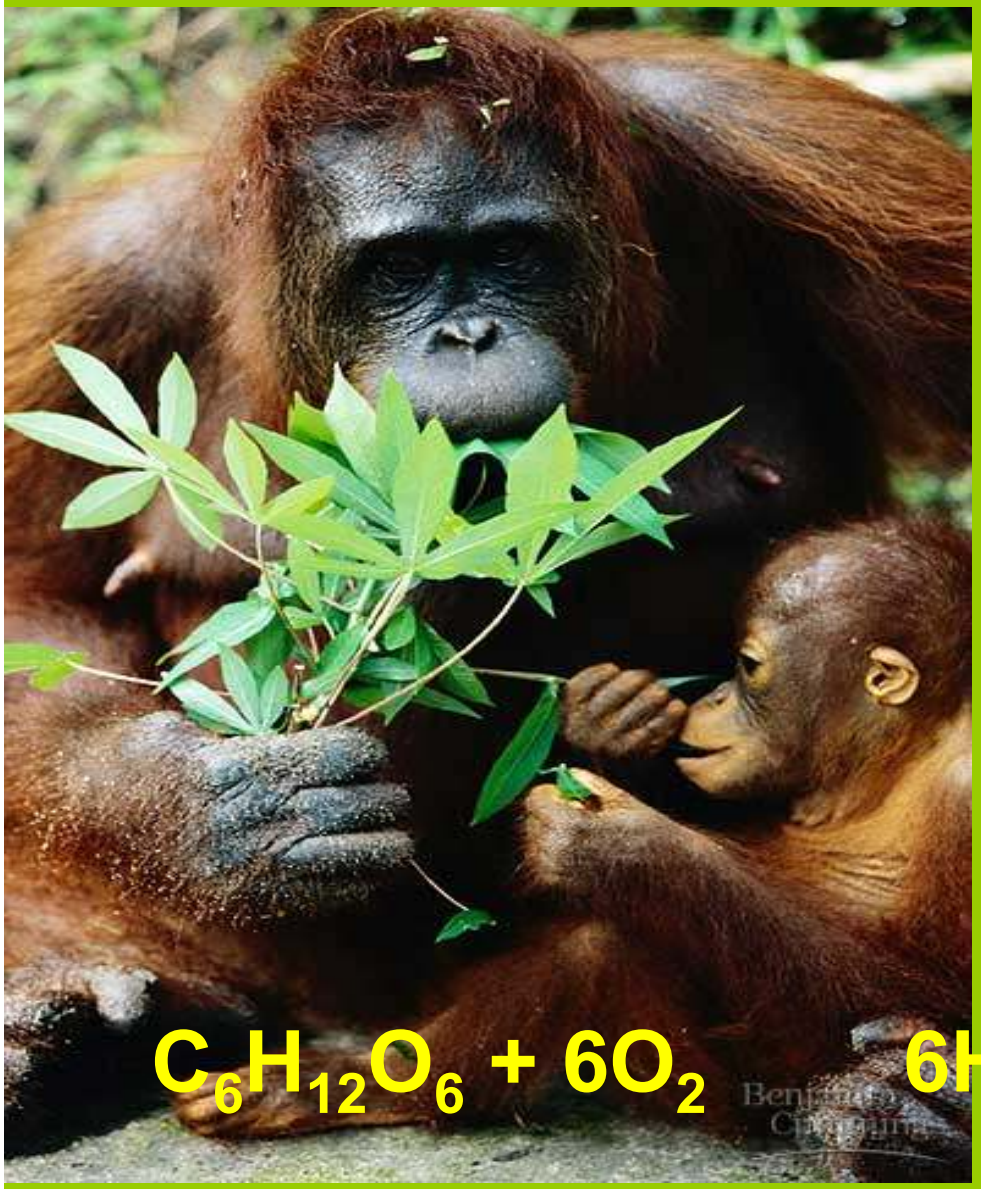


Cellular Respiration
Harvesting
Chemical
Energy

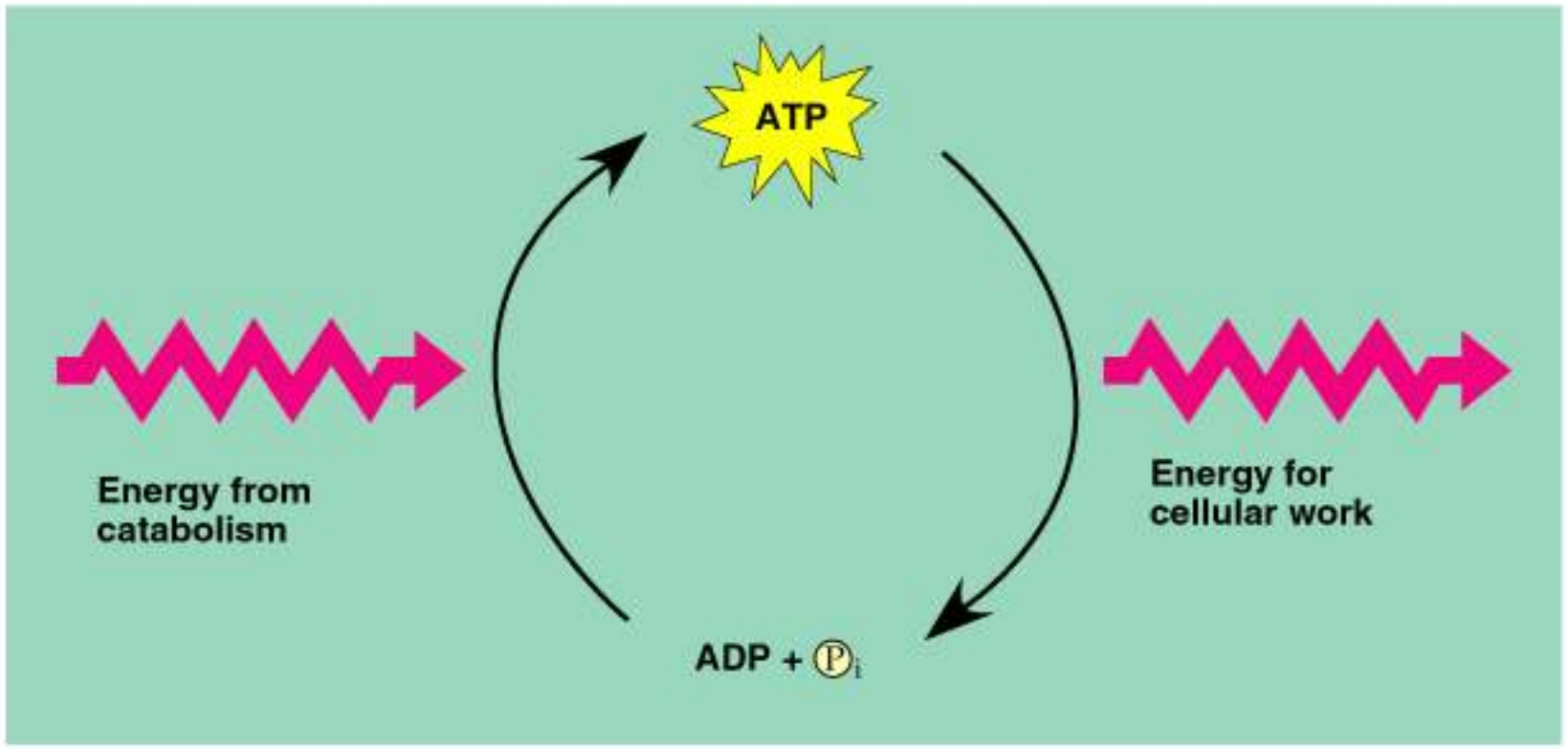
$C_6H_{12}O_6 + 6O_2$ $6H_2O + 6CO_2 + Energy$

