CHAPTER 5:

CELLULAR RESPIRATION AND FERMENTATION

Course Framework

5.1 Aerobic Respiration

5.2 Oxidative Phosphorylation: Electron Transport Chain And Chemiosmosis

5.3 Fermentation And Its Application

5.1 Aerobic Respiration

(a) State the needs for energy and the role of respiration in living organisms.

(b) Outline the complete oxidation of glucose which involves glycolysis, Krebs cycle and oxidative phosphorylation.

ENERGY

Most of the processes taking place in cells need **energy** to make them happen. Examples of **energy** consuming processes in living organisms are:

The conduction of electrical impulses by nerve cells

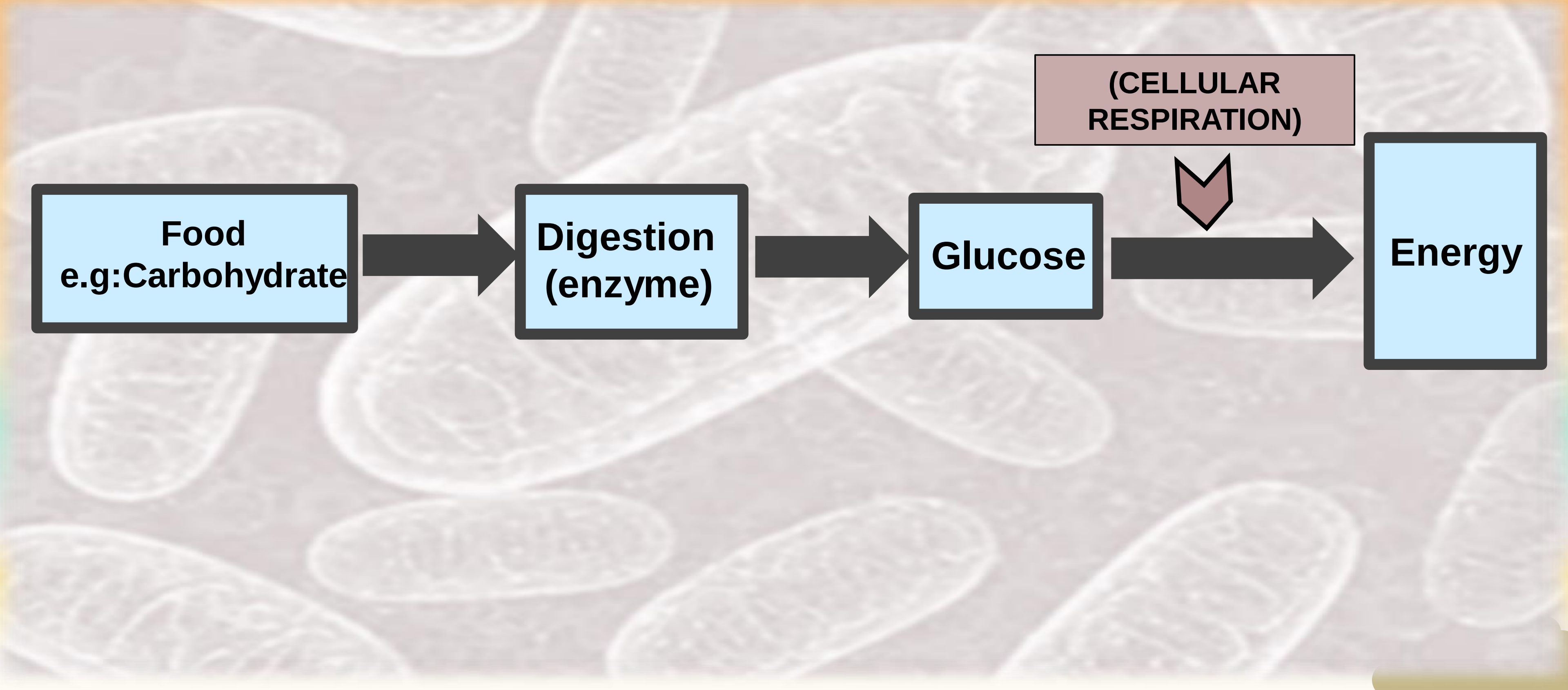
Building up proteins from amino acids

The contraction of muscle cells – to create movement of the organism, or peristalsis.

