

# Prokaryote Nutrition

# Biology:

## What is Life? Properties of Life

**Cellular Structure:** the unit of life, one or many

**Metabolism:** photosynthesis, respiration, fermentation, digestion, gas exchange, secretion, excretion, circulation – processing materials and energy

**Growth:** cell enlargement, cell number

**Movement:** intracellular, movement, locomotion

**Reproduction:** avoid extinction at death

**Behavior:** short term response to stimuli

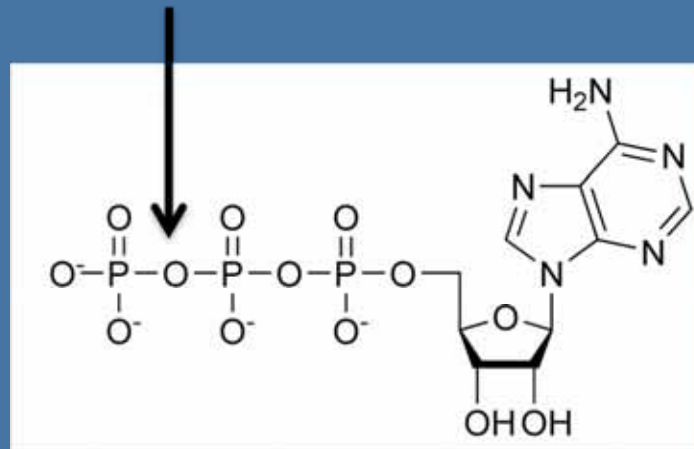
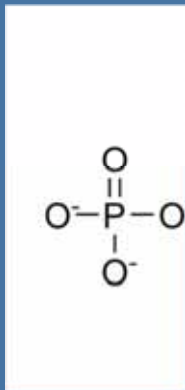
**Evolution:** long term adaptation

# How to organisms get energy?

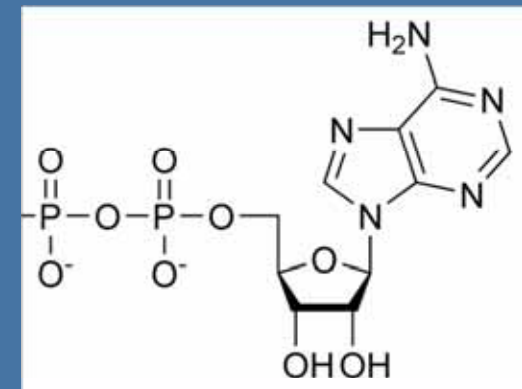
- Cells use a high energy molecule to fuel cellular processes

## Adenosine Triphosphate (ATP)

phosphate

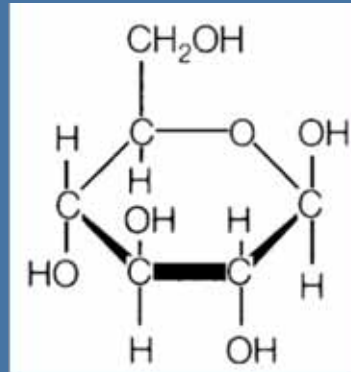


ADP



# How to organisms get energy?

- Glucose is the carbon and energy source used by most cells.



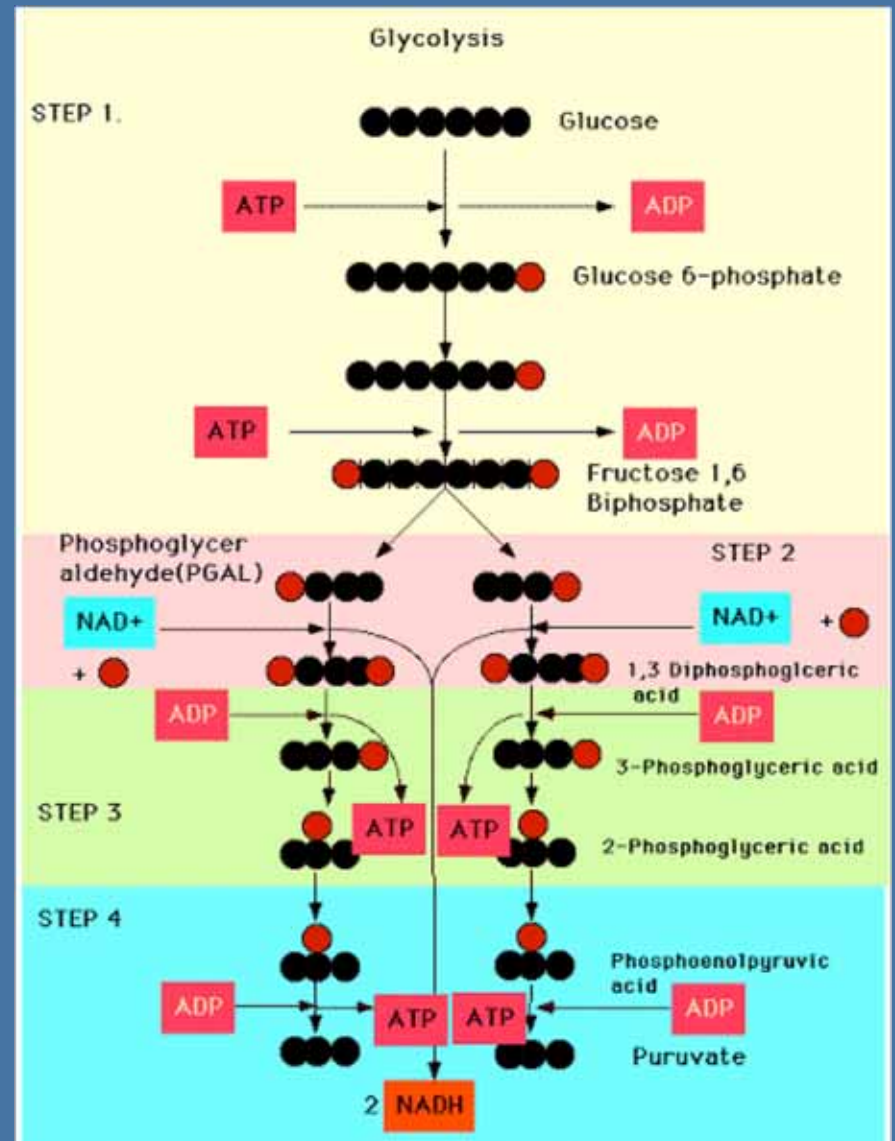
- Glucose is initially broken down in a series of steps called...

