Bohr shift: the chemical trigger

The Bohr shift links carbon dioxide and pH to haemoglobin's affinity for oxygen. Affinity describes how readily haemoglobin binds and retains oxygen under given conditions.

1. FROM RESPIRATION TO OXYGEN RELEASE

More CO_2
From active tissues

→

More H^+
Lower pH

→

Lower affinity
O_2 released more readily

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

In red cells, carbonic anhydrase speeds the first reversible reaction. Carbonic acid then dissociates, producing hydrogen ions.

2. HYDROGEN IONS CHANGE HAEMOGLOBIN

H^+ binds to haemoglobin and favours its lower-affinity shape. Oxygen dissociates more readily. This is a reversible change in the protein's conformation, not permanent denaturation. Haemoglobin also buffers H^+, limiting the fall in pH.

3. AFFINITY IS NOT THE NUMBER OF BINDING SITES

A right shift means less oxygen is bound at the same pO_2. It does not remove haem groups or reduce the four-site maximum of an intact haemoglobin molecule. CO_2 does not compete with O_2 for the iron-binding site; direct CO_2 binding is to globin.

Higher CO_2 → lower pH → lower O_2 affinity

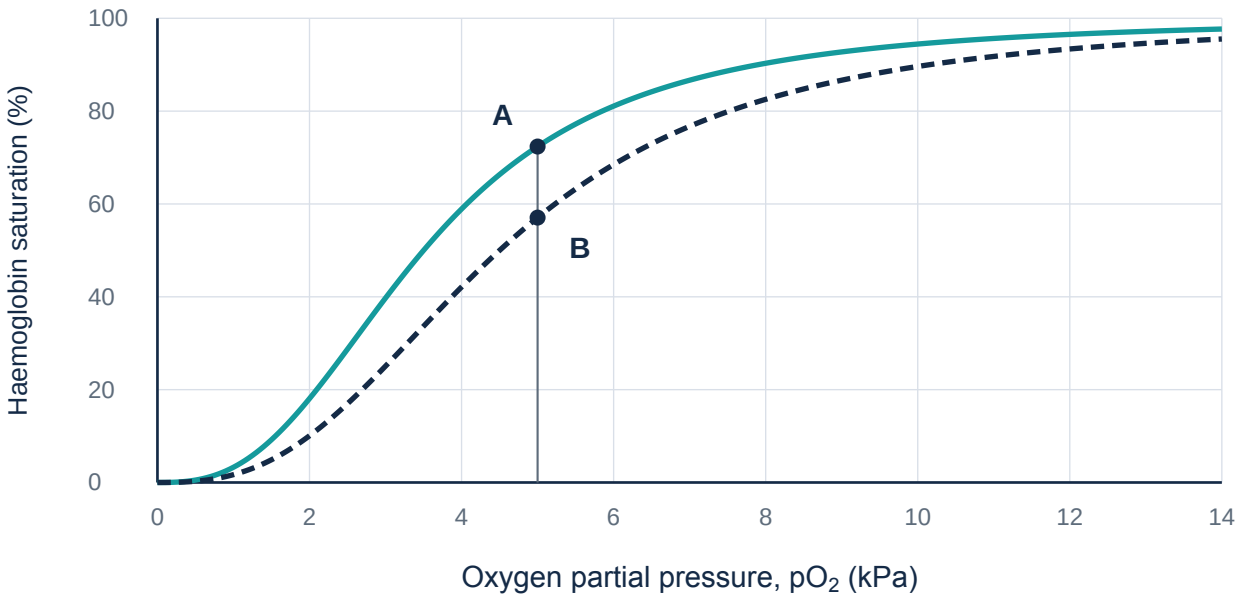
Hydrogen ions and reversible shape change: StatPearls, Physiology, Bohr Effect.
Binding sites and gas transport: OpenStax Anatomy & Physiology 2e, section 22.5.

Scope: Cambridge Biology 9700 syllabus, section 8.2, outcome 6, p. 28.

Read a rightward shift

Compare both curves at the SAME oxygen partial pressure. The curve further right has lower saturation at that pressure, showing lower oxygen affinity.

1. TWO CONDITIONS, ONE PRESSURE COMPARISON



Illustrative Hill curves, not measured data. Both use exponent 2.7; half-saturation pressures are 3.5 and 4.5 kPa. Temperature and other factors are held fixed.

2. AT 5 kPa: THE SAME pO_2

- A: lower CO_2 / higher pH — about 72%
- B: higher CO_2 / lower pH — about 57%

3. WHAT DOES THE DIFFERENCE MEAN?

At 5 kPa, curve B is about 15 percentage points less saturated than curve A. Less oxygen remains bound, so more is available for unloading. A right shift also means a higher pO_2 is needed to reach the same saturation; it does not mean blood pO_2 must increase.

Curve shifts and affinity: Pittman, Regulation of Tissue Oxygenation, chapter 4.
Carbon dioxide, pH and the Bohr shift: StatPearls, Physiology, Bohr Effect.

Scope: Cambridge Biology 9700 syllabus, section 8.2, outcome 6, p. 28.

Match oxygen release to demand

Rapidly respiring tissues both use oxygen and produce carbon dioxide. These changes work together to favour oxygen delivery where it is needed.

1. ACTIVE TISSUES AND LUNGS: OPPOSITE EFFECTS

ACTIVE TISSUES	LUNG CAPILLARIES
1. More CO_2 produced	1. CO_2 removed into alveoli
2. Lower pH	2. Higher pH relative to tissues
3. Lower O_2 affinity	3. Higher O_2 affinity
4. Greater O_2 unloading	4. O_2 loading favoured

Ventilation removes CO_2 from the alveoli and maintains high alveolar pO_2. Together, these conditions help haemoglobin load oxygen again.

2. A FALL IN pO_2 IS NOT ITSELF A BOHR SHIFT

If tissue pO_2 falls while pH and other conditions remain constant, move down the same dissociation curve: saturation falls. If CO_2 rises and pH falls, use a curve shifted to the right. Both changes can occur together in an active muscle.

3. LINK THE WHOLE EXPLANATION

Increased aerobic respiration produces more CO_2. The associated rise in H^+ lowers pH and reduces haemoglobin's oxygen affinity. Oxyhaemoglobin dissociates more readily, and oxygen diffuses into cells down its partial-pressure gradient. This helps sustain aerobic respiration.

Keep the claim precise: the Bohr shift helps match oxygen supply to demand. Total delivery also depends on blood flow, haemoglobin concentration and oxygen loading in the lungs.

Tissue demand and lung loading: OpenStax Anatomy & Physiology 2e, section 22.5.
Partial pressure, saturation and content: Pittman, Regulation of Tissue Oxygenation, ch. 4.

Scope: Cambridge Biology 9700 syllabus, section 8.2, outcome 6, p. 28.