Chapter 14- RESPIRATION IN PLANTS

Living cells require a continuous supply of energy for maintaining various life activities. This energy is obtained by oxidizing the organic food substances present in the cells. The food substances like Carbohydrates, proteins, fats which are used for oxidation during respiration are called 'respiratory substrates'.

What is respiration?

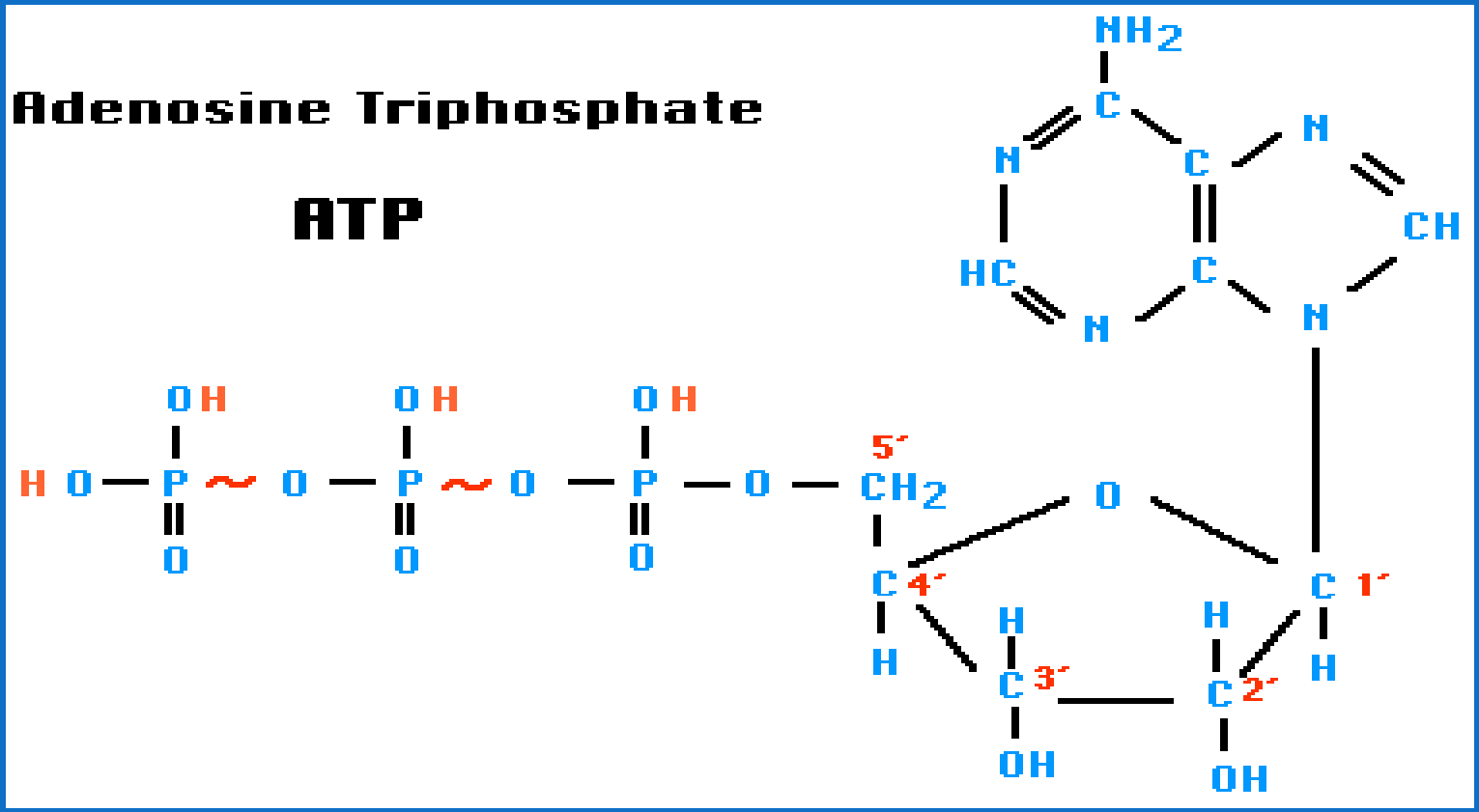
It is a cellular catabolic process, in which the organic food substances (Glucose) are oxidized completely or partially with or without using oxygen, resulting in the formation of ATP molecules. The energy present in the chemical bonds of glucose molecule will be transferred to the phosphate bonds of ATP during respiration.

Adenosine Tri phosphate (ATP)

ATP is also called 'energy currency'. Cells depend upon the energy stored in the phosphate bonds of ATP molecule for all their energy needs. ATP has usable form of energy. The normal bonds C-C and C-H bonds present in the food substances yield less energy while the phosphate bond of ATP yield 7.3 k cals .

ADP + Pi →ATP (Phosphorylation)

Structure of ATP



Types of respiration

There are two types of respiration.