# Glycolysis

- 10 step process to produce ATP, NADH, and pyruvate
- Occurs in the cytosol
- Yields a net 2 ATP, 2 NADH per glucose molecule
- Anaerobic (no oxygen)
  - Used by aerobes and anaerobes

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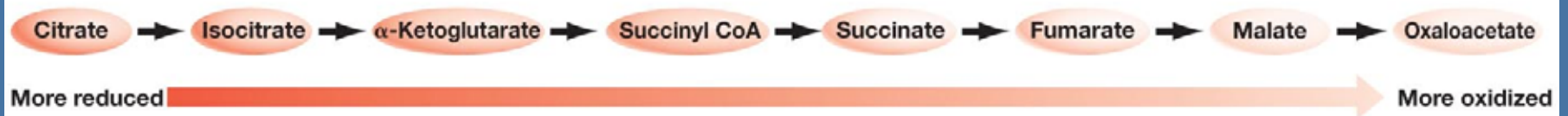


# Krebs Cycle

- Uses a product of Glycolysis to undergo a series of ~10 steps to oxidize pyruvate to  $3\text{CO}_2$
- Produces 3 NADH, 1  $\text{FADH}_2$ , and 1 ATP per pyruvate
- Occurs in the mitochondrial matrix
  - In the cytosol of bacteria

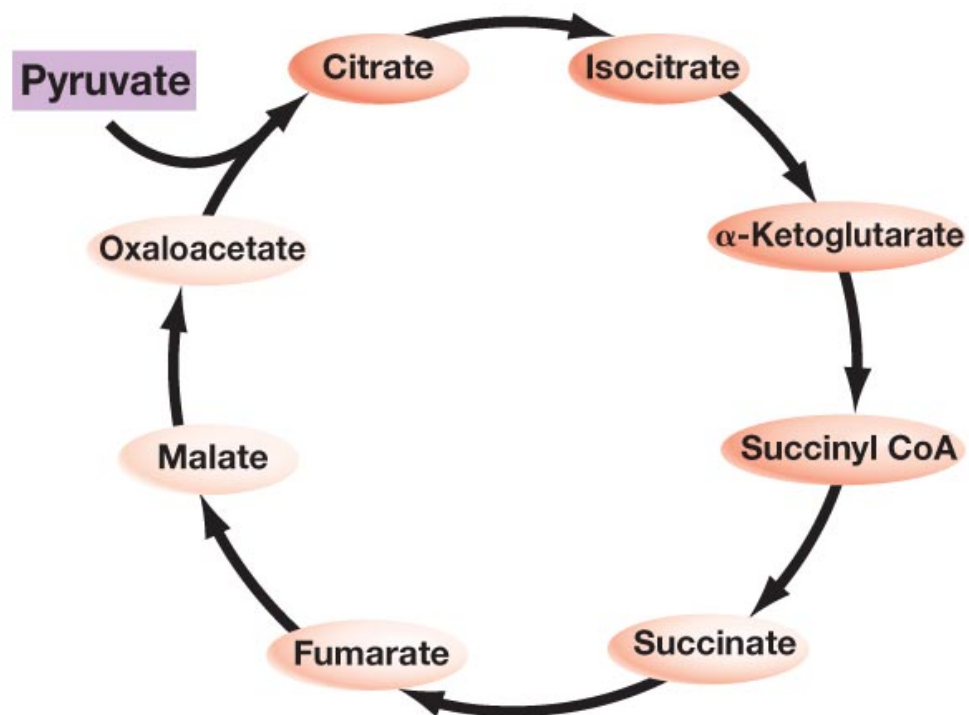
# Not the Krebs Chain, The Krebs Cycle

(a) The carboxylic acids that are oxidized during cellular respiration



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(b) The Krebs cycle hypothesis

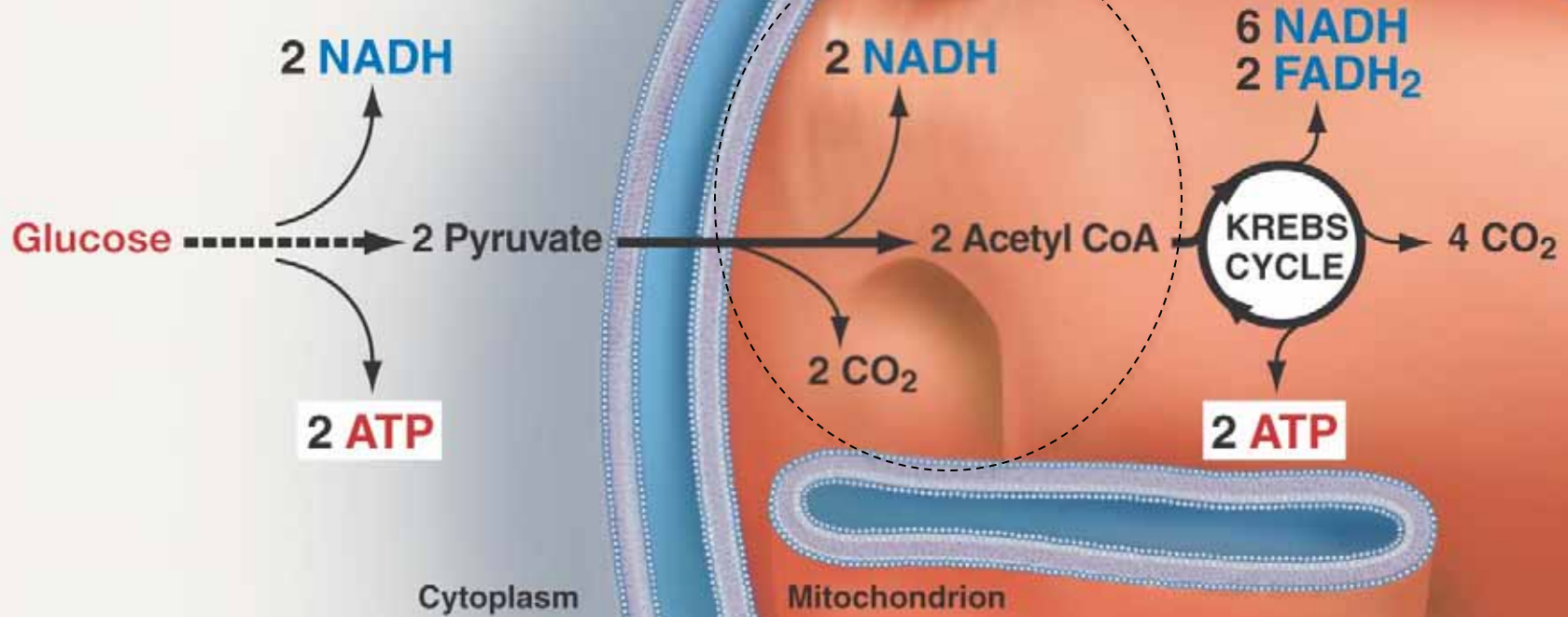


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1940s!

