Exercise walk-through

2.3
Bioenergetics and glycolysis

University Medicine

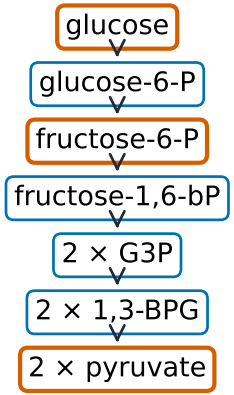
Bioenergetics and glycolysis: split a sugar, bank ATP

1. **Ledger** Glucose $\rightarrow$ 2 pyruvate: invest 2 ATP, get 4 back + 2 NADH - net 2 ATP + 2 NADH, oxygen-free.
2. **Gates** Hexokinase -16.7, **PFK-1** -14.2 (committed), pyruvate kinase -23.0 kJ/mol - only these are irreversible.
3. **Control** PFK-1 reads the cell: AMP/ADP on, ATP/citrate off, fructose-2,6-bP strongly on.

The glycolysis gates

glycolysis, three gates

−2 ATP · +4 back · +2 NADH



hexokinase −16.7 kJ/mol

PFK-1 −14.2 (committed gate)

payoff begins

pyruvate kinase −23.0

PFK-1 control

the gate reads the cell

AMP, ADP: energy low **ON**

ATP, citrate: energy rich **OFF**

F-2,6-BP (insulin) **ON ++**

no O_2 → lactate **NAD^+ recycled**

Invest −2 ATP, pay back +4 ATP + 2 NADH; **PFK-1** is the gate that reads AMP, ATP and fructose-2,6-bP.

Exercises 2.1·2.3

2.1 Where does the carbon of glucose end up anaerobically? [3]

2.2 Name the enzyme of the payoff phase that MAKES ATP directly. [3]

2.3 Why is hexokinase NOT the committed step? [3]

Exercises 2.1·2.3

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2.1

- Two lactate molecules (3 C each): pyruvate reduced by NADH.

2.2 Name the enzyme of the payoff phase that MAKES ATP directly. [3]

2.2

- Phosphoglycerate kinase and pyruvate kinase (both substrate-level).

2.3 Why is hexokinase NOT the committed step? [3]

2.3

- Other sugars (fructose, galactose) also enter via hexokinase-type phosphorylation – the step is not unique to glycolysis; PFK-1 is.

Exercise 3.1

3.1 A cell has 1 glucose and no oxygen.

Trace the fate of all six carbons. Count net ATP and the NAD^+/NADH turnover. Explain why the process must stop if NAD^+ is not regenerated. State the enzyme that performs regeneration. [8]

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3.1

- 6 C $\rightarrow$ 2 $\times$ pyruvate (3 C each) $\rightarrow$ 2 $\times$ lactate.
- Net 2 ATP (invest 2, return 4); 2 NADH made in payoff, consumed by lactate dehydrogenase.
- Without NAD^+ regeneration, G3P dehydrogenase halts and the payoff phase stops.
- Regeneration: lactate dehydrogenase.

Exercise 3.2

3.2 (Fictional) PFK-1 deficiency, exertional cramps, no lactate rise on sprint testing.

Localise the block precisely and explain the absent lactate. State which glycolytic intermediates accumulate. Predict the effect of an infusion of fructose-1,6-bisphosphate bypass candidates and why this does not fully rescue muscle. [7]

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3.2

- Block: after F-6-P, before F-1,6-BP – the committed gate.
- Lactate absent because glycolytic flux never reaches pyruvate.
- Accumulate: glucose-6-P, fructose-6-P (and glucose uptake slows by feedback).
- Downstream intermediates cannot cross the membrane efficiently nor restore the full pathway's regulation in intact muscle.