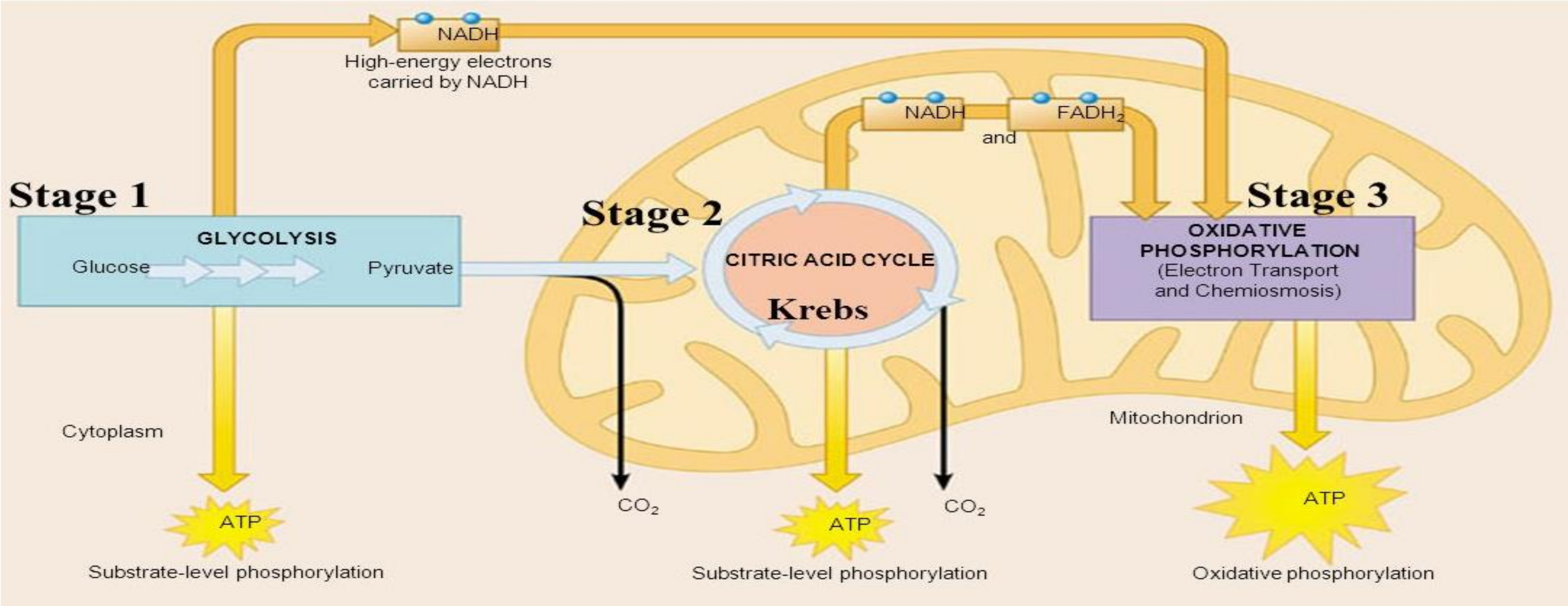
The process of active transport, - the movement of molecules across a cell membrane

The process of cell division to create more cells, or replace damaged or worn out cells, or to make reproductive cells