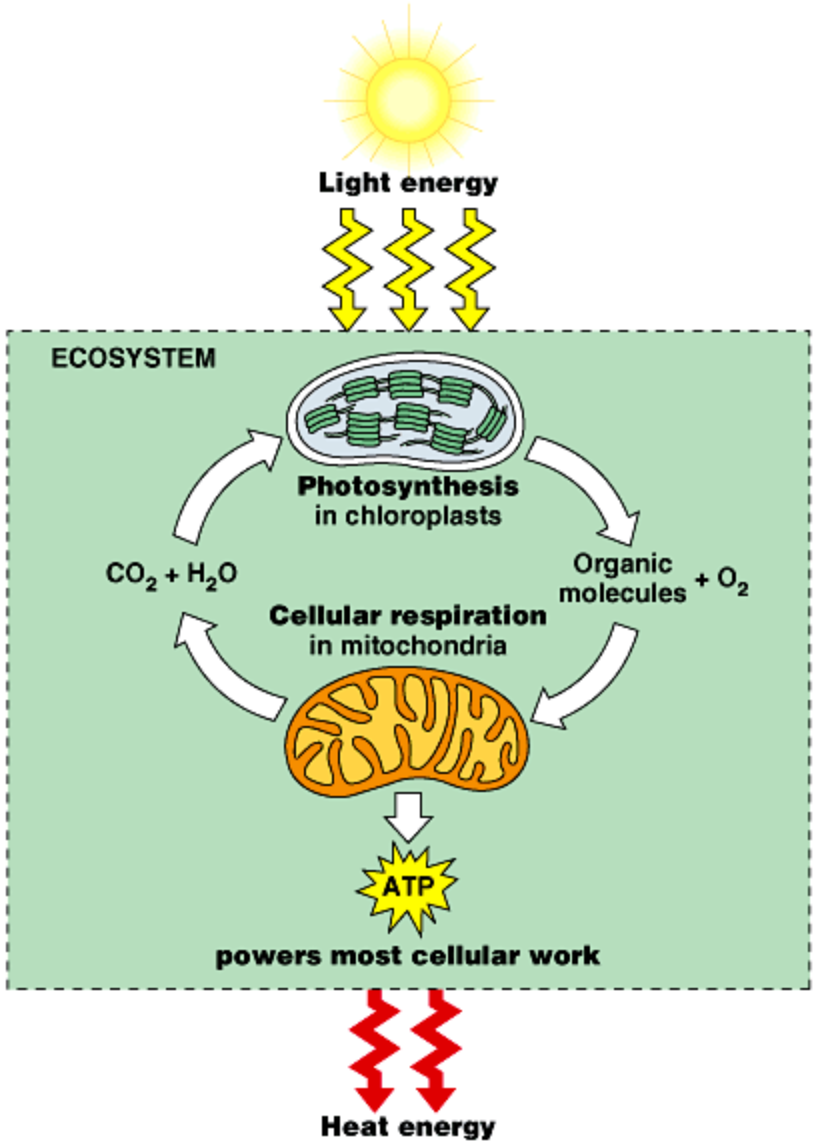
- Organic compounds store energy in their arrangement of atoms
- Fats, CH_2O protein can all be used as fuel . Traditionally, cellular respiration is studied using glucose as the source.
- There are 2 energy-providing (catabolic) pathways
  - **Cellular Respiration**
  - **Fermentation (partial degradation of sugar without oxygen)**

- **The breakdown of glucose is exergonic with a free energy exchange of –686. This means that the products store less energy than the reactants.**

- **Catabolic pathways do not directly do cellular work but are linked to work by a chemical drive shaft: ATP**

