

Exercise walk-through

2.4

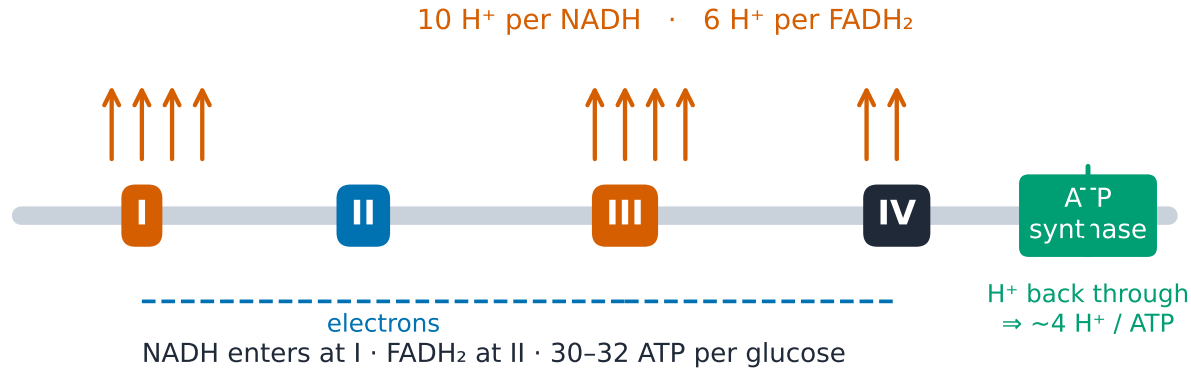
TCA cycle and oxidative phosphorylation

University Medicine

TCA and oxidative phosphorylation: electrons down

- 1 **Cycle** Per acetyl-CoA: $3 \text{ NADH} + 1 \text{ FADH}_2 + 1 \text{ GTP}$; two turns per glucose.
- 2 **Pumps** I+III+IV pump 10 H^+ per NADH, 6 per FADH_2 ; **ATP synthase** charges $\sim 4 \text{ H}^+$ per ATP $\Rightarrow 2.5$ and 1.5 .
- 3 **Total** Per glucose with EVERY carrier: $2 + 5 + 5(\text{PDH}) + 2 \text{ GTP} + 15 + 3 = 32 \text{ ATP}$ (malate shuttle) or 30 (glycerol-P).

The electron transport chain and ATP synthase



Electrons fall to O₂ through I, III, IV pumping 10 H⁺ per NADH; the return flow spins **ATP synthase** at ~4 H⁺/ATP.

Exercises 2.1-2.3

2.1 How many protons does one FADH_2 pump, and why fewer than NADH? [3]

2.2 Compute ATP per acetyl-CoA through TCA + chain. [3]

2.3 Which complex does NOT pump protons? [3]

Exercises 2.1-2.3

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2.1

- 6 H^+ (enters at complex II, skipping I: 4+2).

2.2 Compute ATP per acetyl-CoA through TCA + chain. [3]

2.2

- $3 \times 2.5 + 1 \times 1.5 + 1 \times 1 = 10$ ATP-equivalents ✓.

2.3 Which complex does NOT pump protons? [3]

2.3

- Complex II (succinate dehydrogenase / FADH_2 entry).

Exercise 3.1

3.1 Compute the full aerobic ATP yield per glucose, showing every contribution.

List the NADH/FADH₂ sources with counts, convert with 2.5/1.5, and sum. Compare with the older 36–38 count and explain the difference. [8]

Exercise 3.1

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List the NADH/FADH₂ sources with counts, convert with 2.5/1.5, and sum. Compare with the older 36–38 count and explain the difference. [8]

3.1

- Sources: glycolysis 2 ATP + 2 NADH; PDH 2 NADH; TCA 6 NADH + 2 FADH₂ + 2 GTP.
- Malate shuttle: $2 + 5 + 5 + 15 + 3 + 2 = \mathbf{32\ ATP\ \checkmark}$; glycerol-P shuttle: $2 + 3 + 5 + 15 + 3 + 2 = \mathbf{30\ \checkmark}$.
- The older 36–38 used P/O 3 and 2 – the ratio convention, not the bookkeeping, differs.

Exercise 3.2

3.2 (Fictional) cyanide poisoning vignette.

State the inhibited complex and the immediate consequence for the proton gradient. Explain why venous blood is bright red and lactate rises. Give the mechanism-first rationale for one antidote approach.

[7]

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3.2

- Complex IV blocked: electrons stop, pumping stops, gradient collapses, ATP synthase stalls.
- Tissues cannot consume O_2 (venous blood red); ATP falls $\rightarrow$ glycolysis alone $\rightarrow$ lactate rises.
- Antidote rationale: hydroxocobalamin binds cyanide / nitrites shift Hb to a form that competes – mechanism-first.