7.014 Handout

Biochemistry V-VI
7.014 Glycolysis Reactions Handout

Note: for simplicity, H's are shown as stars (*).

Glucose

\[
\begin{align*}
\text{glucose} & \quad \text{ATP} \\
& \quad \text{ADP}
\end{align*}
\]

Glucose-6-phosphate

\[
\begin{align*}
\text{glucose-6-phosphate} & \quad \text{ATP} \\
& \quad \text{ADP}
\end{align*}
\]

Fructose-6-phosphate

\[
\begin{align*}
\text{fructose-6-phosphate} & \quad \text{ATP} \\
& \quad \text{ADP}
\end{align*}
\]

Fructose 1,6-di phosphate

\[
\begin{align*}
\text{fructose 1,6-di phosphate} & \quad \text{split at this bond}
\end{align*}
\]

Dihydroxyacetone phosphate

\[
\begin{align*}
\text{dihydroxyacetone phosphate} & \quad \text{glyceraldehyde-3-phosphate}
\end{align*}
\]

Glyceraldehyde-3-phosphate

\[
\begin{align*}
\text{glyceraldehyde-3-phosphate}
\end{align*}
\]

(2 molecules of g3p, therefore next reactions are doubled)
Note: $E$ = enzyme (glyceraldehyde 3-phosphate dehydrogenase)

These reactions happen **twice** for each glucose.

side chain of cysteine in protein

transient intermediate (substrate is covalently bound to enzyme)

(enzyme is released unchanged = catalyst)

1,3 diphosphoglycerate

3-phosphoglyceric acid
These reactions happen **twice** for each glucose.

3-phosphoglyceric acid

H–C–O–H
H–C–O–P
H

2-phosphoglyceric acid

H–C–O–P
H–C–O–H
H

H₂O

phospho-enol-pyruvate (PEP)

"ketone" form: more stable (low energy)

"enol" form: less stable (high energy)

ATP

ADP

pyruvate

NAD⁺

NADH + H⁺

(NH₄)₂S

This reaction recycles the NADH in **human muscle cells** when O₂ is low or absent.

(OH)₃

lactate

(Thiamine – a B-vitamin is required for this step)

This reaction recycles NADH in **yeast** (and some bacteria) when O₂ is absent.

H₂O

or

H–C–H
H

ethanol
ATP & ADP

NAD⁺ & NADH

NAD = Nicotinamide Adenine Dinucleotide

Nicotinamide: a vitamin for humans (a.k.a. niacin) but not for yeast or E. coli
Photosynthesis & Electron Transport

Photosynthesis:

Cyclic Photophosphorylation

 Generates H⁺ gradient (used for ATP synthesis) only.

Non-cyclic Photophosphorylation

 Generates H⁺ gradient (used for ATP synthesis) and NADPH.
Respiration

Electron Transport

NADH + H^+ → 2 e^− → NAD^+

H^+ in → H^+ out

H^+ in → H^+ out

H^+ in → H^+ out

O_2 → H_2O

NADH from glycolysis & Krebs’ Cycle is recycled using O_2 and generating H^+ gradient (used for ATP synthesis).

ATP Synthesis from H^+ Gradient
(H^+ gradient is generated by electron transport in photosynthesis & respiration)

H^+ - driven ATP synthetase (proton ATPase)

electron-transfer-driven proton pump