Cells Recycle ATP

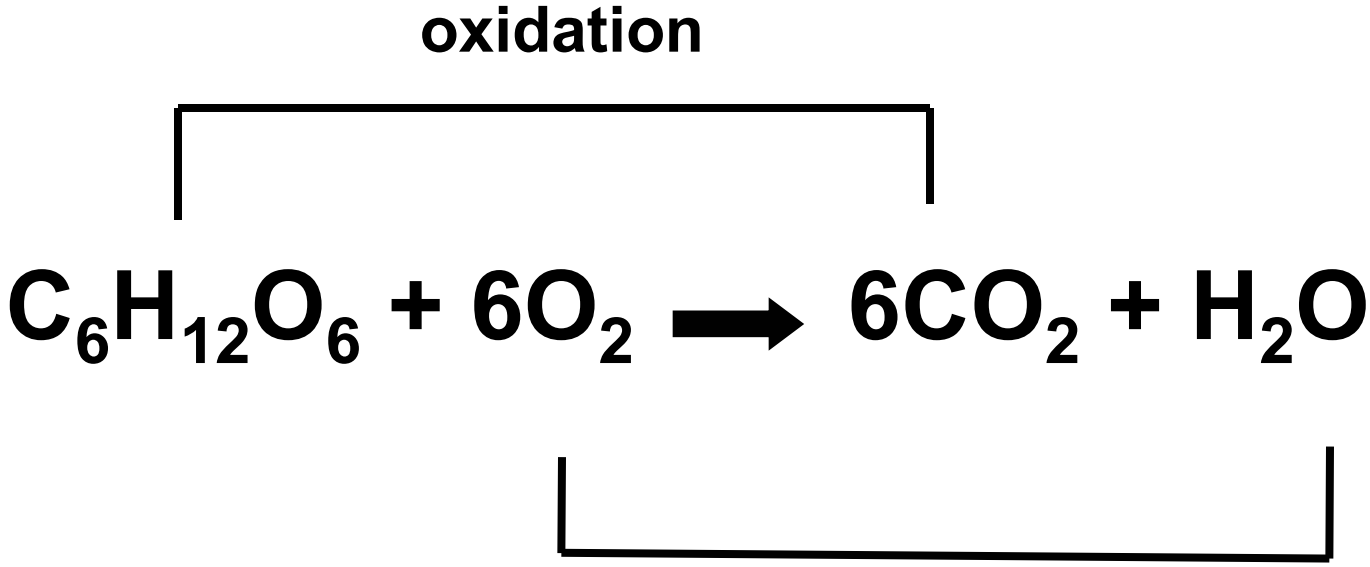




REDOX Reactions

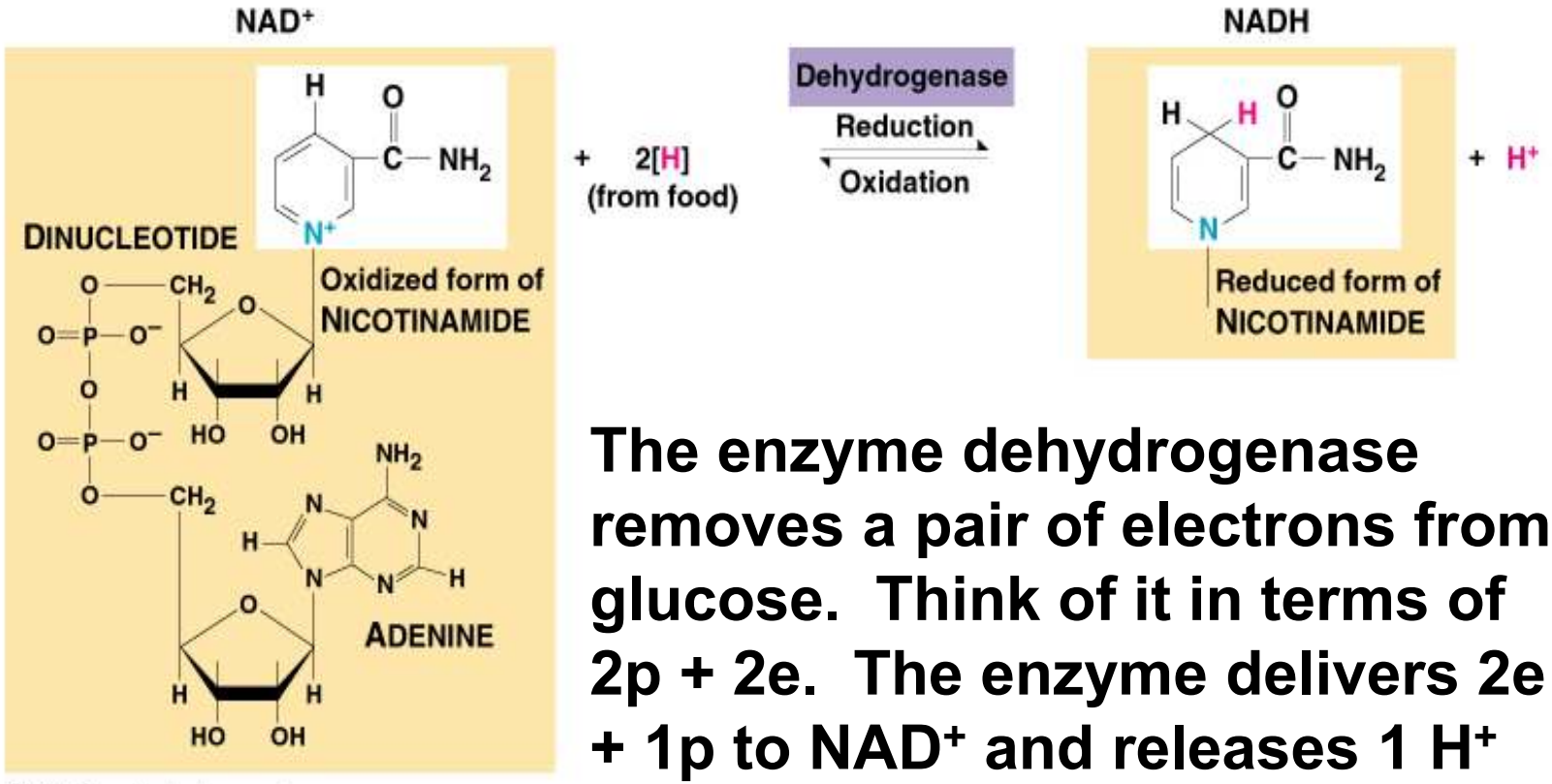
- A chemical reaction in which there is the transfer of one or more electrons from one reactant to another. Oxidation is the loss of electrons and Reduction is the addition of electrons.
- Because the electron transfer requires a donor and an acceptor, oxidation and reduction always go together.

oxidation



reduction

- In general, organic molecules that have an abundance of H atoms are excellent food sources because they have “hilltop” electrons with the potential to “fall” closer to oxygen.
- Glucose loses hydrogen atoms but they are not passed directly to oxygen. They are passed to a coenzyme first NAD+ (nicotinamide adenine dinuclotide). NAD+ serves as the oxidizing agent.