Fig. 9.18

## SUMMARY OF GLUCOSE OXIDATION



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Figure 9.21

# How are we doing so far?

- For each glucose molecule that is fully oxidized, the cell produces:

- 6 CO<sub>2</sub>

- 10 NADH

- 2 FADH<sub>2</sub>

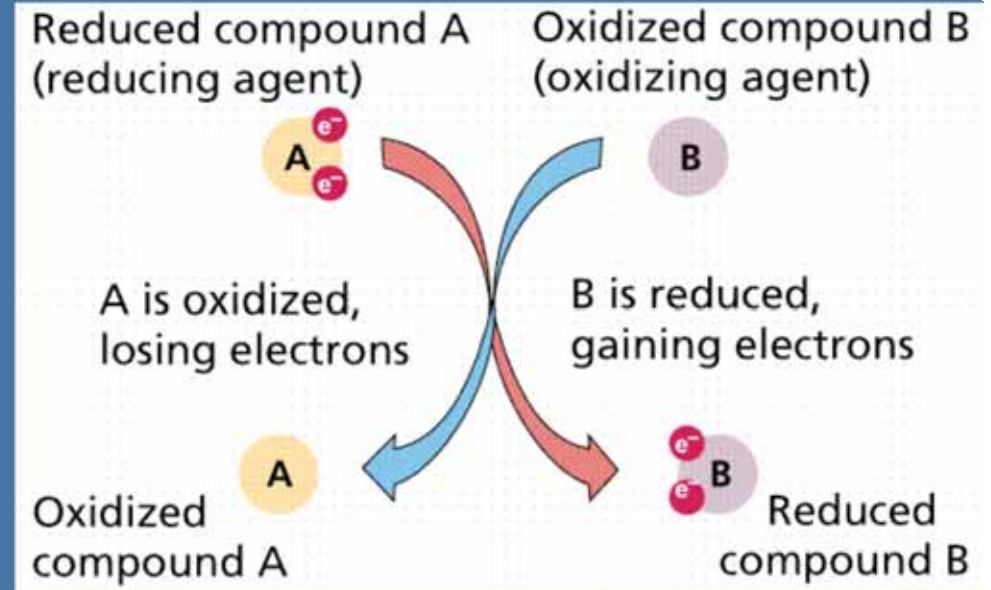
- 4 ATP



Where's all the ATP?

# Redox Reactions

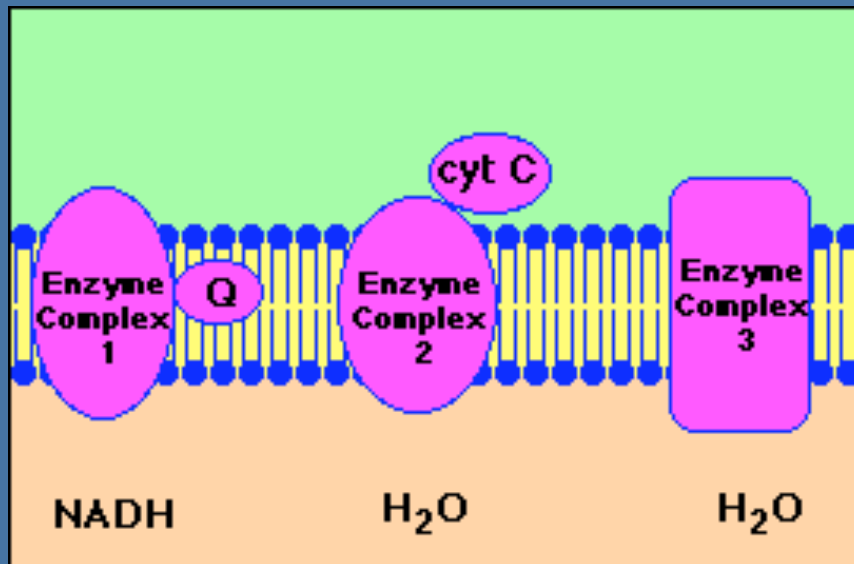
- Oxidation - Reduction
- A class of reactions that cause the loss or gain of an electron.
- An electron donor must always be paired with an electron acceptor



NAD +	e- acceptor	Oxidized
NADH	e- donor	Reduced

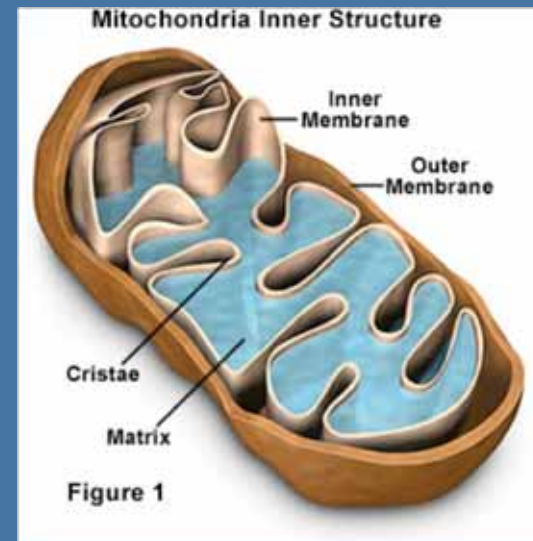
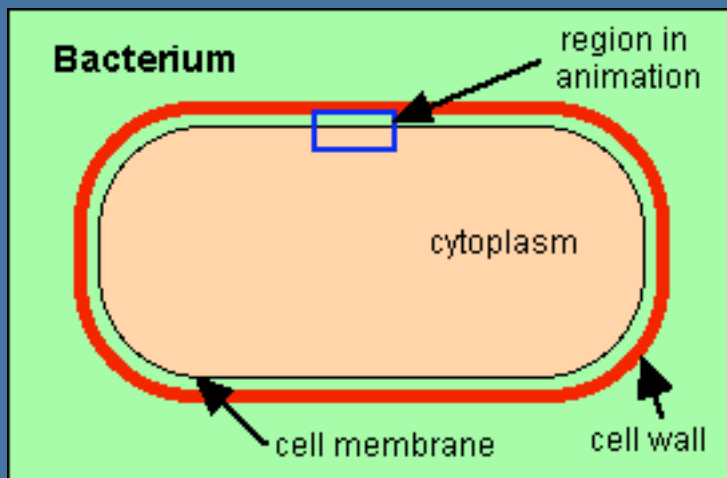
# Redox Reactions