1. Aerobic respiration- takes place in the cells of higher plants and animals, using oxygen for the oxidation of glucose.
2. Anaerobic respiration- takes place, in microorganisms without using oxygen for the oxidation of glucose.

Aerobic respiration

Aerobic respiration has three steps.

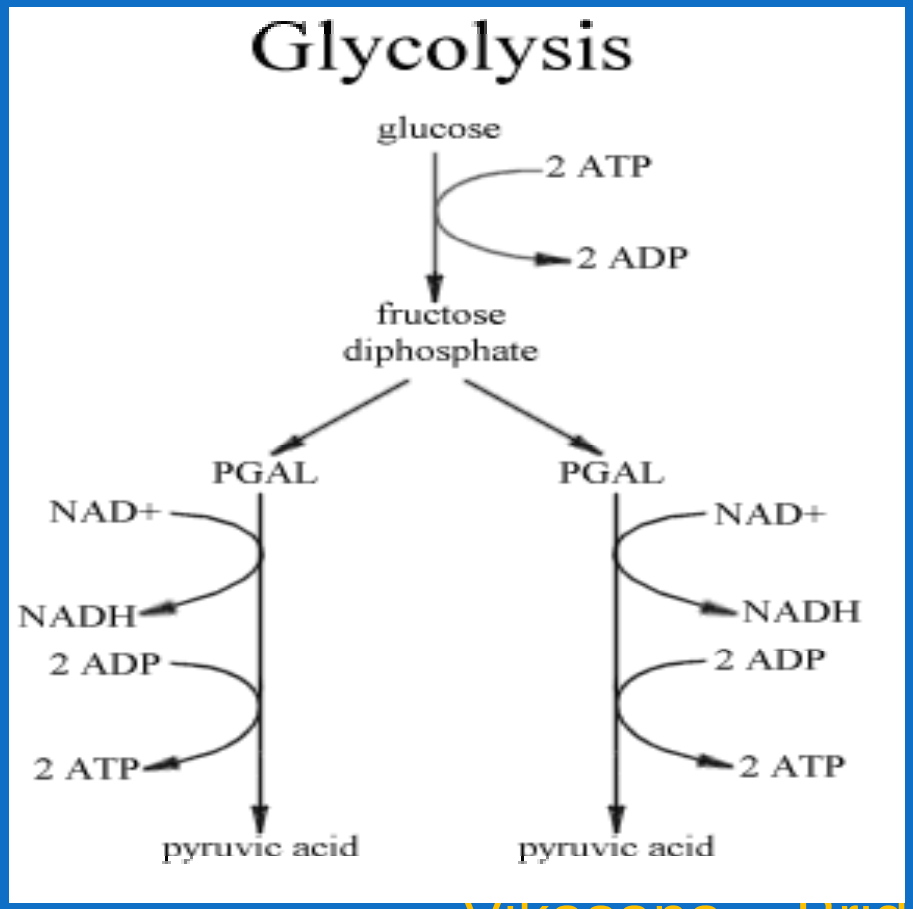
1. Glycolysis (Embden Meyerhof paranas pathway –EMP pathway)
2. Kreb's Cycle or citric acid cycle or Tricarboxylic acid cycle
3. Electron transport system (ETS/ETC)

Glycolysis (Glyco= sugar, Lysis=breaking)

It is the first step of respiration and is common to both aerobic and anaerobic respirations. It takes place in the cytoplasm of the cell.

In glycolysis 6C Glucose is enzymaticaly broken down in a step wise (10) manner into 2 molecules of 3C pyruvic acid .

Glycolysis



Overall reaction-

Glucose(6C)+2ATP+ 4ADP+2NAD→ 2PyruvicAcid(3C) +2ADP+4ATP+ 2NADH

Hydrogen carriers in respiration

The Hydrogen carriers in respiration are NAD (Nicotinamide Adenine Di nucleotide) and FAD (Flavin Adenine Di Nucleotide. They can accept free Hydrogen atom released in the cell during metabolic reactions. Their role is to transport the hydrogen atoms of glucsoe to the the ETS.

Hydrogen acceptors

NAD (OXI) + Hydrogen ⟺ NADH (Red)

FAD (OXI) +Hydrogen ⟺ FADH (Red)

