

12.2 Respiration

Name: _____ Class: _____ Date: _____

Total: 17 marks

KEY WORDS glycolysis 糖酵解 • krebs cycle 克雷布斯循环 • pyruvate 丙酮酸 • oxidative phosphorylation 氧化磷酸化
• electron 电子

Objective

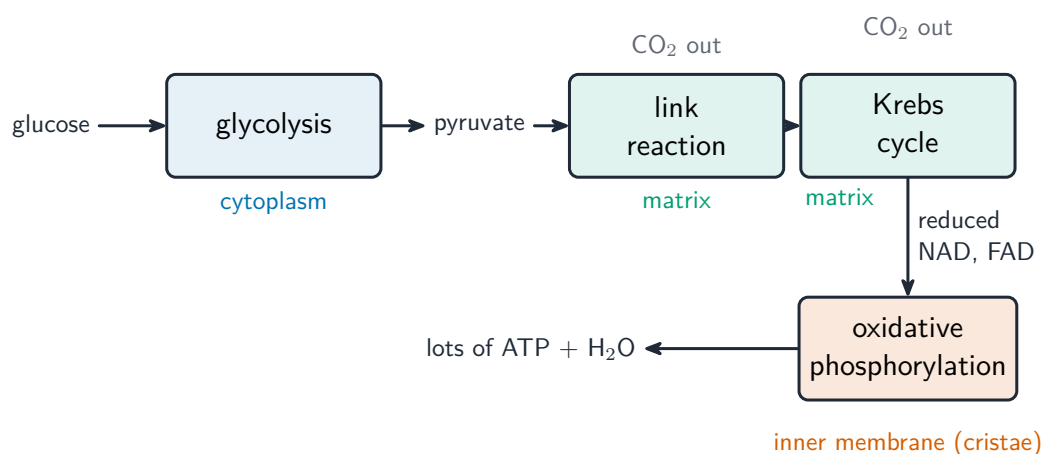
Build the skills to answer exam questions on **respiration** — the four stages of **aerobic** 有氧 respiration, the role of NAD and FAD, **oxidative phosphorylation** 氧化磷酸化, and **anaerobic** 无氧 respiration.

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

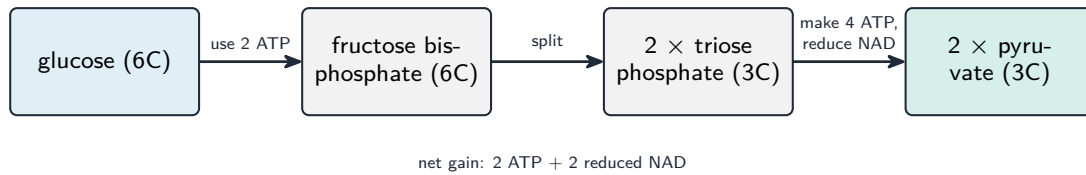
1 Worked examples

■ The four stages and where they happen



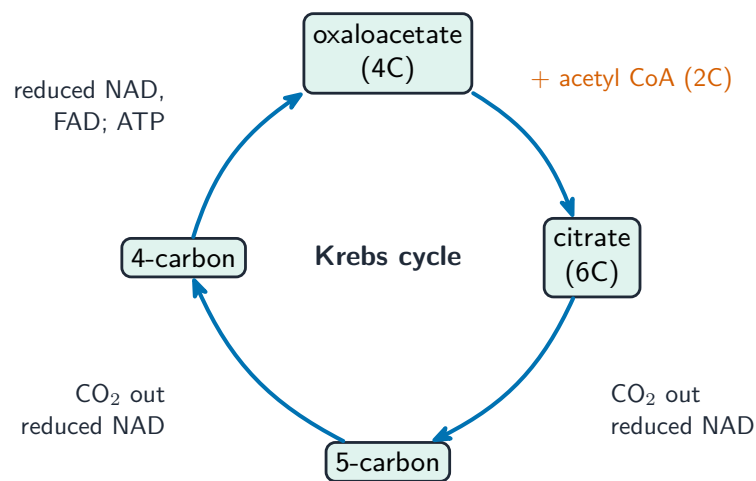
The four stages; reduced NAD and FAD carry hydrogen to the inner membrane where most ATP is made

■ Glycolysis



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

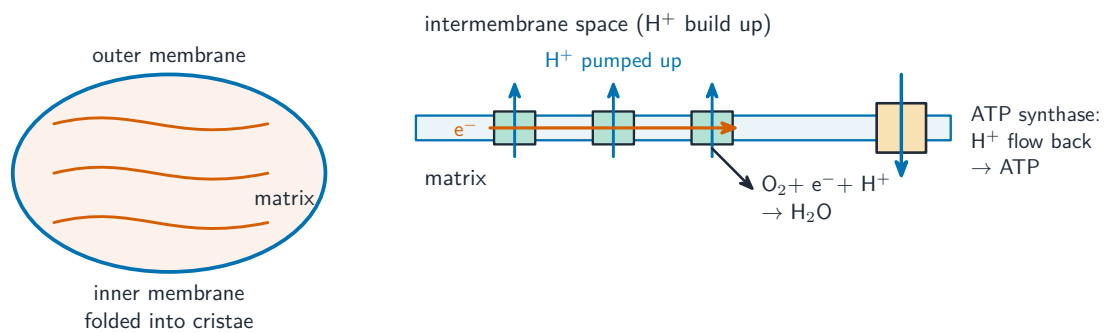
■ The link reaction and Krebs cycle



Each turn: decarboxylation releases CO₂; dehydrogenation reduces NAD and FAD

Link reaction (matrix): pyruvate (3C) loses CO₂ → acetyl (2C), carried by **coenzyme A** 辅酶 A; NAD is reduced. **Krebs cycle** (matrix): acetyl (2C) + oxaloacetate (4C) → citrate (6C), converted back with **decarboxylation** and **dehydrogenation**.

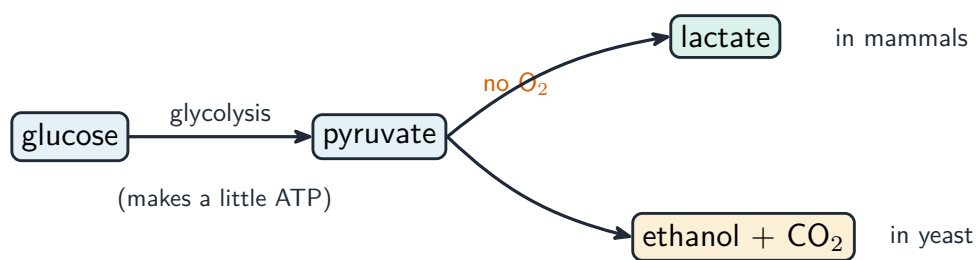
■ Oxidative phosphorylation



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** 电子传递链; 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** 嵴 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

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 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.