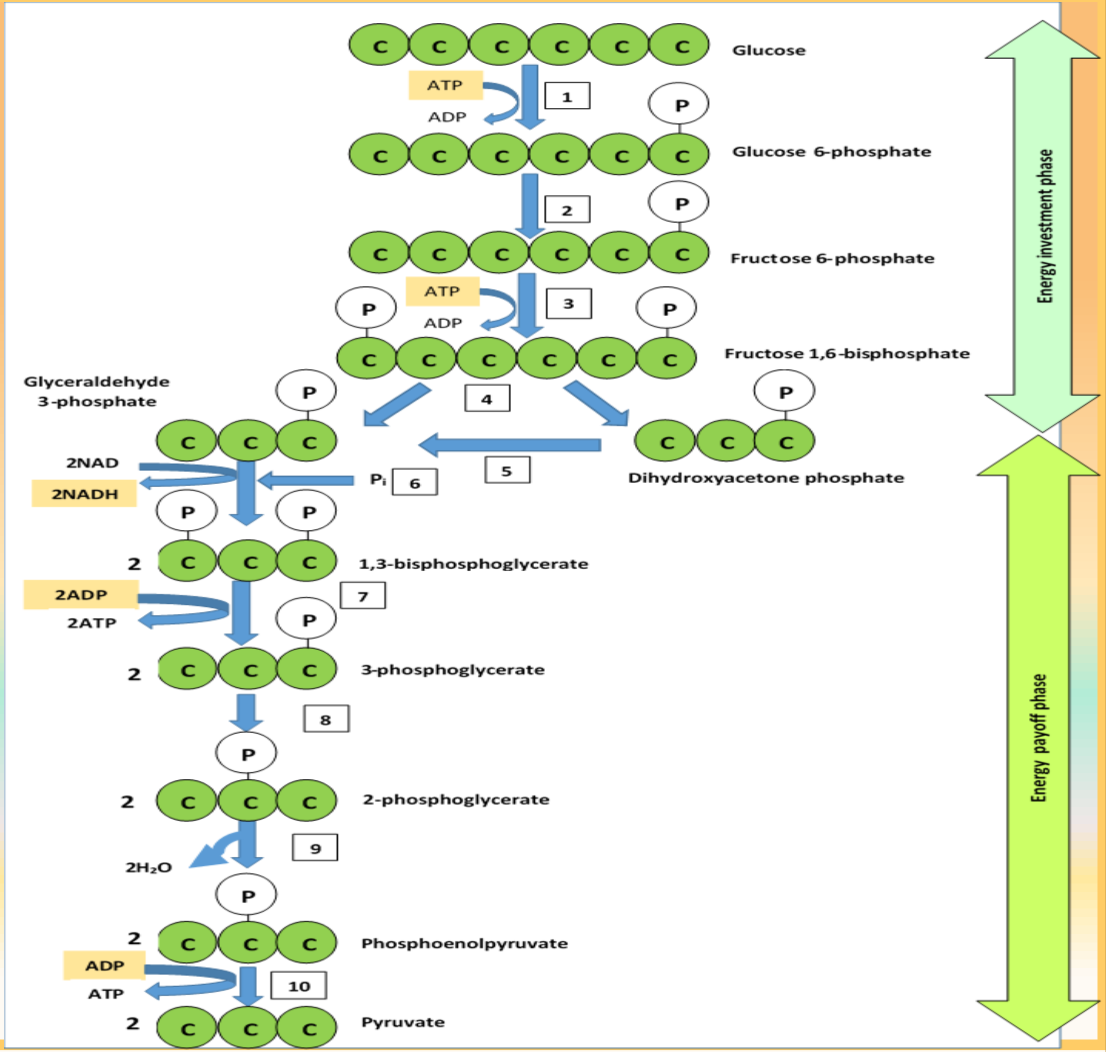
How Do Living Organisms Get Energy?



OVERVIEW OF AEROBIC RESPIRATION



- A catabolic pathway for **organic molecules (glucose)**
- Using **oxygen** as the final electron acceptor in an electron transport chain and producing **ATP**.