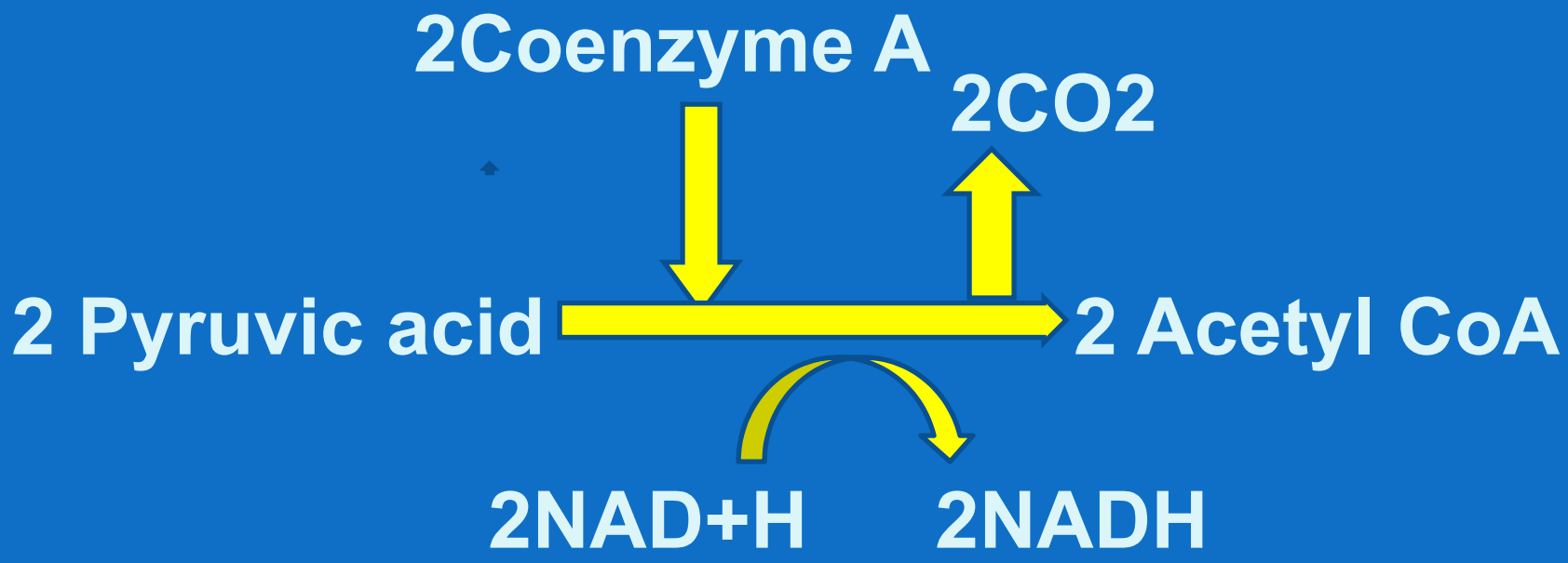
In the ETS, the electron of hydrogen atom pass through series of electron carriers. During this electron movement, at several steps energy is used for the joining of Pi to ADP to get a molecule of ATP.

KREB'S CYCLE OR CITRIC ACID CYCLE

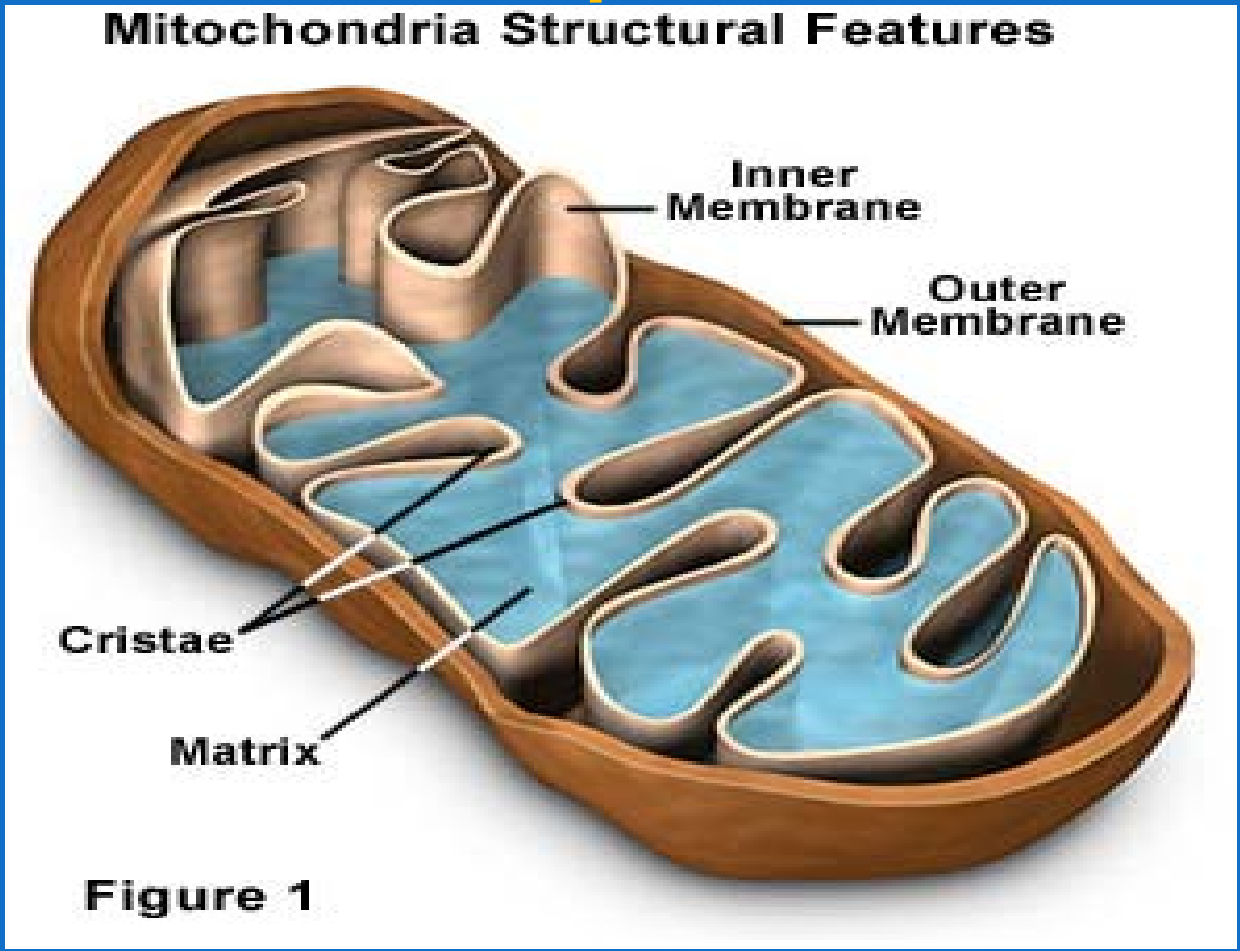
It operates in the mitochondrial matrix.
It occurs only in aerobic respiration.
Initially, the pyruvic acid formed at the end of glycolysis undergo oxidative decarboxylation to form acetyl CoA. This step is called the preparatory Step.