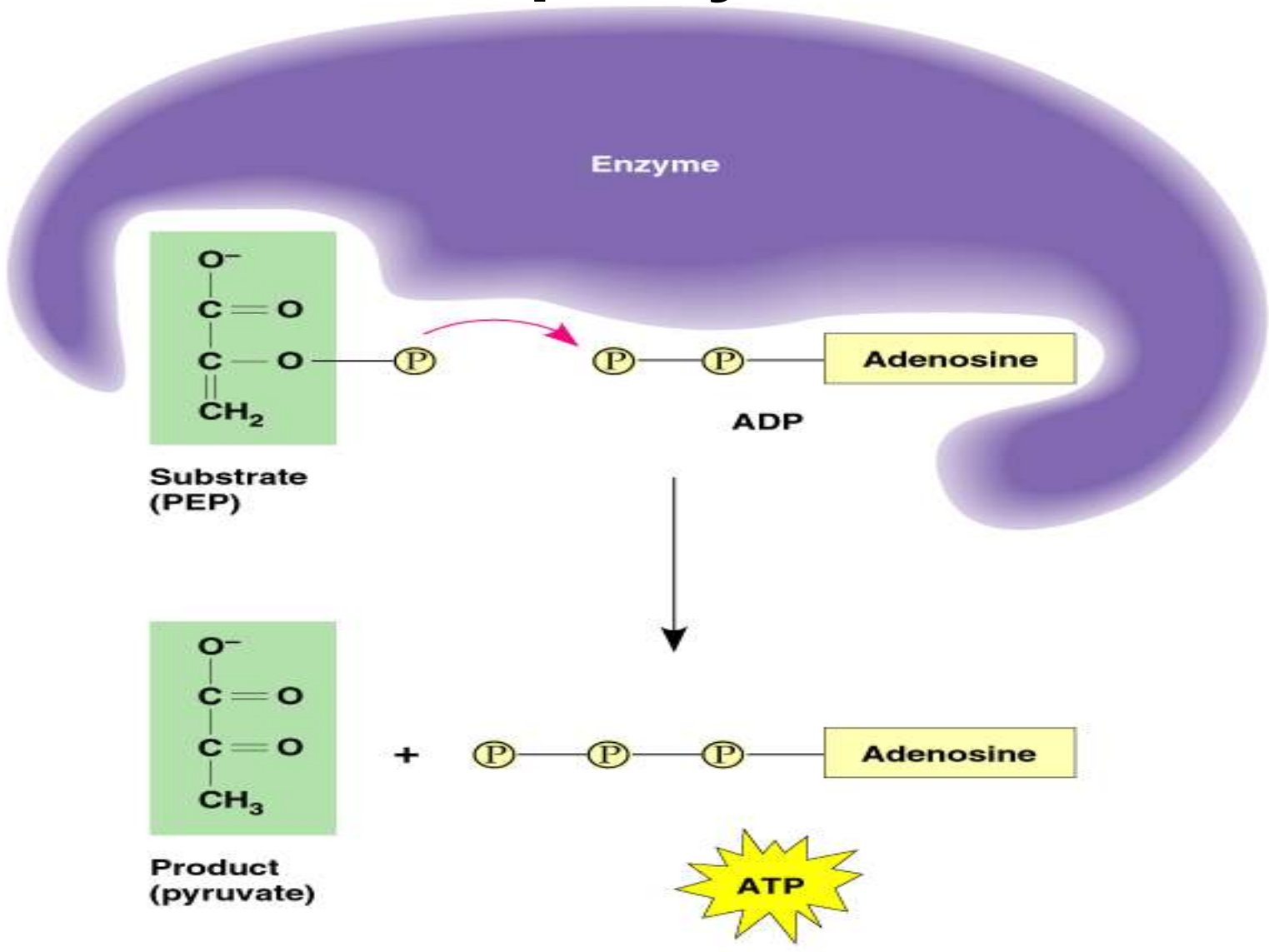


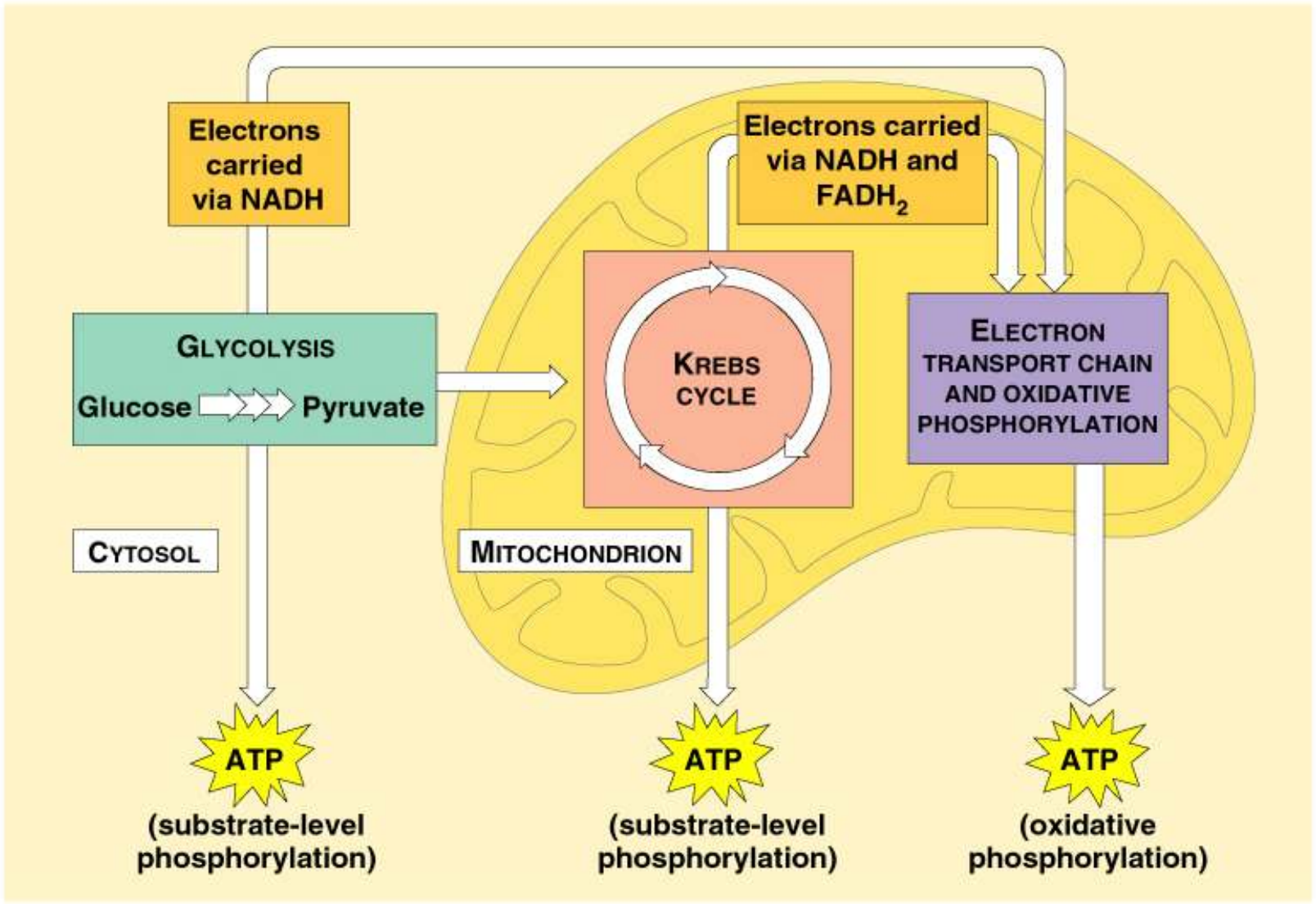
The enzyme dehydrogenase removes a pair of electrons from glucose. Think of it in terms of 2p + 2e. The enzyme delivers 2e + 1p to NAD^+ and releases 1 H^+ into the surrounding solution.

NAD^+ + 2e and 1p = NADH. Electrons lose very little of their potential when transferred from food to NAD^+

- **Respiration uses an electron chain to break the “fall” of electrons to several steps.**
- **Oxidation phosphorylation accounts for 90% of the ATP generated by respiration.**
- **Substrate level phosphorylation produces a smaller amount of ATP. In this synthesis, ATP is produced when an enzyme transfers a phosphate from a substrate to ADP.**