Inter-membrane proteins and cofactors help move protons created by redox reactions to the outside of the membrane



# Redox Reactions

- Redox reactions are essential to produce more ATP in the Electron Transport Chain (ETC)
  - indirectly via chemiosmosis



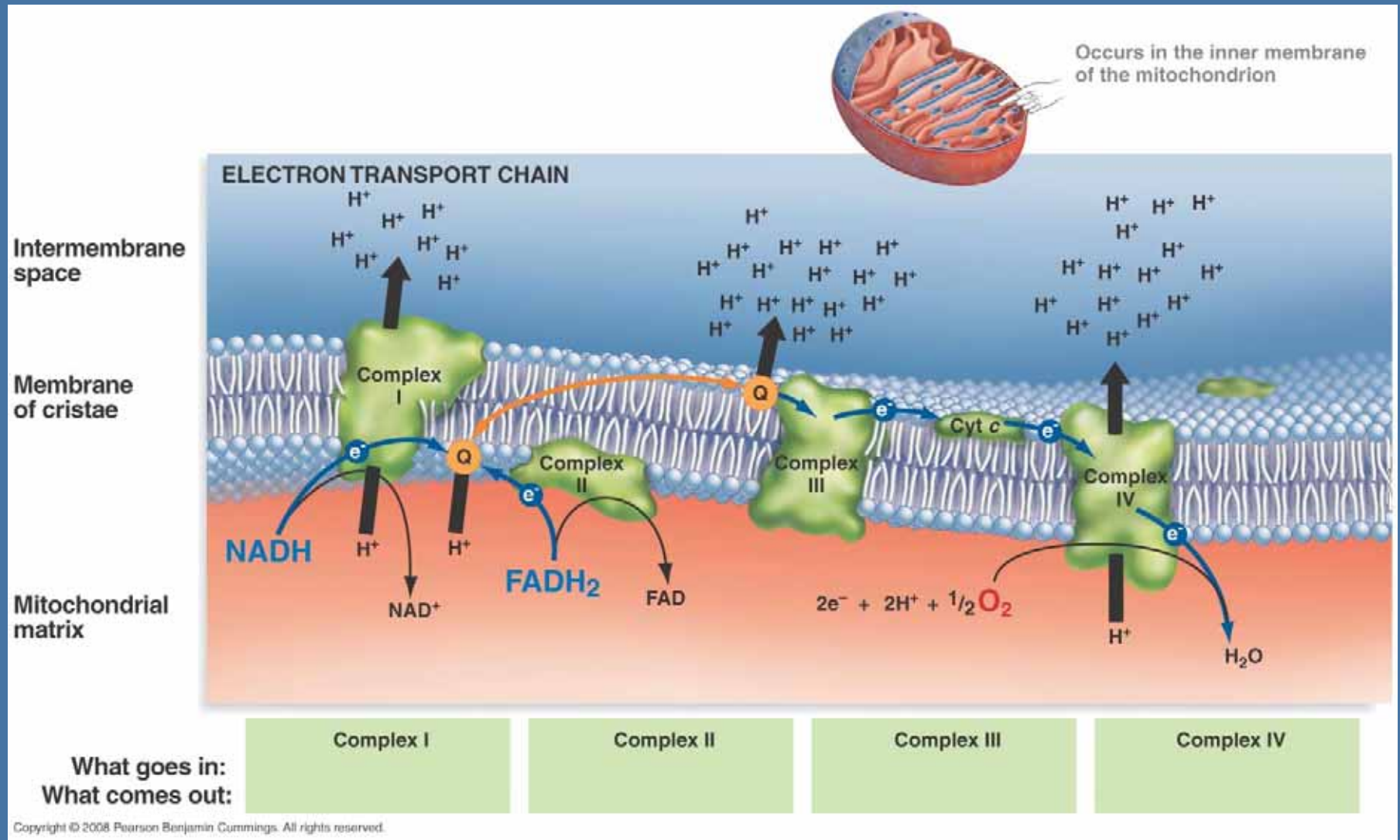
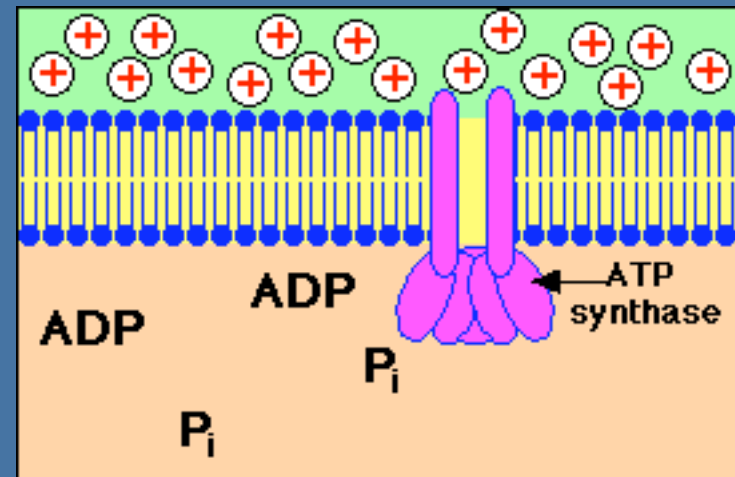
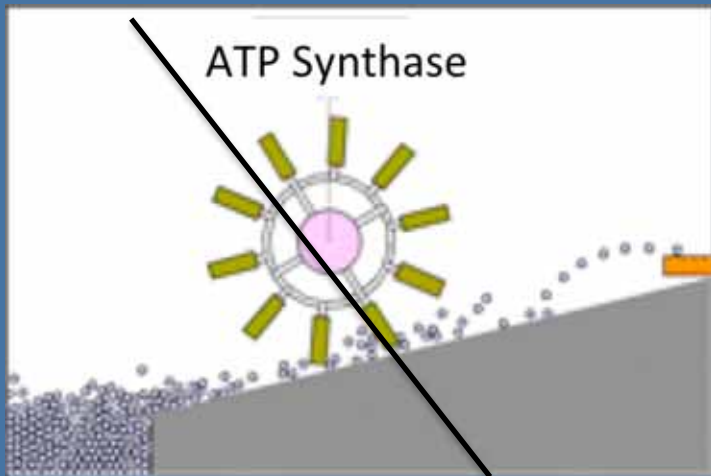


