

Exercise walk-through

1.4

Haemoglobin and gas transport (statement 1.9)

Pearson Edexcel · International A-Level · Biology

Read a health study like an examiner

Your turn

Gum disease correlates with endothelial damage. List three checks before claiming causation.

- A. Who was sampled, how selected, how many?
- B. Were confounders like smoking, age, diet controlled?
- C. Is there a mechanism and a dose-response pattern?

Four routes across a membrane

Route	Gradient	Protein	ATP
Diffusion	down	none	no
Facilitated	down	channel or carrier	no
Active transport	against	carrier pump	yes
Osmosis	water, down water potential	partially permeable membrane	no

DNA copies itself semi-conservatively

Unzip : helicase breaks the hydrogen bonds between the strands

Template : each old strand pairs with free nucleotides by complementary base pairing

Join : DNA polymerase links the nucleotides into a new strand

Exercises 2.1·2.3

2.1 Describe the structure of a haemoglobin molecule, using the term quaternary. [3]

2.2 Explain why the oxygen dissociation curve is S-shaped rather than a straight line.[3]

2.3 State the effect of increasing carbon dioxide concentration on the position of the dissociation curve and name this effect. [2]

Exercises 2.1·2.3

2.1 Describe the structure of a haemoglobin molecule, using the term quaternary. [3]

2.1 Four polypeptide chains – two α and two β – each folded around a haem group containing Fe^{2+} . A protein of several chains is a quaternary protein.

2.2 Explain why the oxygen dissociation curve is S-shaped rather than a straight line.[3]

2.2 At low pO_2 only one site loads with difficulty (low affinity); the first O_2 changes the shape so later sites bind more easily – cooperative binding; at high pO_2 nearly all sites are occupied so saturation flattens – together, a shallow–steep–flat S shape.

2.3 State the effect of increasing carbon dioxide concentration on the position of the dissociation curve and name this effect. [2]

2.3 Shifts the curve to the right; the Bohr effect.

Exercise 3.1

3.1 The table shows haemoglobin saturation at two carbon dioxide partial pressures: curve A (low CO₂) and curve B (high CO₂).

pO ₂ / kPa	Curve A saturation / %	Curve B saturation / %
2	30	14
4	60	34
6	82	62
8	91	80

Calculate the percentage of the total oxygen carried that is unloaded between the lungs (8 kPa) and resting tissue (2 kPa) for each curve, and use your answers to explain the biological advantage of the Bohr effect.

[6]

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3.1 Curve A unloads $91 - 30 = 61\%$ of its carrying capacity; curve B unloads $80 - 14 = 66\%$. The higher-CO₂ curve releases more of its load over the same pO₂ range. Advantage: actively respiring tissue produces the CO₂ that raises its own unloading, so oxygen is redirected to where it is needed most without any change in total blood flow or lung loading.

Exercises 3.2-3.3

3.2 Myoglobin is a single-chain protein with one haem group; its dissociation curve is hyperbolic, reaching 90 % saturation at 1 kPa. Explain why myoglobin is suited to oxygen storage in muscle while haemoglobin is suited to transport, referring to the shapes of their curves. [5]

3.3 A person at high altitude breathes air with a pO_2 of 8 kPa in the alveoli. Using curve A above, describe the effect on the saturation of haemoglobin leaving the lungs, and explain one way the body compensates over days at altitude. [4]

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3.2 Myoglobin's hyperbolic curve reaches high saturation at very low pO_2 , so it stays almost fully loaded even when muscle pO_2 is low – it holds oxygen until demand is high. Haemoglobin's sigmoid curve loads fully at alveolar pO_2 and unloads steeply across tissue pO_2 values, and its cooperativity makes it sensitive to small pO_2 changes, ideal for transport. Myoglobin, single chain with no cooperativity, cannot steepen its release this way.

3.3 A person at high altitude breathes air with a pO_2 of 8 kPa in the alveoli. Using curve A above, describe the effect on the saturation of haemoglobin leaving the lungs, and explain one way the body compensates over days at altitude. [4]

3.3 At 8 kPa curve A gives about 91 % rather than the ~98 % at 13 kPa – modest reduction. Compensation: increased red-cell production (erythropoietin) raises the haemoglobin concentration, so despite lower saturation the total oxygen delivered per unit blood volume is restored; (accept increased ventilation rate or a right-shifted curve aiding tissue unloading).