Phosphorylation

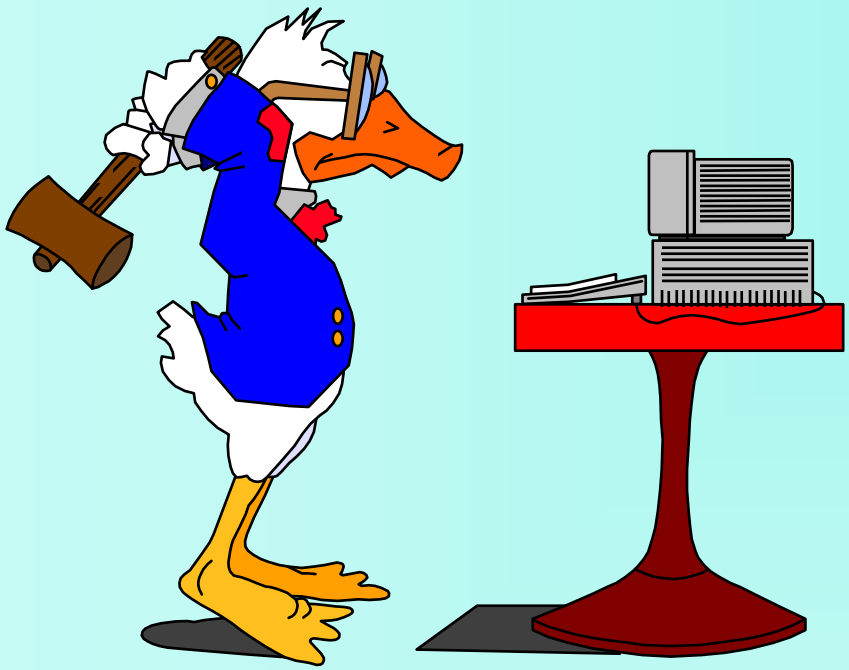




Four Stages of Cellular Respiration

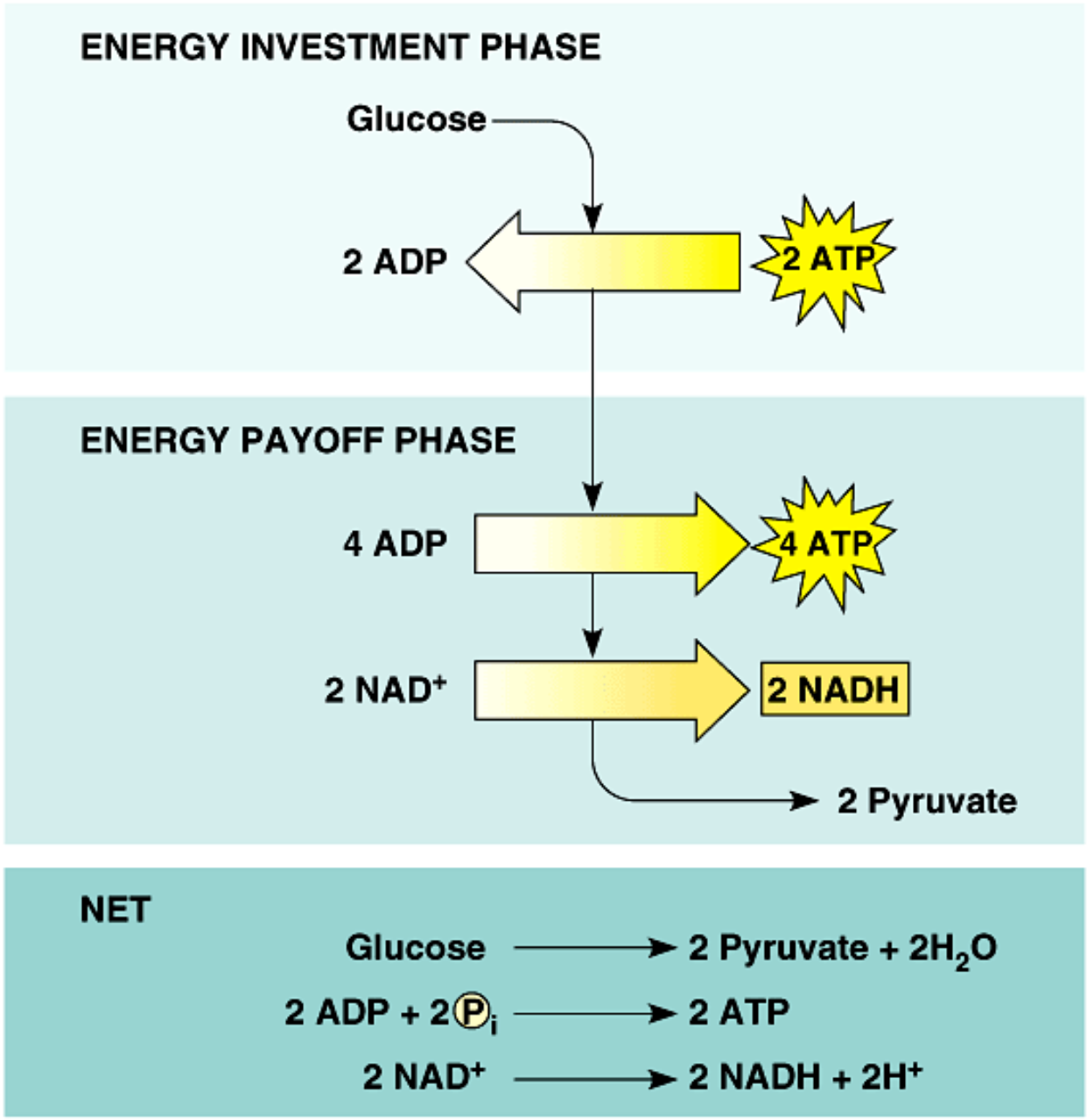
- Glycolysis
- Preparation for Citric Acid Cycle
- Citric Acid Cycle
- Electron Transport

Glycolysis

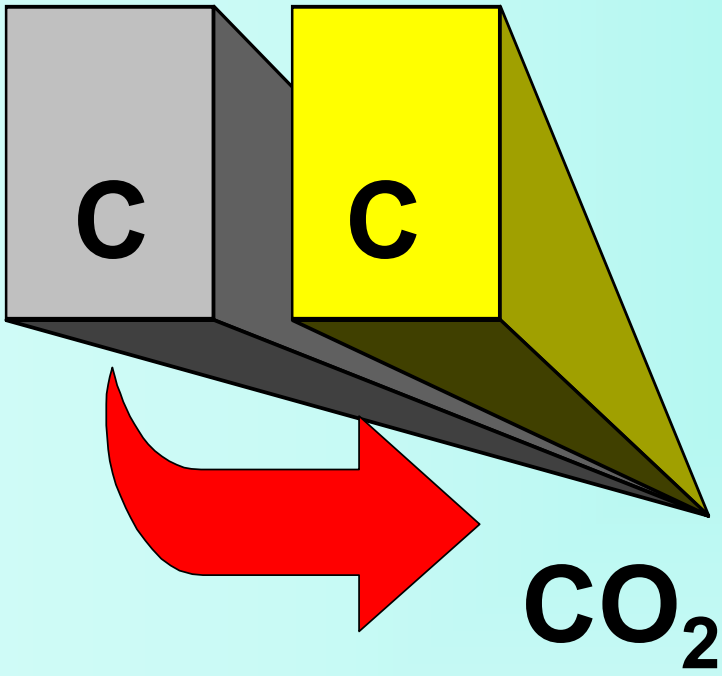


Splits a glucose molecule into 2 - 3 Carbon molecules called PYRUVATE.

