Glycolysis

The essential metabolic pathway of glycolysis involves the oxidative breakdown of one glucose into two pyruvate with the capture of some energy as ATP and NADH. Glycolysis is important in the cell because glucose is the main source of fuel for tissues in the body. For example, glucose is the only source of energy for the brain. To ensure normal brain function, the body must maintain a constant supply of glucose in the blood. Glycolysis is also important because the metabolism of glucose produces useful intermediates for other metabolic pathways, such as the synthesis of amino acids or fatty acids.

The major themes to remember when studying glycolysis include:

- Glycolysis is a sequence of enzymatic reactions
- ATP is invested, then recaptured with a net gain of 2 ATP
- Pathway is regulated at key steps when $\Delta G \ll 0$
- Production of useful intermediates for other metabolic pathways

Cellular respiration

Glycolysis is the first step of cellular respiration

1. Glucose $\rightarrow$ 2 Pyruvate

Anaerobic Respiration

In the absence of oxygen pyruvate is converted into lactate or CO$_2$ or malate
Pyruvate + NADH ---> Lactate + NAD⁺

Pyruvate ---> CO₂ + acetaldehyde + NADH ---> ethanol + NAD⁺

Pyruvate + CO₂ ---> OAA + NADH ---> Malate + NAD⁺

OR

**Aerobic Respiration**

In the presence of oxygen pyruvate is converted into CO₂ and H₂O

Pyruvate ---> CO₂ + H₂O

**Overall Reaction for Aerobic Cellular Respiration**

C₆H₁₂O₆ + 6O₂ ---> 6CO₂ + 6H₂O

ΔG° = -2840 KJ/mol

In respiration some ΔG° (~35%) is retained as formation as ATP

**Priming: Investment of Energy (2 ATP):** There are five reactions during the priming phase

- Reactions with an overall ΔG << 0 can be regulated (turn the enzyme on or off)
- Hexokinase is allosterically inhibited by G-3-P (Km~0.1mM)
- Glucokinase is not allosterically inhibited (Km ~10mM), keeps glucose in the cell

**Reaction 1:** Hexokinase and Glucokinase pick up a phosphate from ATP and bind it to glucose.

\[
\Delta G'' = +13.8 \text{ kJ/mol} \\
\Delta G' = \Delta G'' + RT \ln \left[ \frac{[P]}{[R]} \right] \\
\Delta G' = -33.9
\]

Note: Mg²⁺ is required if ATP is needed (1 per ATP molecule)

**Reaction 2:** Phosphoglucoisomerase converts glucose into fructose (changes the bonds around).
Not regulated because $\Delta G$ is near equilibrium

\[
\Delta G^0' = +1.67 \text{ kJ/mol} \\
\Delta G' = -2.92 \text{ kJ/mol}
\]

**Reaction 3:** Phosphofructokinase picks up another phosphate from ATP and attaches it to fructose.

- ATP is an allosteric inhibitor
- AMP reverses ATP inhibition (if ATP decreases by 8%, AMP increase 4 fold)
- AMP is the controlling factor of the enzyme
- If ATP decreases and AMP increases, the reaction proceeds forward

\[
\Delta G^0' = +16.3 \text{ kJ/mol} \\
\Delta G' = -30.5 \\
    = -14.2 \\
\Delta G' = -18.89
\]

**Reaction 4:** Fructose biphosphate aldolase splits F-1,6-bisP into two 3 carbon compounds

\[
\Delta G^0' = +23.8 \text{ kJ/mol} \\
\Delta G' = -0.23 \text{ kJ/mol}
\]

**Reaction 5:** Triose phosphate isomerase converts DHAP into G-3-P

\[
\Delta G^0' = +7.56 \text{ kJ/mol} \\
\Delta G' = +2.41 \text{ kJ/mol}
\]

**$\Delta G$ of overall reaction:**

\[
\text{glucose + 2 ATP} \rightarrow 2 \text{ G-3-P} + 2 \text{ ADP}
\]

\[
\Delta G^0' = +63.13 \text{ kJ/mol} \\
\Delta G' = -61.0 \\
    = -2.13
\]

\[
\Delta G' = -53.4 \text{ kJ/mol}
\]

(from relative concentrations in cells)

Payoff:

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**Internal Links**

- [http://chemwiki.ucdavis.edu/Biologic...ism/Glycolysis](http://chemwiki.ucdavis.edu/Biologic...ism/Glycolysis)