Pyruvicacid+CoA+ NAD.....→Acetyl CoA + CO_2 + NADH

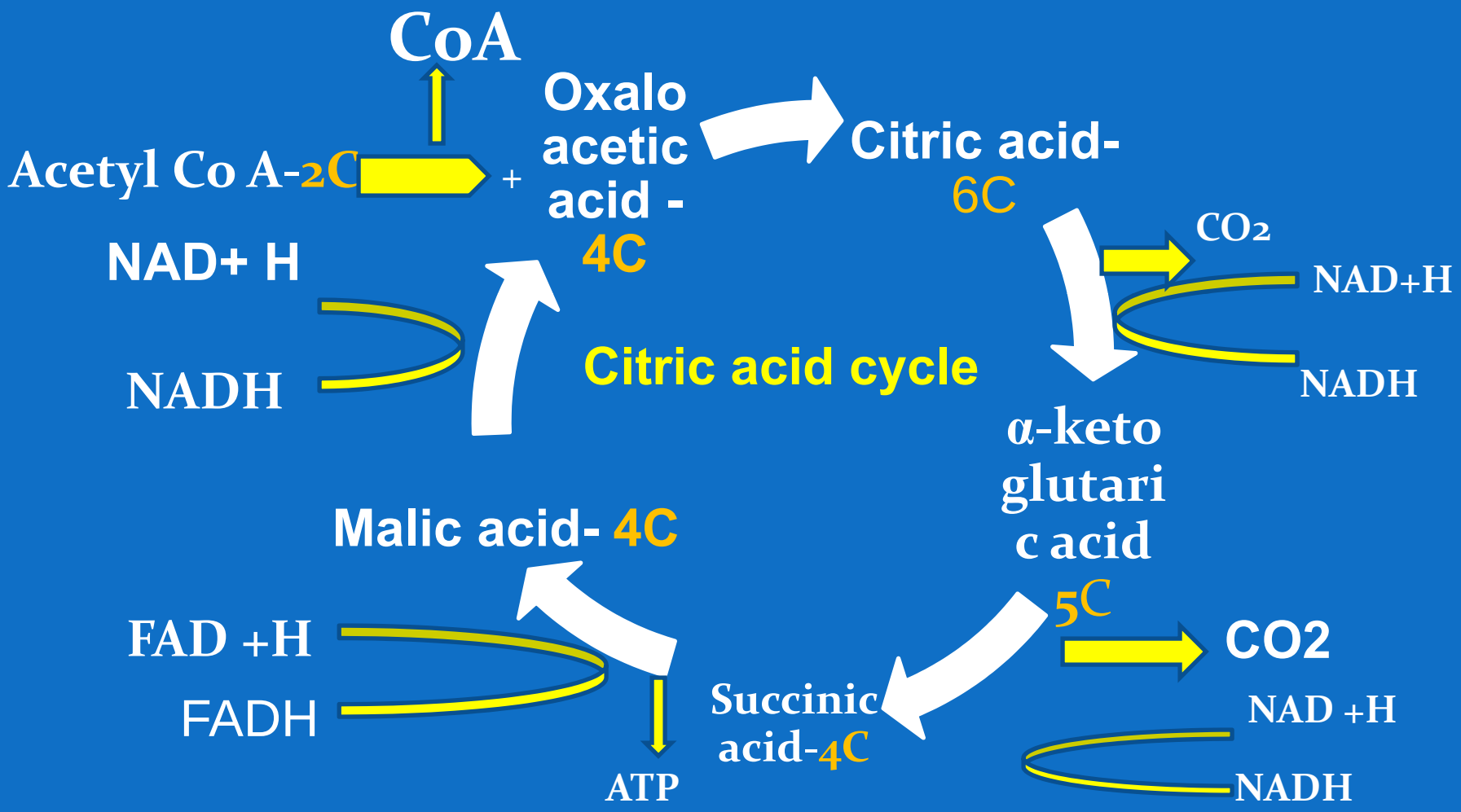
Kreb cycle- preparatory stage



Mitochondia- The power house of the cell



Kreb's cycle


CoA
Acetyl Co A-2C
+
Oxalo acetic acid - 4C
Citric acid- 6C
CO2
NAD+H
NADH
NAD+ H
NADH
Citric acid cycle
