12.2 Respiration

Name: _____ Class: _____ Date: _____ **Total: 17 marks**

KEY WORDS pyruvate • glycolysis • aerobic • oxidative phosphorylation • link reaction

Objective

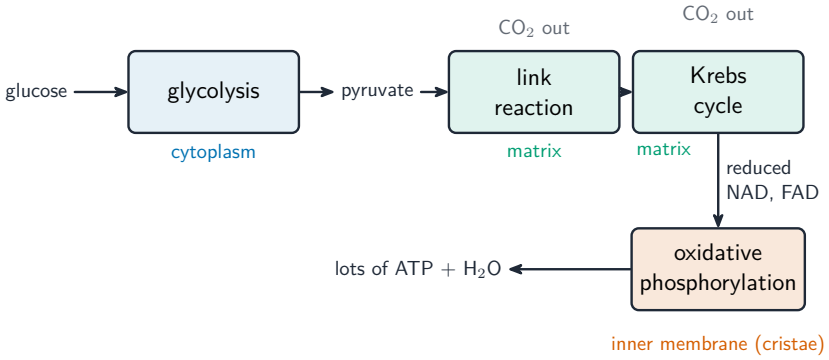
Build the skills to answer exam questions on **respiration** – the four stages of **aerobic** respiration, the role of NAD and FAD, **oxidative phosphorylation**, and **anaerobic** respiration.

You must be able to:

- state where glycolysis, the link reaction, the Krebs cycle and oxidative phosphorylation occur
- outline each stage, including decarboxylation, dehydrogenation and chemiosmosis
- relate mitochondrial structure to function and describe anaerobic respiration

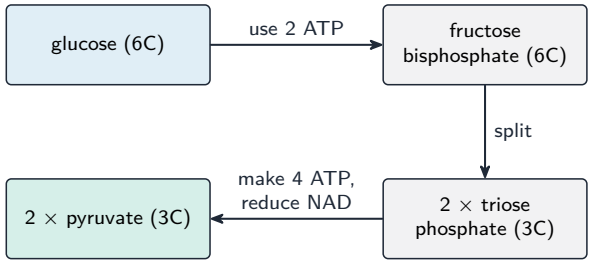
1 Key knowledge and worked examples

The four stages and where they happen



The four stages; reduced NAD and FAD carry hydrogen to the inner membrane where most ATP is made

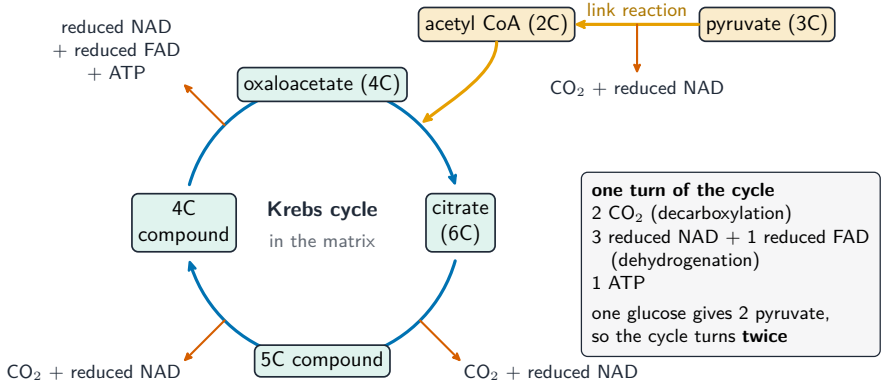
Glycolysis



net gain: 2 ATP + 2 reduced NAD

Glycolysis (cytoplasm) spends 2 ATP but makes 4 → net gain 2 ATP + reduced NAD; needs no oxygen

