Bind oxygen, then let it go

Haemoglobin carries most of the oxygen transported in blood. Its haem iron provides a reversible binding site: oxygen can attach and later detach without destroying the carrier.

ONE HAEM SITE: REVERSIBLE OXYGEN BINDING



Unoccupied site + oxygen **Oxygen bound**

Binding-site schematic: globin and the detailed haem ring are omitted.

1. IRON IS THE BINDING CENTRE

Each haem group contains an iron ion, conventionally described as Fe^{2+} in functional haemoglobin. One O_2 molecule binds at each haem iron. The iron is not consumed or released with the oxygen.

2. REVERSIBILITY MAKES DELIVERY POSSIBLE

Oxygen-bound haemoglobin is called oxyhaemoglobin. Binding that could not be reversed would trap oxygen instead of supplying tissues. Loading and unloading involve the same carrier molecule.

Oxygenation means binding oxygen; it is not simply rusting the iron. The O_2 molecule remains intact during carriage, and oxygen release does not require peptide-bond hydrolysis.

Supporting reading: RCSB PDB-101, Molecule of the Month: Hemoglobin.

Scope: Cambridge Biology 9700 syllabus, section 2.3, outcome 6, p. 18.

Load in lungs, unload to tissues

Oxygen moves down partial-pressure gradients. High oxygen partial pressure favours haemoglobin loading; lower oxygen partial pressure in respiring tissues favours release.

ONE CIRCULATING CARRIER, TWO LOCAL CONDITIONS

LUNGS	TISSUES
Higher oxygen partial pressure	Lower oxygen partial pressure
O_2 loads onto Hb	**O_2 leaves Hb**

Blood carries oxygen-bound haemoglobin to tissue capillaries.

Haemoglobin stays inside red blood cells as they circulate.

1. LOADING

Oxygen diffuses from alveolar air into blood and red blood cells. Binding to haemoglobin greatly increases how much oxygen blood can carry compared with dissolved oxygen alone.

2. UNLOADING

Respiring cells use oxygen, helping maintain a gradient from blood to tissues. Oxygen dissociates from haemoglobin and diffuses to the cells. Haemoglobin can then return to the lungs and bind oxygen again.

Haemoglobin does not actively pump oxygen into cells. Not all sites must empty in the tissues: the amount released depends on local conditions and oxygen demand.

Supporting reading: OpenStax Biology 2e, 39.4 Transport of gases.

Scope: Cambridge Biology 9700 syllabus, section 2.3, outcome 6, p. 18.

Connect the feature to the benefit

A structure-function explanation needs both parts: identify a feature of haemoglobin, then state how that feature helps it transport oxygen.

STRUCTURAL FEATURE	FUNCTIONAL CONSEQUENCE
Four chains, each with a haem group	Four oxygen-binding sites per molecule.
Iron within each haem group	A site for reversible oxygen attachment.
Folded globin surrounding haem	A protein environment that supports controlled binding and release.
Soluble, compact globular protein	Can remain dispersed at high concentration inside red blood cells.

CAPACITY IS A MAXIMUM, NOT A CONSTANT LOAD

1 Hb molecule → up to 4 O_2 molecules

That is eight oxygen atoms when fully loaded, not eight O_2 molecules. An individual haemoglobin molecule may have fewer than four occupied sites.

SUPPORTING LINK: COOPERATIVE BINDING

Binding at one site changes the protein and can increase affinity at other sites. Communication between subunits helps explain why quaternary structure matters. Detailed dissociation curves are left for later transport lessons.

Supporting reading: RCSB PDB-101, Molecule of the Month: Hemoglobin.

Scope: Cambridge Biology 9700 syllabus, section 2.3, outcome 6, p. 18.