products: 2 ATP, NADH and pyruvate



Preparation for the Citric Acid Cycle

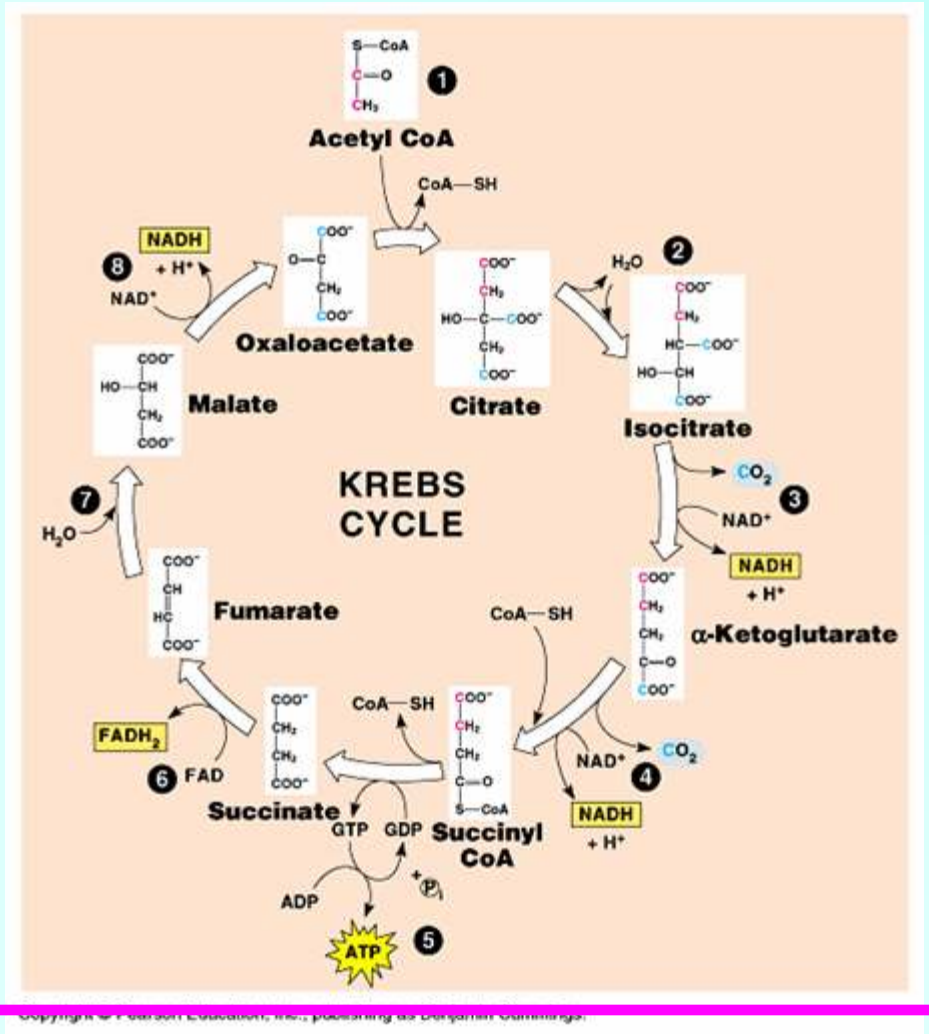


The pyruvate looses a carbon leaving the 2 carbon molecule

Acetyl CoA

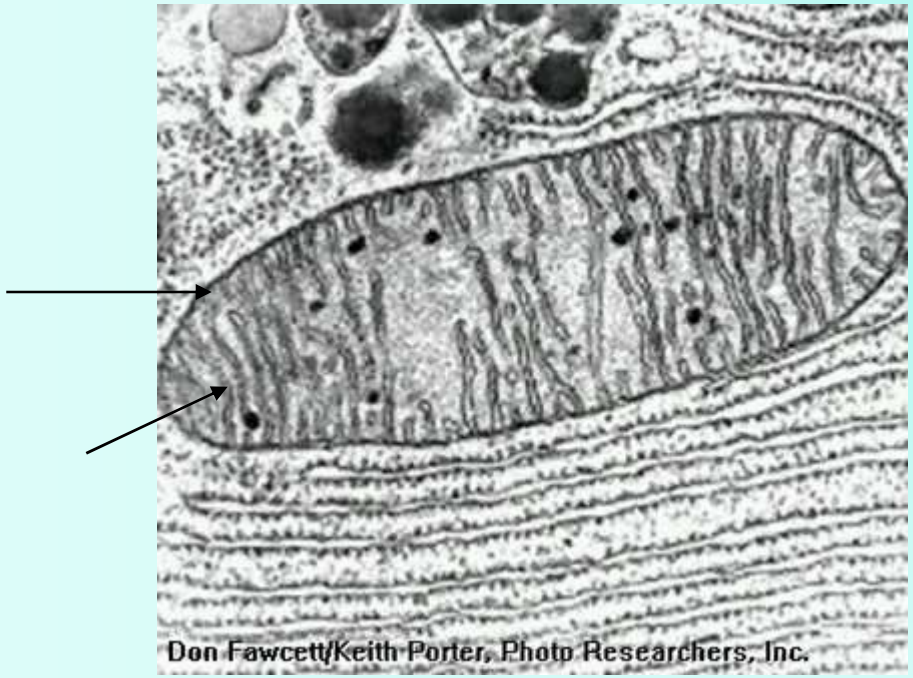
products: CO_2, Acetyl CoA and NADH

The Citric Acid Cycle



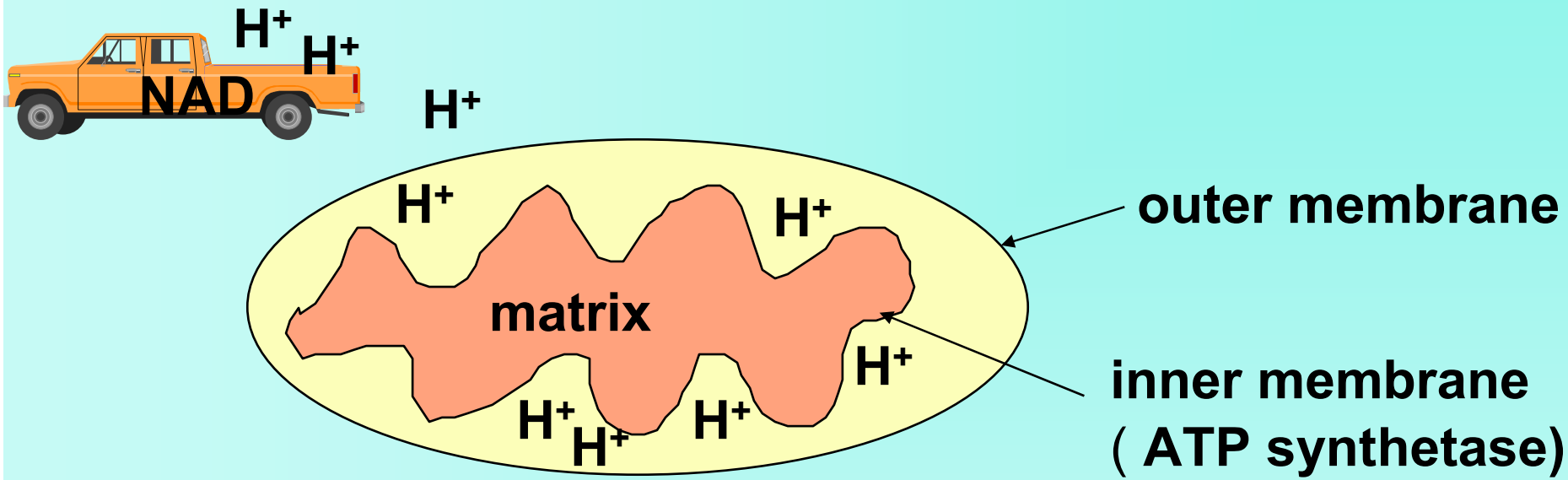
Products: CO_2 ATP, NADH, FADH

Electron Transport



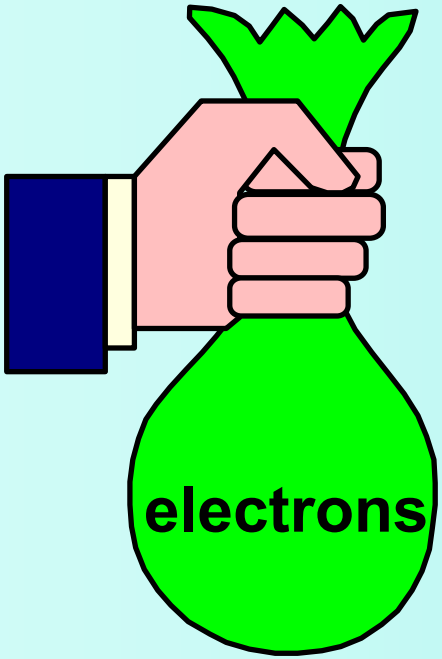
The mitochondria has two membranes--the outer one and the inner membrane which is convoluted. The H+ which are brought to mitochondria accumulate between these two membranes.