Figure 9.24

# Electron Transport Chain

- Proton Gradient Created
- ATP synthase takes advantage of gradient
- Produces ~ 26 ATP molecules per glucose
- Membrane-bound process



# Oxidative Phosphorylation

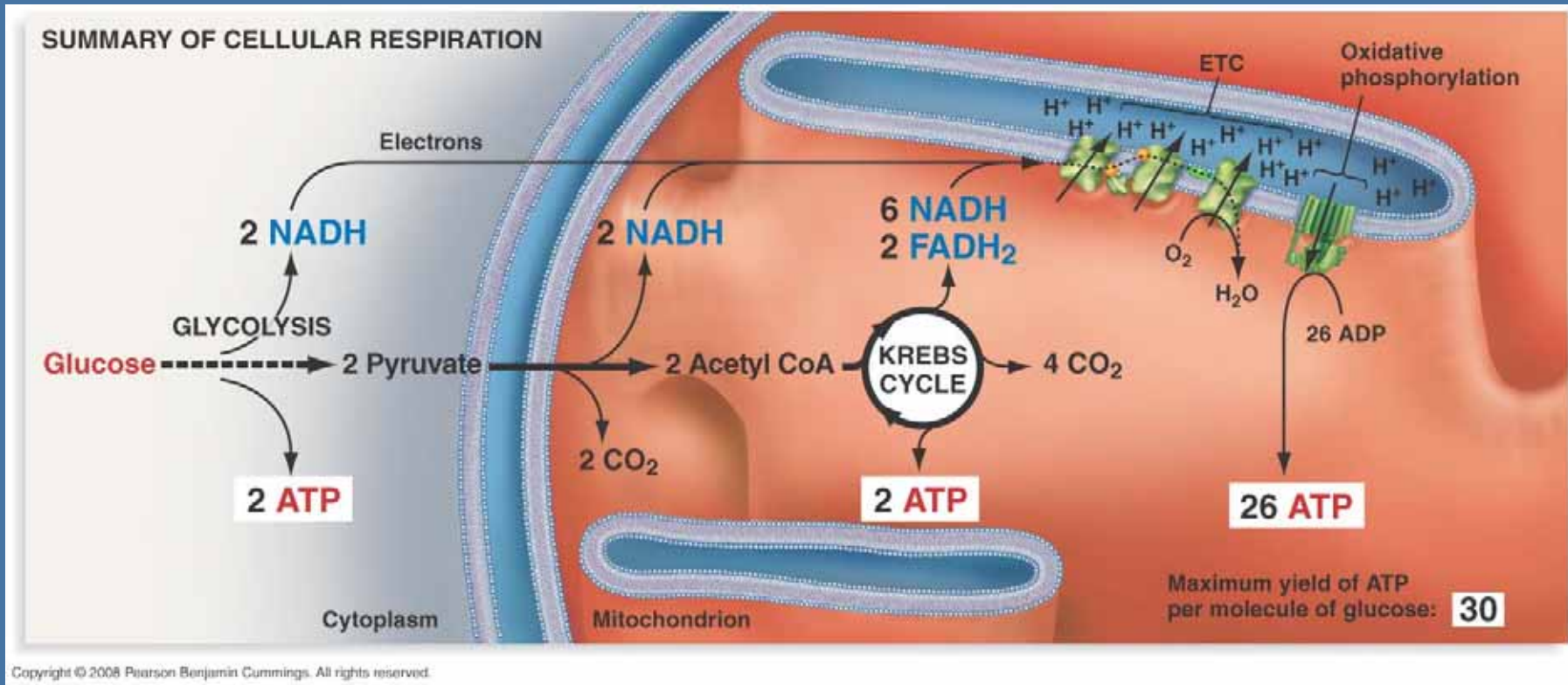
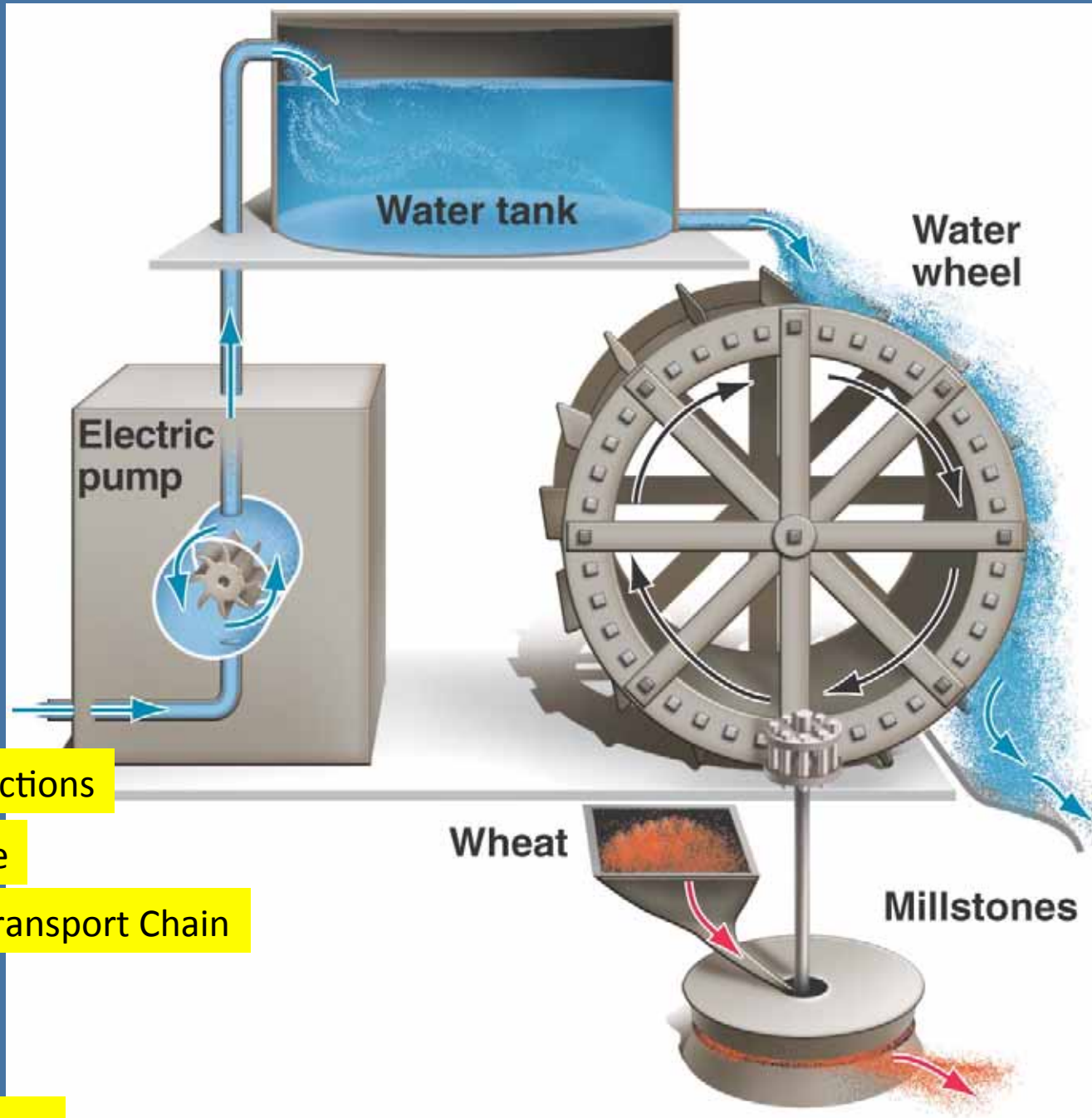