α-keto glutari c acid 5C
CO2
NAD +H
NADH
Succinic acid-4C
Malic acid- 4C
FAD +H
FADH
ATP

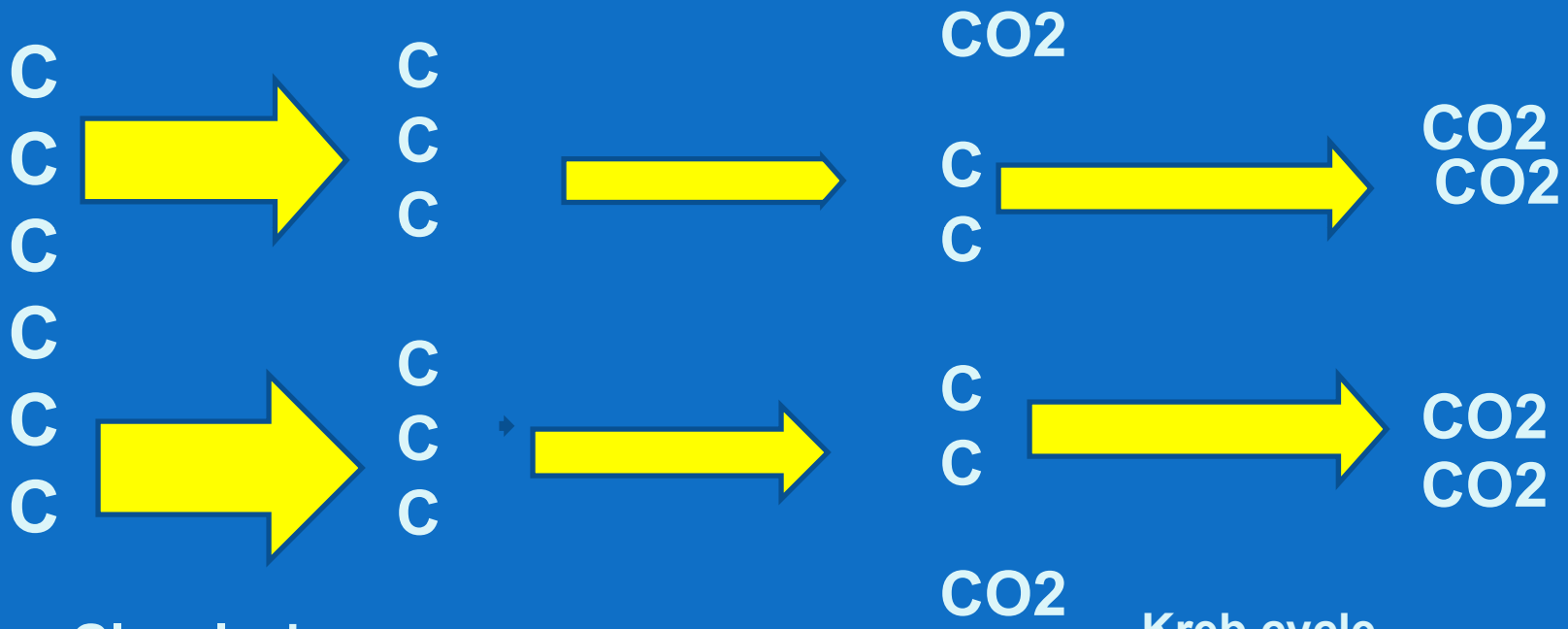
Overall reaction of Kreb's cycle

1. OAA is regenerated during this cycle. 2. Each pyruvic acid molecule gives three molecules of CO_2, 4 NADH, 2 FADH and one ATP .