Mitochondria



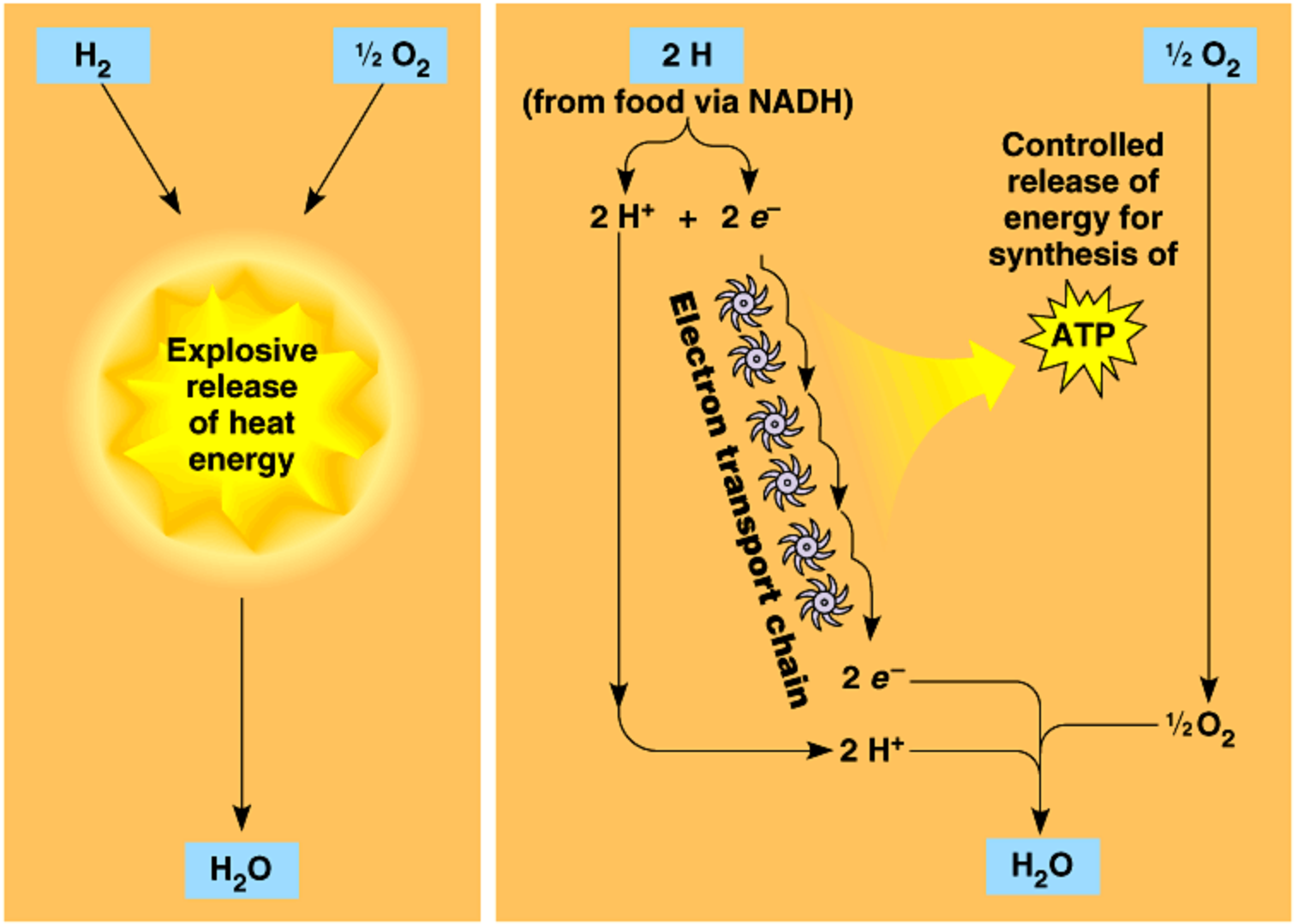
The matrix is a protein rich solution which contain the enzymes which run electron transport.

ATP SYNTHETASE is the enzyme which is responsible for making ATP.



The electrons are passed back and forth across the membrane where their energy is gradually decreased and used to transport H^+ through the membrane. Oxygen is the final electron acceptor and it joins with the H^+ to produce H_2O.

If there is no oxygen, the electron chain cannot continue because there is no way to release electrons .



(a) Uncontrolled reaction (b) Cellular respiration

Products of the Electron Transport Chain

34 ATP

+

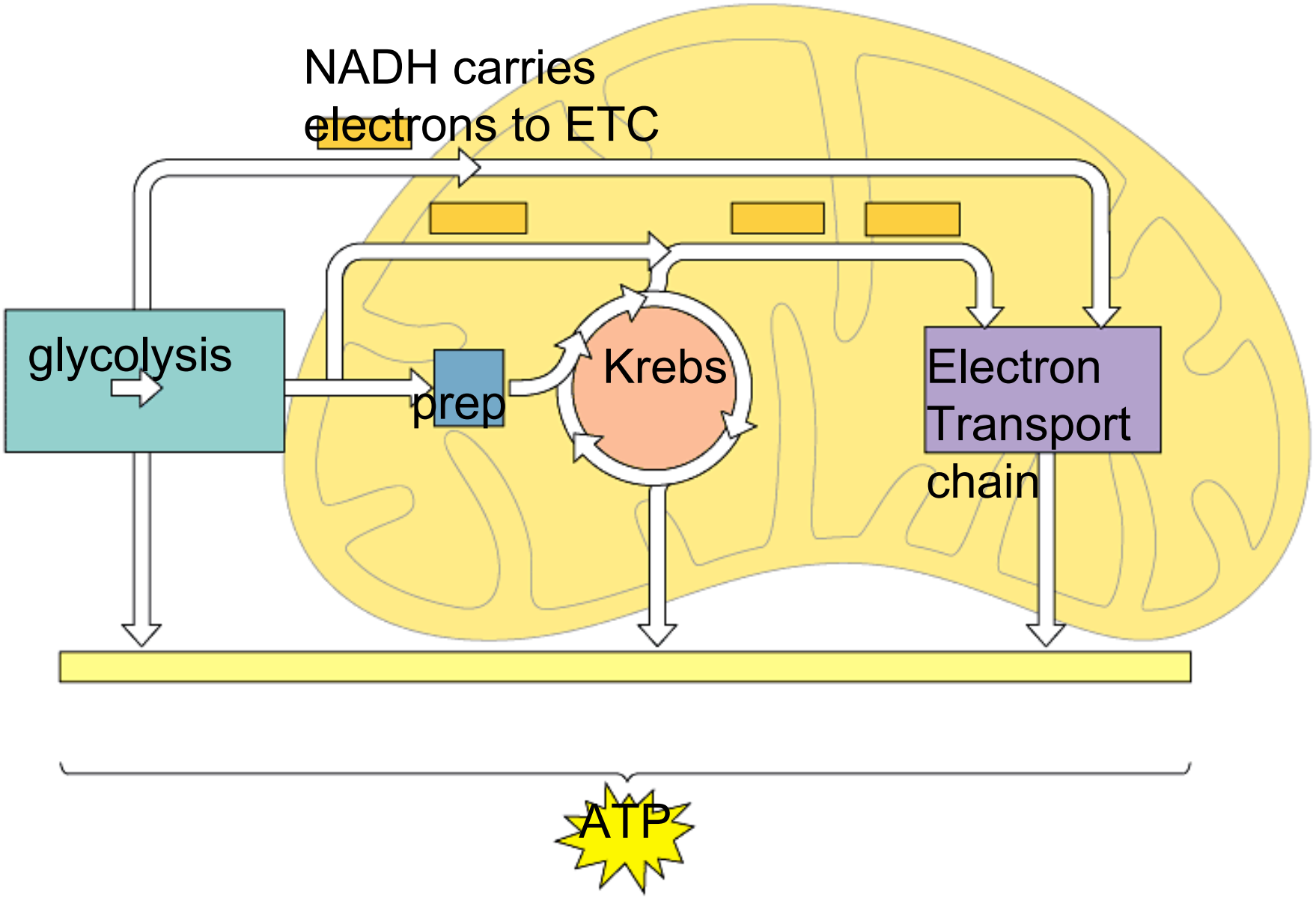
Water

ONE GLUCOSE MOLECULE PRODUCES **38 ATP**

Each NADH ⟶ 3 ATP

Each FADH ⟶ 2 ATP

•Glycolysis (2 NADH)	6 ATP
•Prep for Citric Acid	6 ATP
•Citric Acid (6 NADH)	18 ATP
• (2 $FADH_2$)	4 ATP
•	34 ATP
•direct	4 ATP
•total	**38 ATP**



