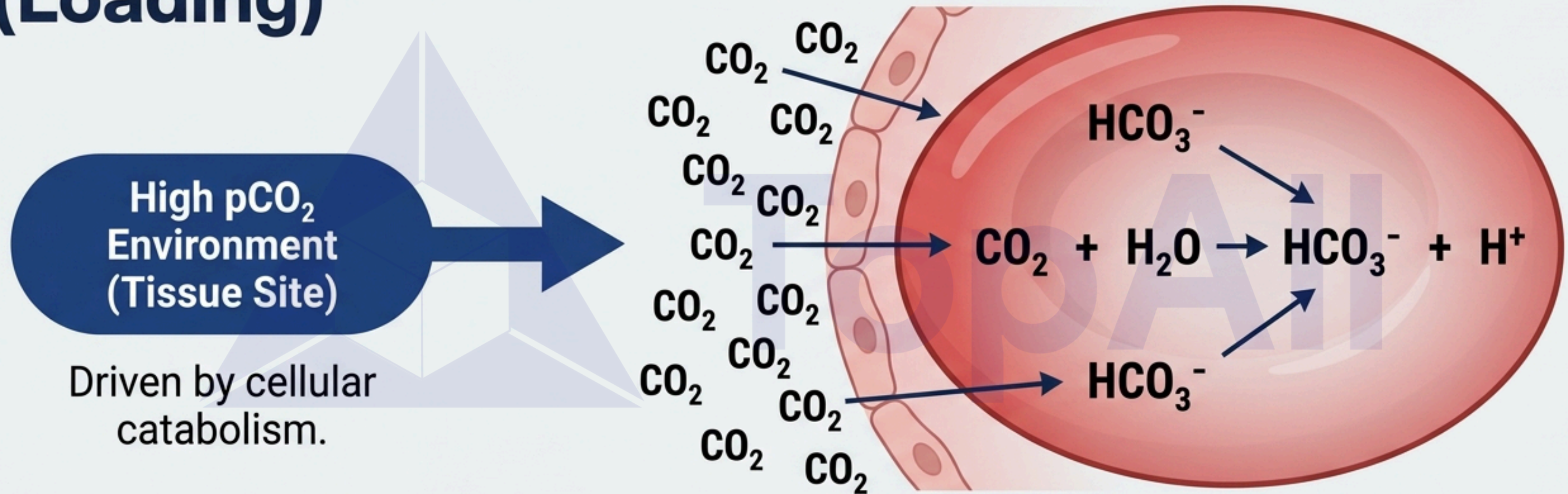
Carbonic Anhydrase



Reversibility

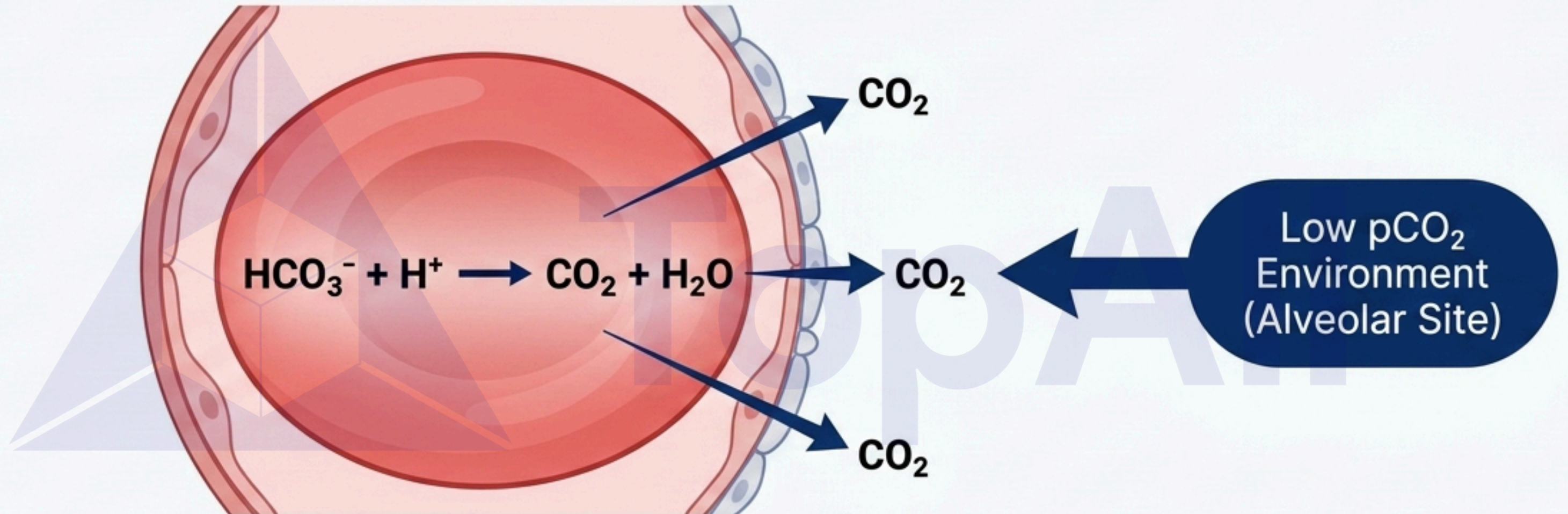
This exact same enzyme facilitates the reaction in both directions depending on local concentration gradients.

Phase 1: Bicarbonate Formation Formation (Loading)



High partial pressure of CO₂ forces the gas into the blood, where Carbonic Anhydrase instantly converts it into bicarbonate (HCO₃⁻) and hydrogen ions (H⁺) for transport.

Phase 2: CO₂ Release (Unloading)



The low partial pressure of CO₂ in the alveoli pulls the reaction backward. The trapped bicarbonate is rapidly converted back into CO₂ and water, allowing the CO₂ to be exhaled.

Synthesis: Tissue vs. Alveolar Dynamics

	Tissue Site (Loading)	Alveolar Site (Unloading)
pCO ₂ Level	High	Low
pO ₂ Level	Low	High
Reaction Direction	Forward →	Reverse ←
Primary Action	Trapping as HCO ₃ ⁻	Release as CO ₂

System Efficiency

100 mL
Deoxygenated Blood

4 mL
CO₂ Delivered

Under normal physiological conditions, every 100 mL of deoxygenated blood successfully delivers approximately 4 mL of CO₂ to the alveoli for expulsion.



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