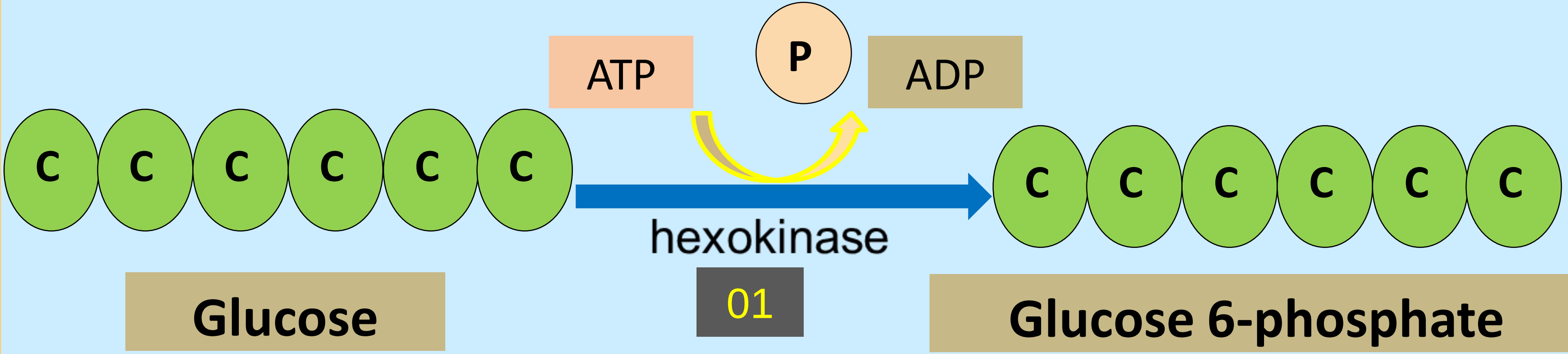


GLYCOLYSIS

- **"Splitting of Sugar"**
- In the **cytoplasm.**
- Break down glucose (6C) into **two** molecules of pyruvate (3C).
- Occurs with or without O_2 .
- Has two major phases:
  1) **Energy investment phase**
     - 2 ATP used
     - Phosphorylate Sugar
  2) **Energy payoff phase**
     - 4 ATP yielded

- Net ATP yield : **2 ATP**
- Produces : **2 NADH + 2H$^+$**
- No carbon is released as CO_2

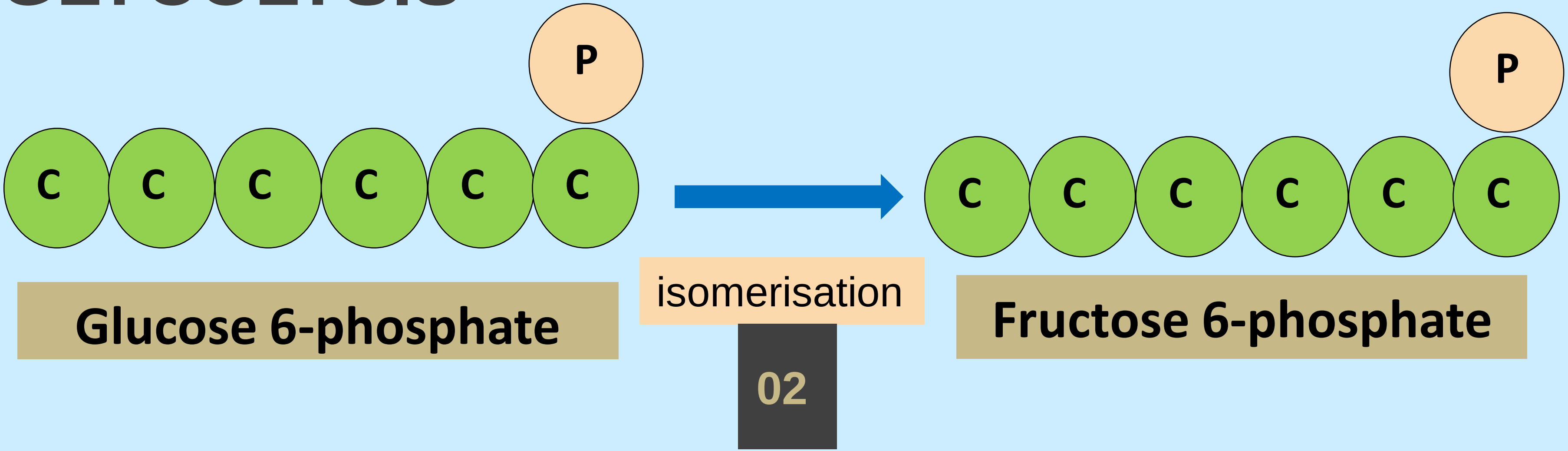
GLYCOLYSIS



01

- ✓Glucose undergoes phosphorylation to become glucose-6-phosphate.
- ✓Catalysed by hexokinase.
- ✓ATP is used.