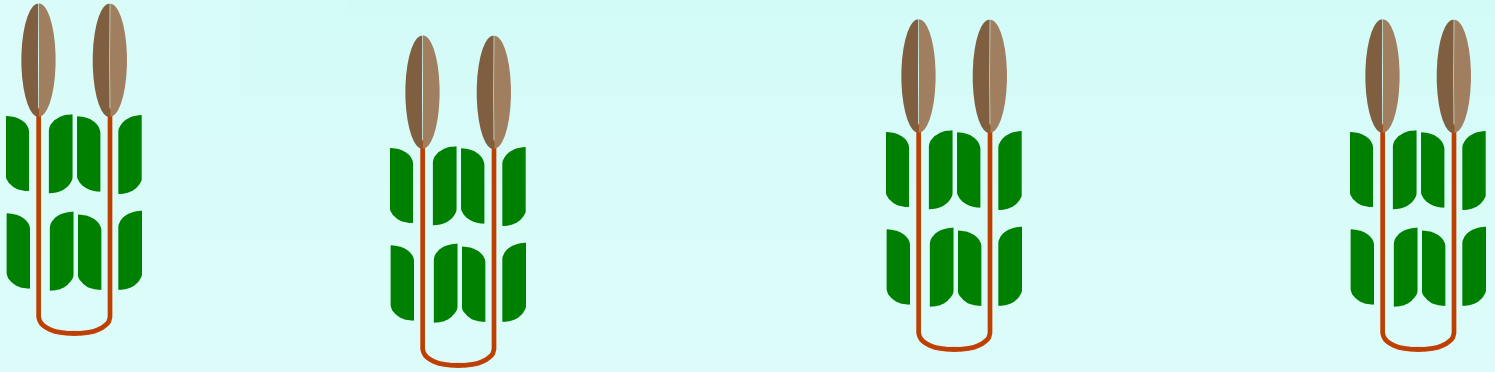
What happens when there is no oxygen to accept the electrons?

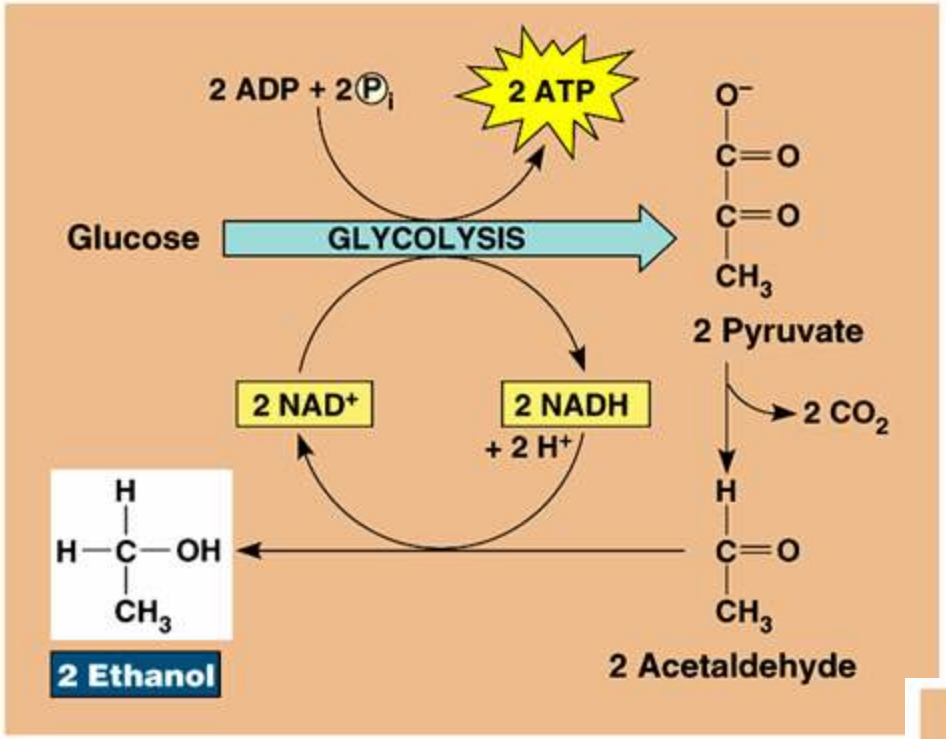
Only the process of glycolysis is carried out and lactic acid is produced in the muscles. The body cannot tolerate much lactic acid and it must eventually be converted in the liver to pyruvate.

results in muscle soreness

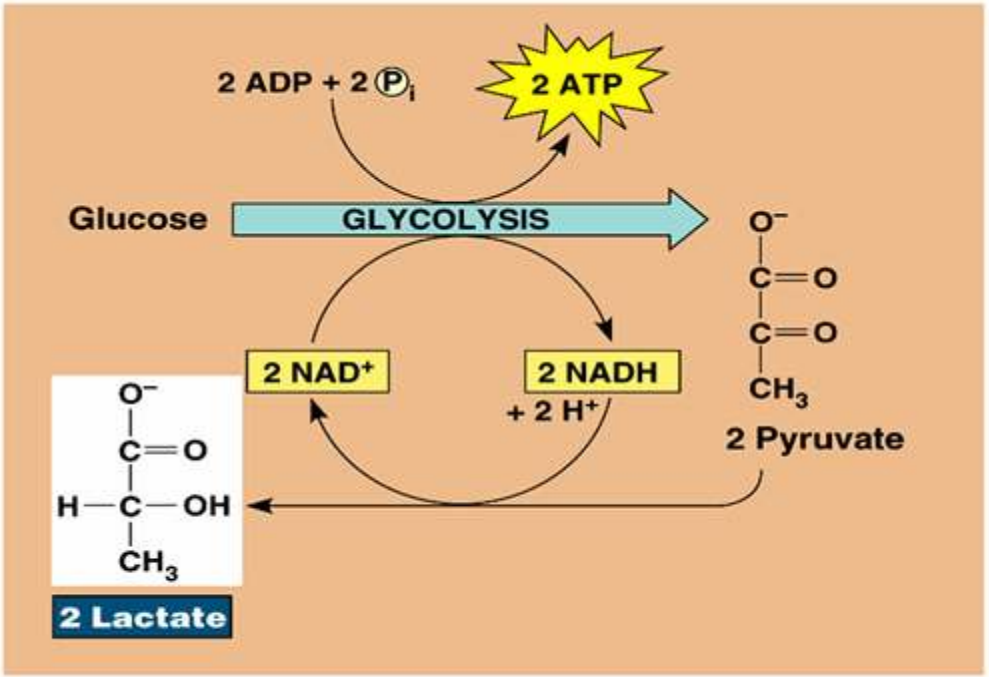
Alcoholic Fermentation

Some organisms carry out alcoholic fermentation. This was discovered by Louis Pasteur in his study of the chemistry of wines. Yeasts break down the sugars in the juice to pyruvate by glycolysis, then the pyruvate is dismantled to yeild CO_2 and ETHANOL. If the fermentation continues until all the sugar is used, a dry wine is produced. If fermentation is stopped before all the sugar is used, then a sweet wine is produced.





(a) Alcohol fermentation



(b) Lactic acid fermentation