Figure 9.26



Redox Reactions

Krebs cycle

Electron Transport Chain

ADP

ATP

ATP Synthase

# Oxidative Phosphorylation



Glucose + oxygen  $\rightsquigarrow$  Carbon dioxide + water + energy

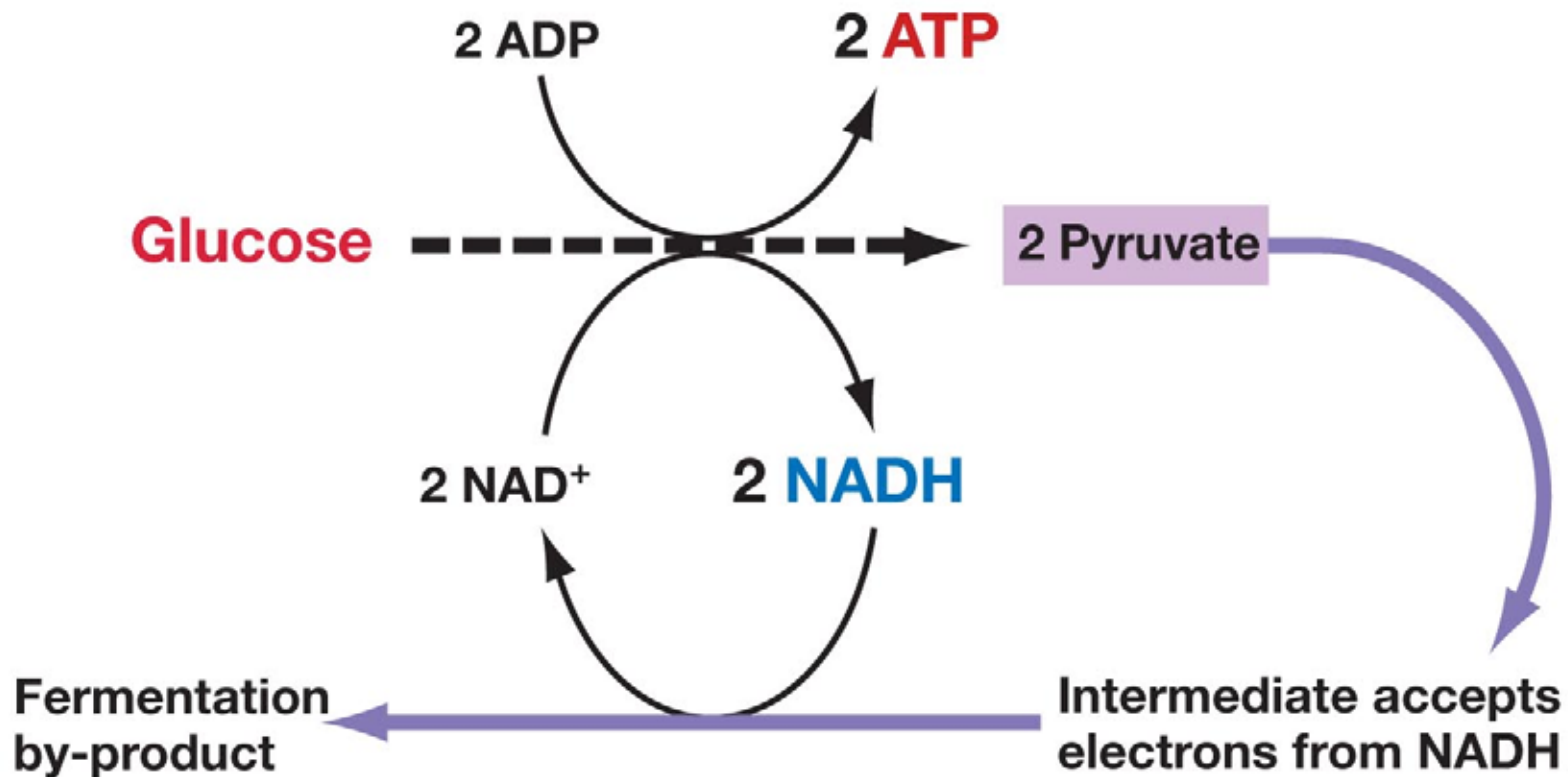
- Oxygen is the best electron acceptor, but what if it is not around?