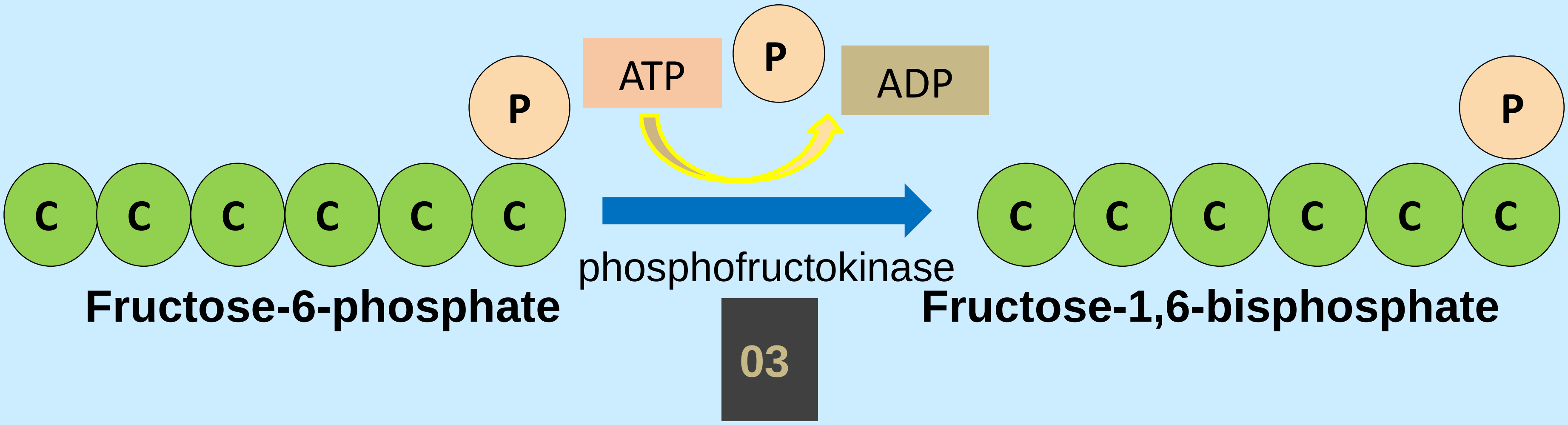
GLYCOLYSIS



02

✓Glucose-6-phosphate is converted to its isomer, fructose-6-phosphate.

