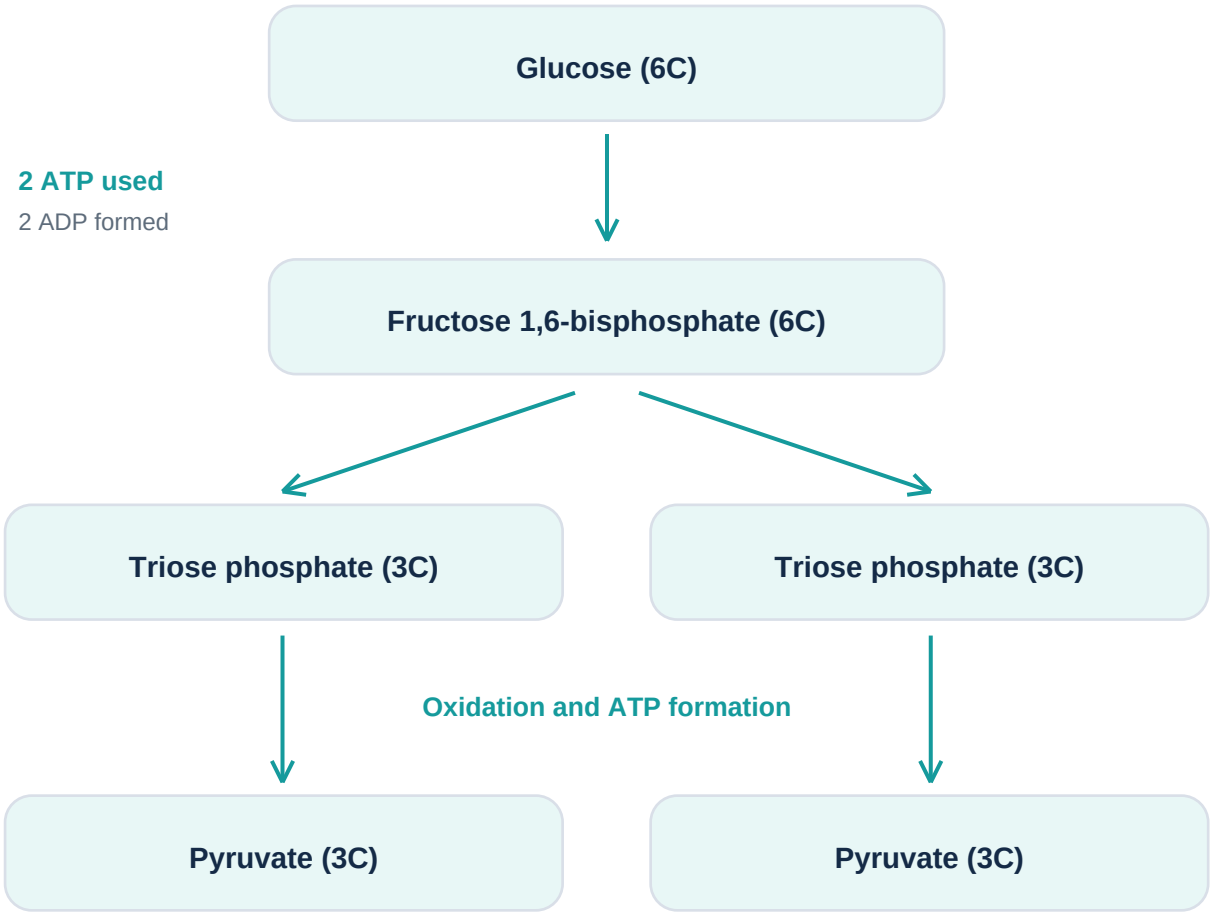
One glucose, two pyruvates

Glycolysis is an enzyme-controlled pathway in the cytoplasm (cytosol). It does not use oxygen directly and can occur in aerobic or anaerobic conditions.

1. TRACK THE CARBON



Simplified pathway: intermediate reactions are grouped. Both three-carbon molecules proceed through the same payoff reactions.

2. PHOSPHORYLATE, SPLIT, OXIDISE

Two ATP molecules supply phosphate during the investment phase. The six-carbon bisphosphate splits; after isomerisation, two triose phosphates proceed through oxidation to pyruvate. All six carbons remain in the two pyruvates: glycolysis releases no carbon dioxide.

Investment, splitting and payoff stages: OpenStax, Biology 2e 7.2.
Carbon fate and pathway overview: Alberts et al., How Cells Obtain Energy from Food.

Scope: Cambridge Biology 9700, section 12.2, outcomes 1-2, p. 33.

Count the net ATP gain

State all yields per glucose molecule. After splitting, each payoff reaction happens twice because there are two three-carbon substrates.

1. ATP ACCOUNTING PER GLUCOSE

Investment	**2 ATP used**	Phosphorylation of the sugar
Payoff	**4 ATP produced**	2 ATP from each 3C pathway
Net gain	**2 ATP**	4 produced minus 2 used

2. SUBSTRATE-LINKED PHOSPHORYLATION

A phosphate group transfers directly from a phosphorylated intermediate to ADP, forming ATP. This is also called substrate-level phosphorylation. It does not require an electron transport chain or ATP synthase.

3. THE MAIN PRODUCTS PER GLUCOSE

2	2	2
pyruvate	ATP net	reduced NAD

Four ATP is the gross output, not the net yield. Reduced NAD carries reducing power; it is not an extra ATP molecule.

ATP investment and payoff: OpenStax, Biology 2e 7.2.
Direct phosphate transfer and energy conservation: Alberts et al., Energy from Food.

Scope: Cambridge Biology 9700, section 12.2, outcomes 1-2, p. 33.

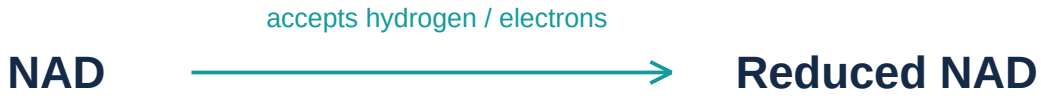
Keep NAD available

Oxidation of the triose phosphate is linked to reduction of NAD. Glycolysis can continue only while oxidised NAD is available to accept more hydrogen and electrons.

1. OXIDATION AND REDUCTION ARE LINKED

Triose phosphate loses hydrogen and electrons during oxidation. NAD accepts them and becomes reduced NAD. An inorganic phosphate is also incorporated during this stage; later reactions transfer phosphate to ADP.

2. NAD CHANGES REDOX STATE



Reduced NAD is commonly written NADH. ATP transfers energy; NAD carries electrons in redox reactions.

3. WHEN OXYGEN IS AVAILABLE

In aerobic eukaryotic cells, pyruvate can enter mitochondria for the link reaction. Reducing equivalents from glycolysis can supply the respiratory electron transport system via shuttles. NAD is regenerated; glycolysis itself remains in the cytoplasm.

4. WHEN OXYGEN IS UNAVAILABLE

In animal cells, pyruvate can be reduced to lactate, reoxidising reduced NAD. In yeast, ethanol fermentation regenerates NAD and releases carbon dioxide after glycolysis. These reactions allow glycolysis to continue but add no ATP beyond its net yield.

The fate of pyruvate is a link to later lessons, not an additional step of glycolysis.

Oxidation and NAD reduction: Cooper, The Cell, Metabolic Energy.
NAD regeneration without oxygen: OpenStax, Biology 2e 7.5.

Scope: Cambridge Biology 9700, section 12.2, outcomes 1-2, p. 33.