# Fermentation

- When oxygen is low or absent, ATP can still be produced via fermentation.
- $\text{NAD}^+$  is oxidized from NADH so glycolysis can begin again

# Fermentation

(a) Fermentation pathways allow cells to regenerate  $\text{NAD}^+$  for glycolysis.



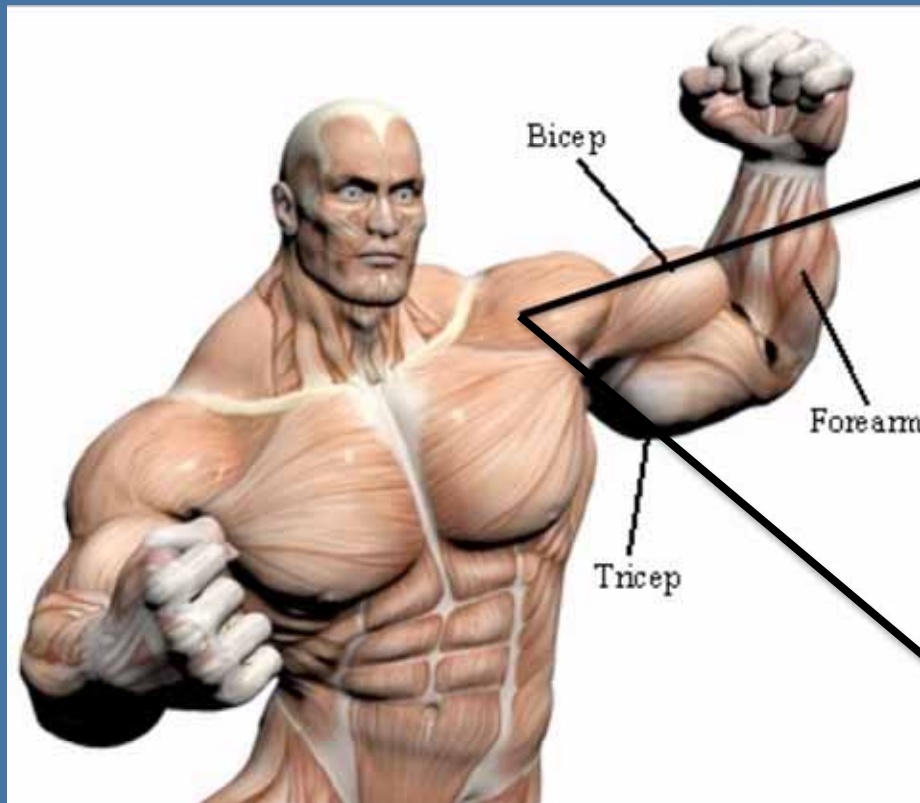
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Figure 9.27

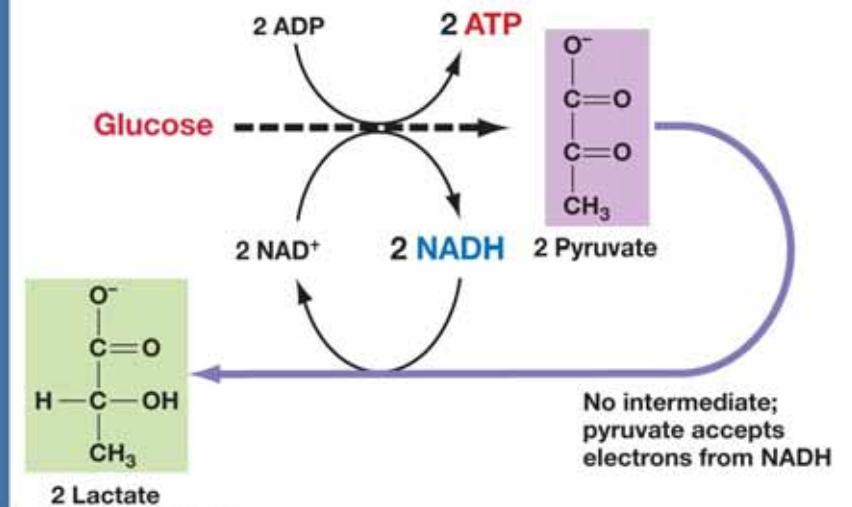
# Lactic acid Fermentation

Pyruvate\* to Lactate

\*final electron acceptor



(b) Lactic acid fermentation occurs in humans.