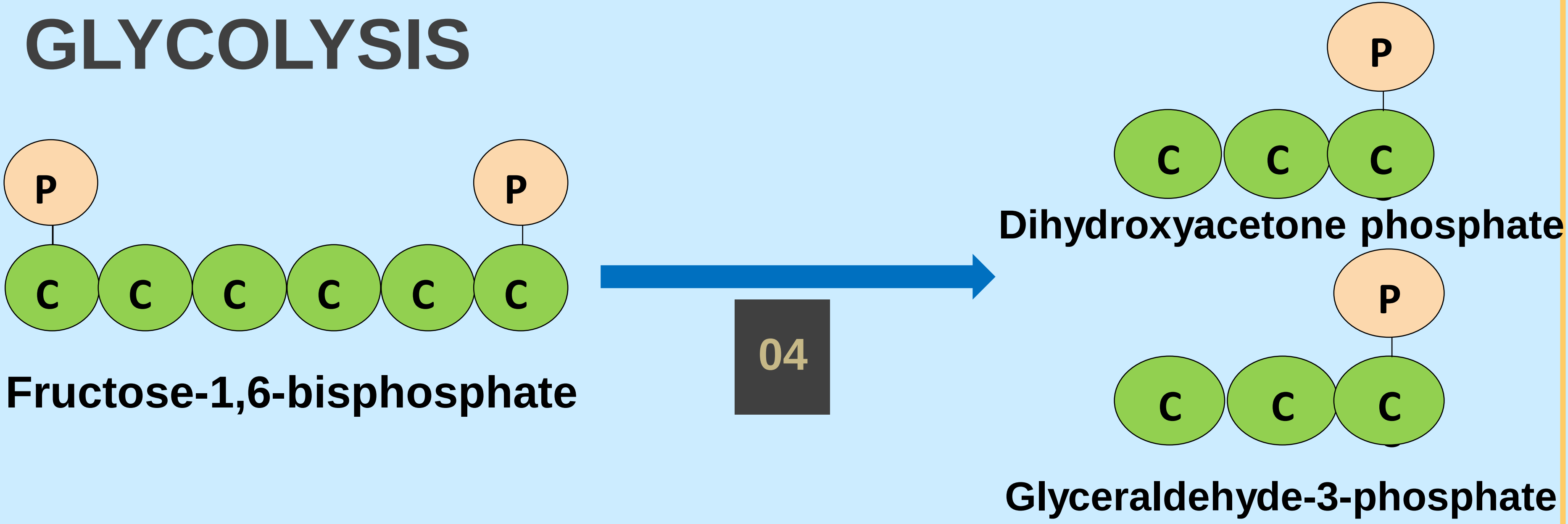
GLYCOLYSIS



03

- ✓Fructose-6-phosphate undergoes phosphorylation to become fructose-1,6-bisphosphate.
- ✓Catalysed by phosphofructokinase.
- ✓ATP is used.

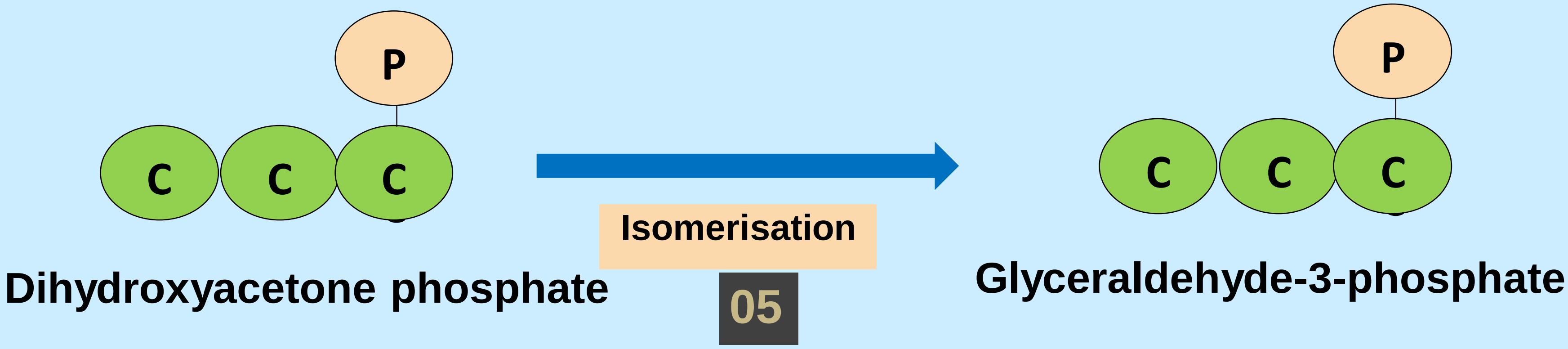
GLYCOLYSIS



04

✓Fructose-1,6-bisphosphate split into dihydroxyacetone phosphate & glyceraldehyde-3-phosphate.