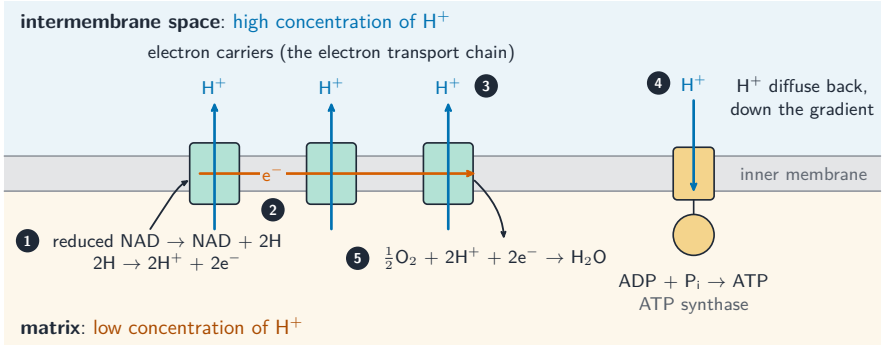
The link reaction and Krebs cycle



Each turn: decarboxylation releases CO_2; dehydrogenation reduces NAD and FAD

Link reaction (matrix): pyruvate (3C) loses CO_2 → acetyl (2C), carried by **coenzyme A** A; NAD is reduced. **Krebs cycle** (matrix): acetyl (2C) + oxaloacetate (4C) → citrate (6C), converted back with **decarboxylation** and **dehydrogenation**.

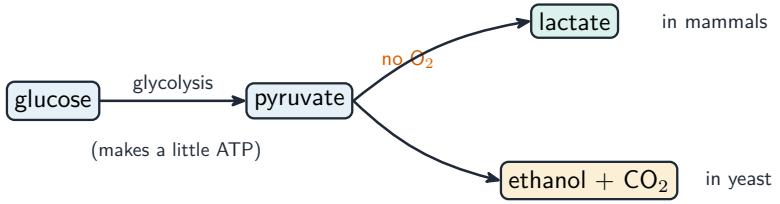
■ Oxidative phosphorylation



Electrons pump H^+ into the intermembrane space; they flow back through ATP synthase to make ATP (chemiosmosis)

Energetic electrons pass along the **electron transport chain** ; the energy pumps protons across the inner membrane; protons flow back through **ATP synthase** to make ATP; **oxygen** is the final electron acceptor, forming water. **Cristae** give a large surface for this.

■ Anaerobic respiration



this regenerates NAD so glycolysis can keep running (far less ATP than aerobic)

Without oxygen, pyruvate becomes lactate (mammals) or ethanol (yeast), regenerating NAD for glycolysis

2 Practice

2.1 State where in a eukaryotic cell each stage occurs: glycolysis; Krebs cycle; oxidative phosphorylation. [3]

2.2 State the net number of ATP molecules made directly in glycolysis. [1]

3 Exam-style questions

3.1 In which stage does oxygen act as the final electron acceptor? [1]

☐ **A** glycolysis
B the link reaction
C the Krebs cycle
D oxidative phosphorylation

3.2 What is produced when pyruvate undergoes lactate fermentation in a muscle? [1]

☐ **A** ethanol and carbon dioxide
B lactate
C acetyl coenzyme A
D citrate

3.3 (a) Describe what happens in the link reaction. [3]

(b) Explain how the folding of the inner mitochondrial membrane into cristae helps respiration. [2]

3.4 (a) Explain how ATP is made during oxidative phosphorylation, with reference to protons and ATP synthase. [4]

(b) Explain why anaerobic respiration releases far less energy than aerobic respiration. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- glycolysis – cytoplasm; Krebs cycle – mitochondrial matrix; oxidative phosphorylation – inner mitochondrial membrane

2.2

- 2 (a net gain of 2 ATP)

3.1 D

- In oxidative phosphorylation oxygen is the final electron acceptor

3.2 B

- In mammals, anaerobic respiration converts pyruvate to lactate

3.3

(a)

- pyruvate enters the mitochondrial matrix; it loses a CO_2 (decarboxylation) and is oxidised to a 2C acetyl group, reducing NAD; the acetyl group joins coenzyme A to form acetyl coenzyme A

(b)

- cristae give a large surface area for more electron carriers and ATP synthase, so more ATP is made

3.4

(a)

- energetic electrons pass along the electron transport chain, releasing energy; this pumps protons across the inner membrane into the intermembrane space; the protons flow back into the matrix through ATP synthase; this flow provides energy to make ATP (chemiosmosis)

(b)

- anaerobic respiration uses only glycolysis, without the link reaction, Krebs cycle and oxidative phosphorylation that release most of the ATP