Pyruvic acid+4NAD+FAD+2H_2O+ADP+Pi $\rightarrow$ 3$CO_2\uparrow$+4NADH+4H^++FADH+ATP

Two kreb's cycles operate per glucose molecule, as 2 PA are formed per glucose during glycolysis.

Summary of Glucolysis and kreb cycle



Glycolysis
2pyruvate,
2ATP
2NADH

Acetyl CoA
2 Acetyl Co A
2CO2
2NADH

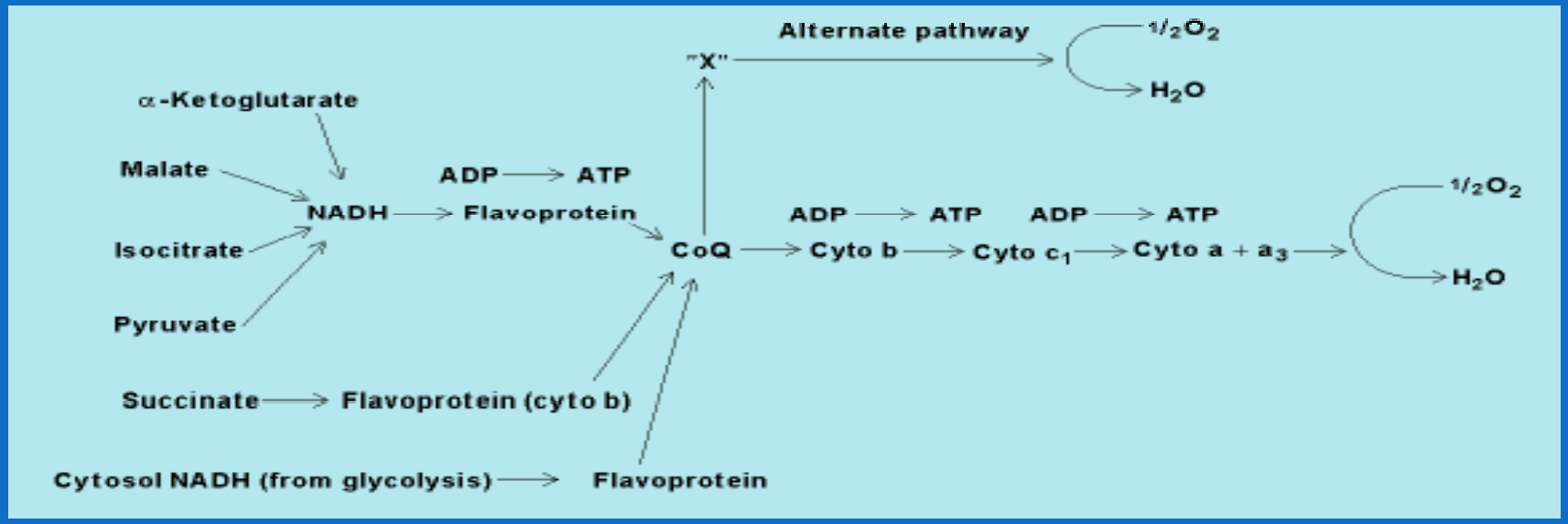
Kreb cycle
4CO2, 2ATP,
6NADH
2FADH2

Electron transport system (ETS/ETC)

