

# Biology Lecture Notes

## The Fermentation of Pyruvate

### >> Key Concepts:

- ⚡ **Review:** In the process of glycolysis, a net profit of two ATP was produced, two  $\text{NAD}^+$  were reduced to two  $\text{NADH} + \text{H}^+$ , and glucose was split into two **pyruvate** molecules.
- ⚡ When oxygen is not present, pyruvate will undergo a process called **fermentation**. In the process of fermentation the  $\text{NADH} + \text{H}^+$  from glycolysis will be recycled back to  $\text{NAD}^+$  so that glycolysis can continue.

<p>glucose <math>\xrightarrow{(2) \text{NAD}^+}</math> (2) <math>\text{NADH} + \text{H}^+</math> <math>\xrightarrow{\text{in mitochondria}}</math> <math>\text{NAD}^+</math></p> <p>2 ATP invested      2 pyruvate      total 4 ATP (2 ATP profit)</p>			<p>In the process of glycolysis, <math>\text{NAD}^+</math> is reduced to form <math>\text{NADH} + \text{H}^+</math>. If <math>\text{NAD}^+</math> is not present, glycolysis will not be able to continue. During aerobic respiration, the <math>\text{NADH}</math> formed in glycolysis will be oxidized to reform <math>\text{NAD}^+</math> for use in glycolysis again.</p> <p>When oxygen is not present or if an organism is not able to undergo aerobic respiration, pyruvate will undergo a process called <b>fermentation</b>. Fermentation does not require oxygen and is therefore anaerobic. Fermentation will replenish <math>\text{NAD}^+</math> from the <math>\text{NADH} + \text{H}^+</math> produced in glycolysis.</p>
<p><b>yeast</b></p> <p>wine</p> <p>pyruvate <math>\rightarrow</math> alcohol</p>	<p><b>many bacteria</b></p> <p>pyruvate <math>\rightarrow</math> lactate</p>	<p><b>muscle cells</b> <i>(in oxygen debt)</i></p> <p>pyruvate <math>\rightarrow</math> lactate</p>	<p>One type of fermentation is <b>alcohol fermentation</b>. First, pyruvate is decarboxylated (<math>\text{CO}_2</math> leaves) to form acetaldehyde. Hydrogen atoms from <math>\text{NADH} + \text{H}^+</math> are then used to help convert acetaldehyde to ethanol. <math>\text{NAD}^+</math> results.</p> <p><b>Facultative anaerobes</b> are organisms that can undergo fermentation when deprived of oxygen. Yeast is one example of a facultative anaerobe that will undergo alcohol fermentation.</p>
<p>now <math>\text{NAD}^+</math> can recycle</p> <p>Glycolysis <math>\rightarrow</math> (2) <math>\text{NAD}^+</math> <math>\rightarrow</math> (2) <math>\text{NADH} + \text{H}^+</math> <math>\rightarrow</math> (2) <math>\text{NAD}^+</math></p> <p>(2) <math>\text{NAD}^+</math> <math>\rightarrow</math> (2) <math>\text{NADH} + \text{H}^+</math> <math>\rightarrow</math> (2) <math>\text{NAD}^+</math></p> <p>(2) pyruvate <math>\xrightarrow{\text{decarboxylation}}</math> (2) acetaldehyde <math>\xrightarrow{(2) \text{NADH} + \text{H}^+}</math> (2) ethanol</p>			<p>Some organisms, such as some bacteria, will undergo <b>lactate fermentation</b>. Two pyruvates are converted to two lactic acid molecules, which ionize to form lactate. In this process two <math>\text{NADH} + \text{H}^+</math> are converted to two <math>\text{NAD}^+</math>.</p> <p>Our muscle cells can undergo this process when they are in oxygen debt. If enough oxygen is not present to undergo aerobic respiration, pyruvate will undergo lactic acid fermentation.</p>
<p><b>yeast</b></p> <p>wine</p> <p>pyruvate <math>\rightarrow</math> alcohol</p>	<p><b>many bacteria</b></p> <p>pyruvate <math>\rightarrow</math> lactate</p>	<p><b>muscle cells</b> <i>(in oxygen debt)</i></p> <p>pyruvate <math>\rightarrow</math> lactate</p>	<p>(2) <math>\text{NADH} + \text{H}^+</math> <math>\rightarrow</math> (2) <math>\text{NAD}^+</math> recycled!</p> <p>(2) pyruvate <math>\rightarrow</math> (2) lactate</p>