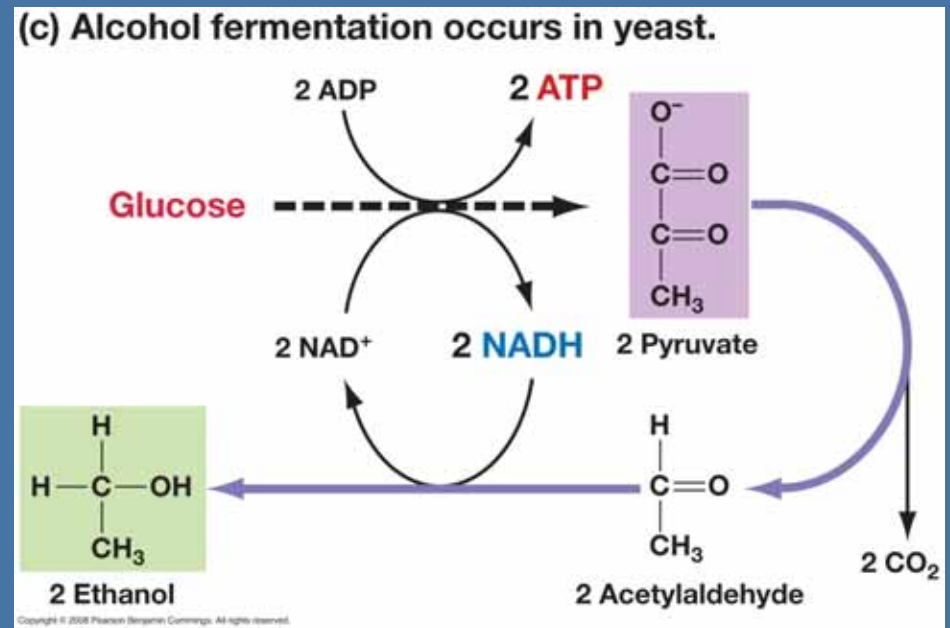


# Alcohol Fermentation

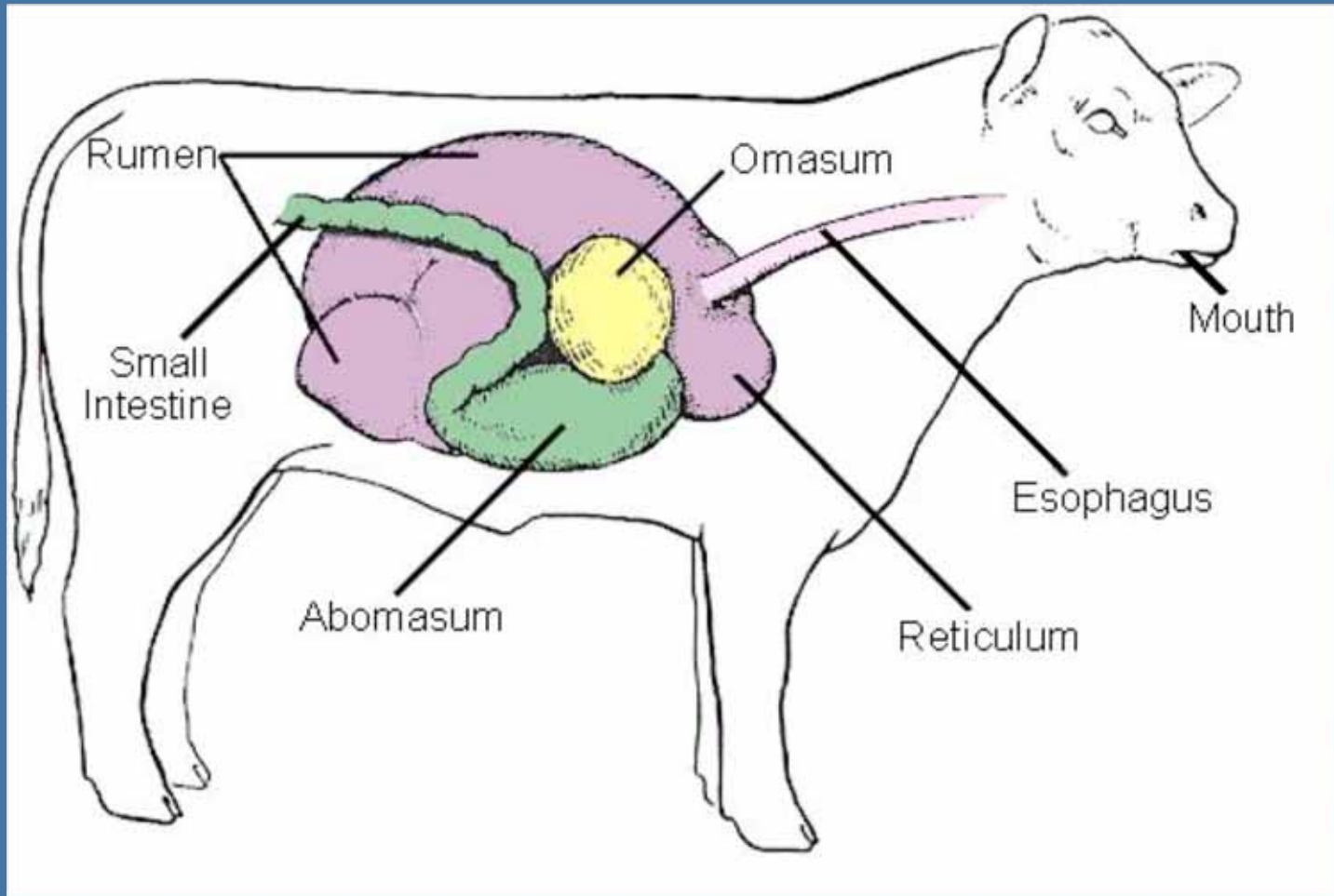


Acetylaldehyde\* to Ethanol

\*final electron acceptor



With all this oxygen around, who  
'ferments' anymore?

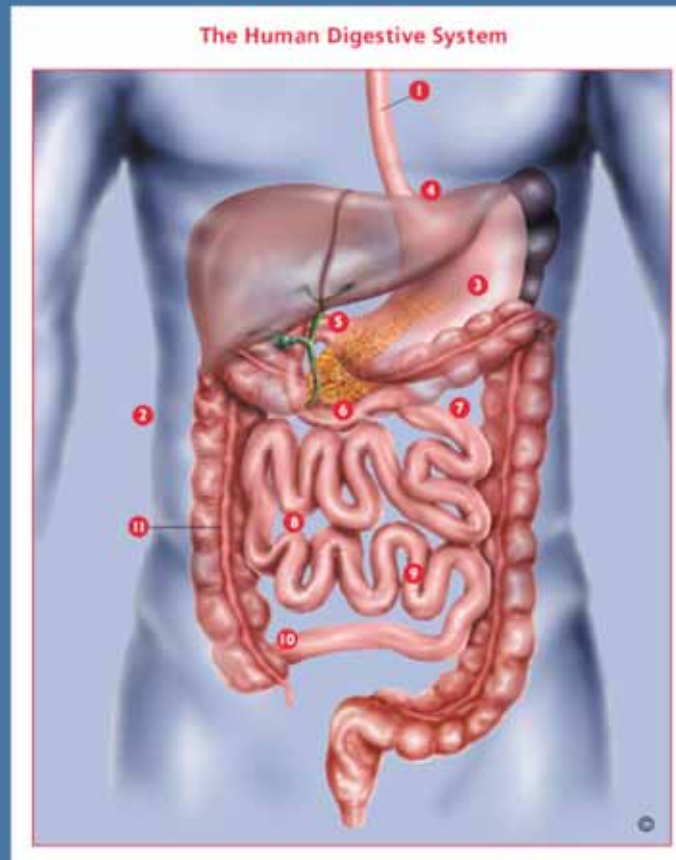


10 billion bacterial cells per milliliter of fluid

# With all this oxygen around, who 'ferments' anymore?

Up to 100 trillion individual bacterial cells, representing more than 1,000 species

These bacteria are introduced into the intestines through food and natural human contact. They change very little after year 3 of life.



# Symbiosis

## Aphids and Proteobacteria *Buchnera*



Fermentation is inefficient,  
but who cares?  
We're swimming in sugar!