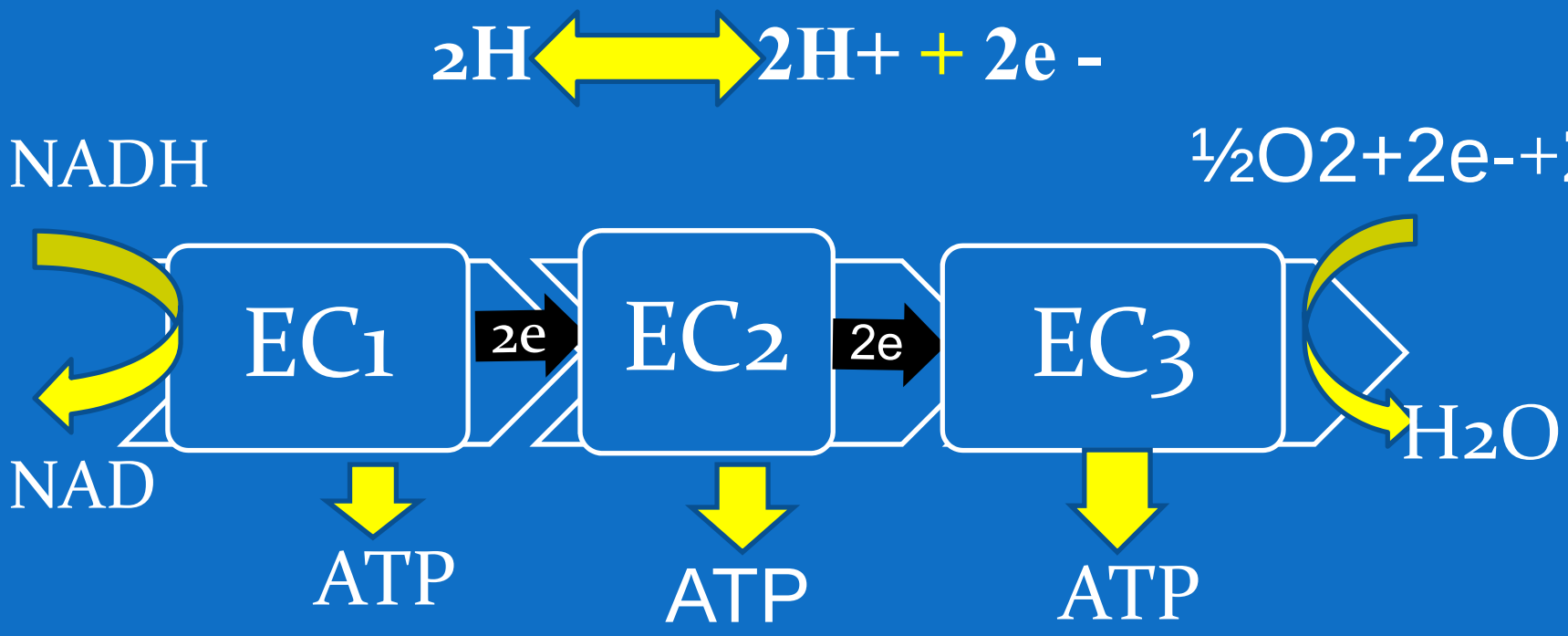
It is the third step in aerobic respiration, in which oxygen is used. It opertes on the Racker's particles present on the cristae of Mitochondira. In this step NADH and FADH formed during glycolysis and Kreb's cycle get oxidized. The Hydrogen released by them dissociates into proton and electron.

ETS- oxidative phosphorylation

Then as the electrons pass through series electron carriers of ETS, ADP is phosphorylated to ATP.



Electron transport chain



Terminal oxidation

Oxidation of one NADH yields 3ATP and one FADH gives 2 ATP molecules. At the end of ETS, molecular oxygen combines with hydrogen to form water. Hence it is called terminal oxidation. Thus the other product of aerobic respiration water is formed during ETS.

ATP account during aerobic respiration

Pathway	Substrate-Level Phosphorylation	Oxidative Phosphorylation	Total ATP
Glycolysis	2 ATP	2 NADH = 6 A T P	8
Preparatory step	-	2 NADH = 6 ATP	6
Krebs Cycle	2 ATP	6 NADH = 18 ATP 2 $FADH_2$ = 4 ATP	24
TOTAL	4 ATP	34 ATP	38

Summary- Aerobic respiration

Glucose ($C_6H_{12}O_6$) + $6O_2 \rightarrow 6CO_2 + 6H_2O$ +38ATP

1. Glucose is completely oxidized.

2. Takes place in the cells of higher plants and animals

3. Takes place in the cytoplasm and mitochondria of the cell, in three steps.

4. Products are $6CO_2 + 6H_2O$ +38ATP

Anaerobic respiration

It is the partial oxidation of glucose molecule without using oxygen.

Anaerobic respiration which takes place in microorganisms is called ‘fermentation’.

There are two types of fermentation depending upon the end products.