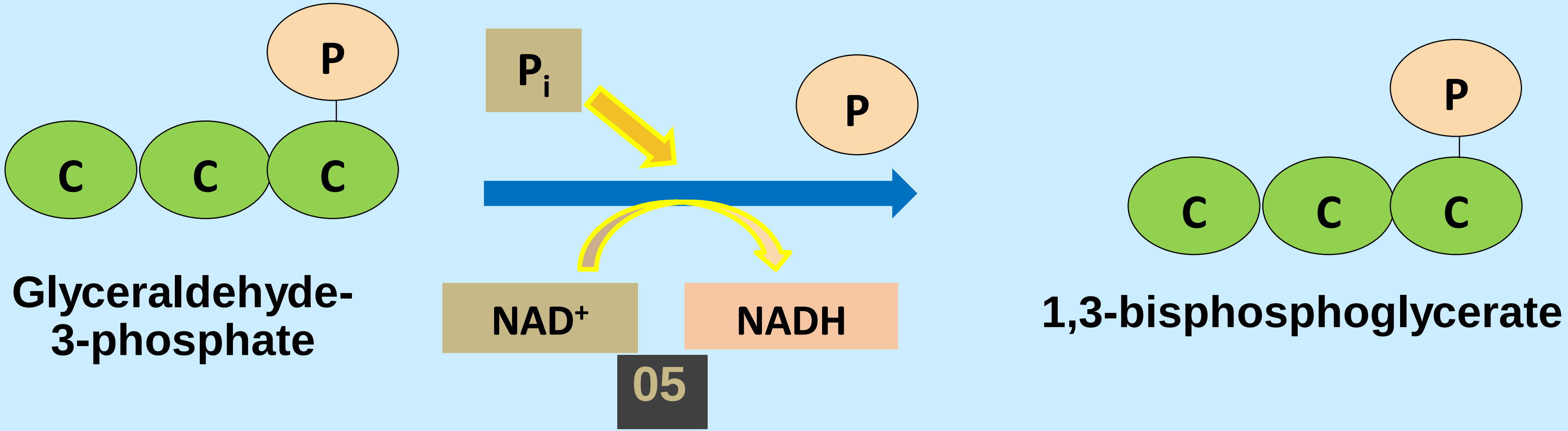
GLYCOLYSIS



05

✓Dihydroxyacetone phosphate is converted into glyceraldehyde-3-phosphate.

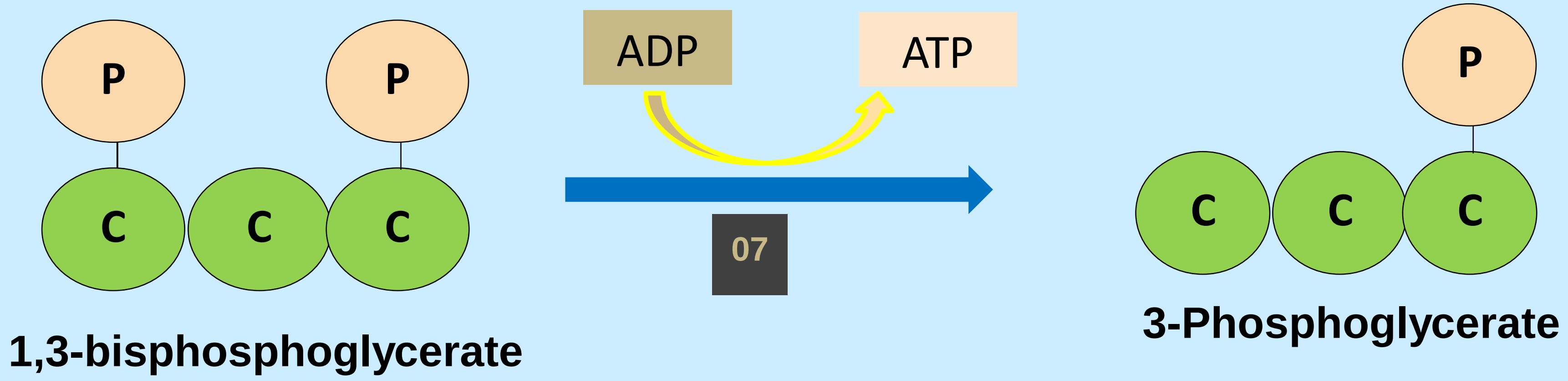
GLYCOLYSIS



06

- ✓Glyceraldehyde-3-phosphate is oxidized and undergoes phosphorylation to become 1,3-bisphosphoglycerate.
- ✓ NADH is produced.