1. Ethyl alcohol fermentation
2. Lactic acid fermentation

Ethyl alcohol fermentation

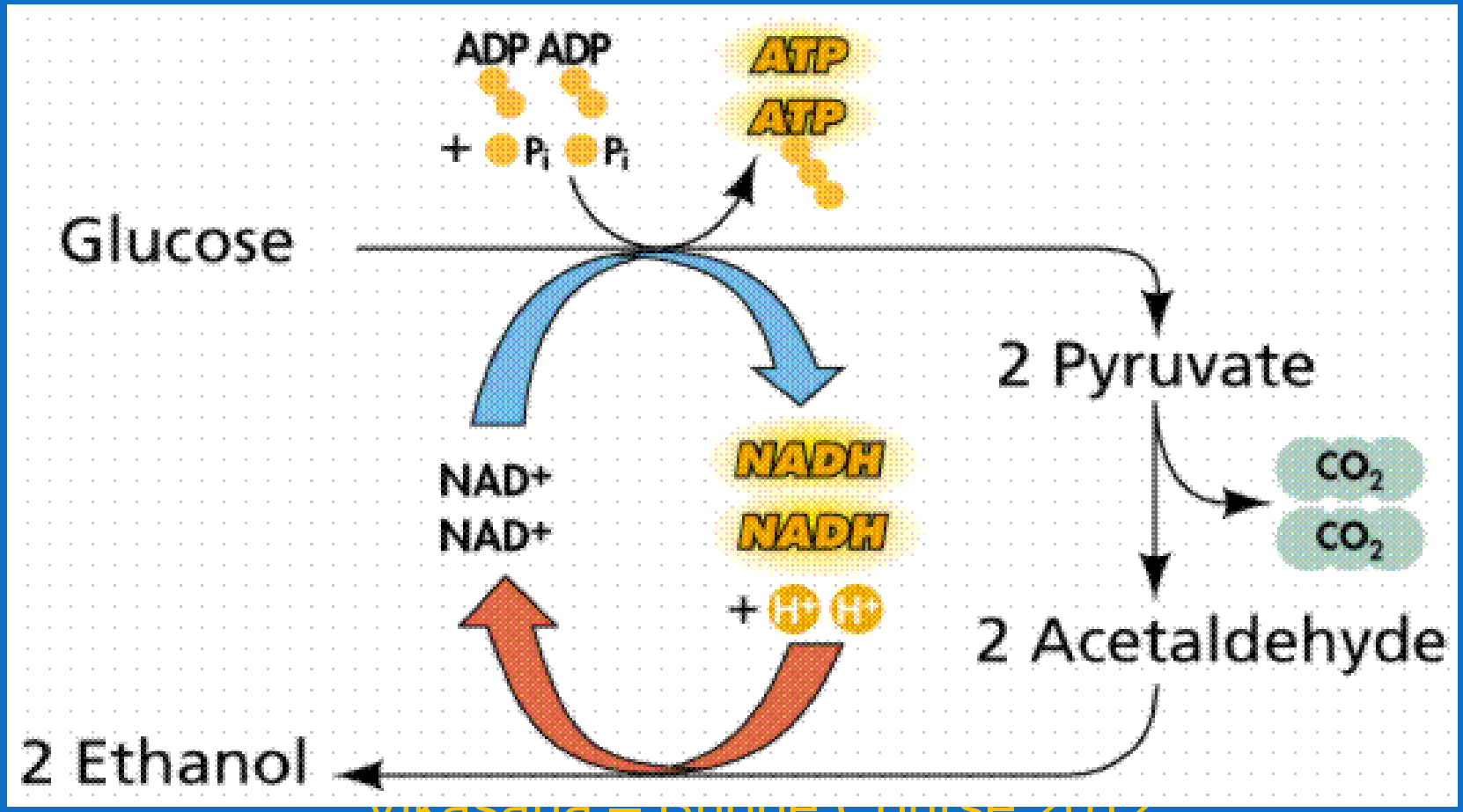
It is seen in yeast and in root cells of plants in the absence of oxygen. Reactions include,

1.Glucose→Pyruvic acid +2ATP + NADH +H

2. Pyruvic acid→Acetaldehyde + CO_2.

3.Acetaldehyde + NADH+H→Ethyl alcohol + NAD

Ethyl alcohol fermentation



Lactic acid fermentation

It takes place in some bacteria and animal tissue when oxygen is absent. The end product Is lactic acid.

1.Glucose →Pyruvic acid + NADH+H+ 2ATP

2.Pyruvic acid+NADH+H→Lactic acid+NAD

Fermentation process has wide industrial application.

Differences between aerobic and anaerobic respiration

- Aerobic
- Oxygen is used for the process
- Takes place in the cells of higher plants and animals
- Glucose is completely oxidized
- The end products are carbon dioxide and water
- Complete oxidation of one molecule of glucose yields 38 ATP molecules
- Process takes place in both cytoplasm and mitochondria of the cell.

- Anaerobic
- oxygen is not utilized for the process.
- Takes place normally in some bacteria, and fungi .
- Glucose is partially oxidized
- The end products are carbon dioxide and either ethyl alcohol or lactic acid
- Partial oxidation of one molecule of glucose yields only 2 ATP molecules.
- Takes place only in cytoplasm of the cell
-

Respiratory quotient (RQ)

Respiratory quotient is the ratio of volume of carbon dioxide released to the volume of oxygen consumed during respiration.
RQ value indicates the type of substrate used during respiration

$$RQ = \frac{\text{Volume of carbon dioxide evolved}}{\text{Volume of oxygen consumed}} \text{ during respiration}$$

RQ values

RQ value of carbohydrate is one

RQ value of proteins and fats is <one (0.7 to 0.9)

RQ value of organic acids is > one (1.3 to 4)

RQ value in anaerobic respiration is infinity as oxygen is not used.

Summary

Respiration is simply a process where in the unusable energy present In glucose molecule is transferred to ATP molecule in a step wise manner.

Step wise transfer prevents loss of energy .

Respiration makes energy available to the cells for their vital activities.

It can be of aerobic type or anaerobic type.

Anaerobic respiration has wide industrial application.

Thank you

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