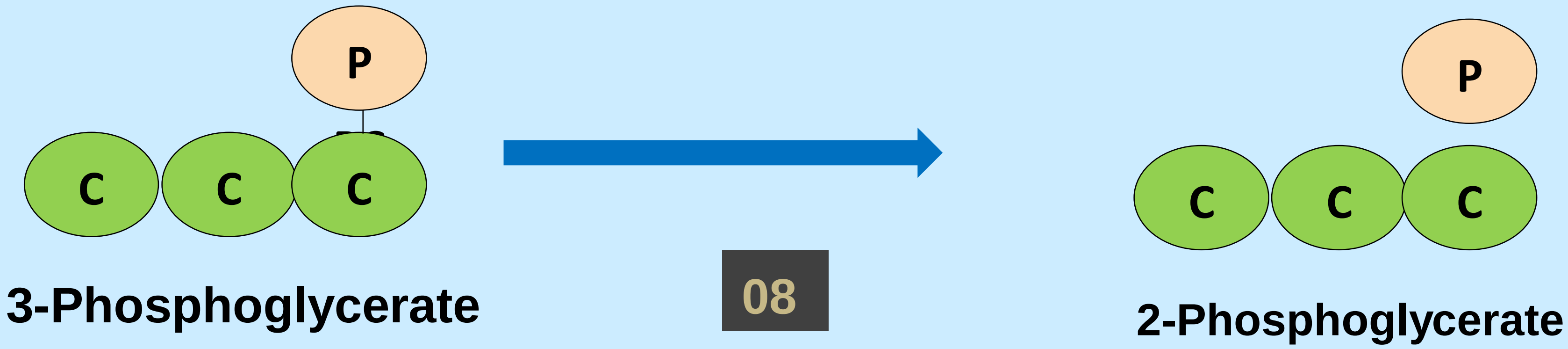
GLYCOLYSIS



07

- ✓Phosphate group of 1,3-bisphosphoglycerate is removed to become 3-phosphoglycerate.
- ✓ ATP is produced by substrate-level phosphorylation.

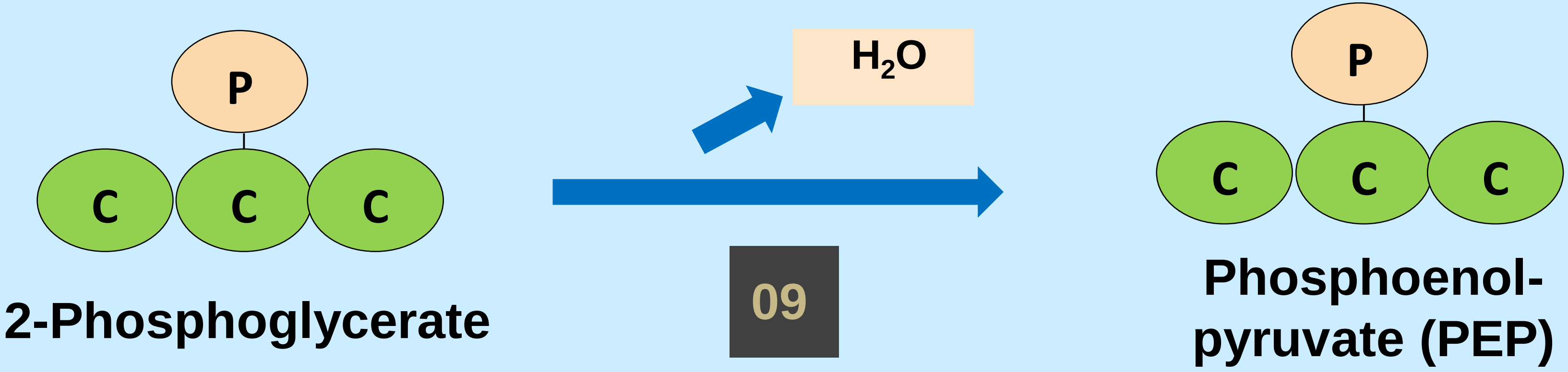
GLYCOLYSIS



08

✓ Phosphate group of 3-phosphoglycerate is relocated to become 2-phophoglycerate.

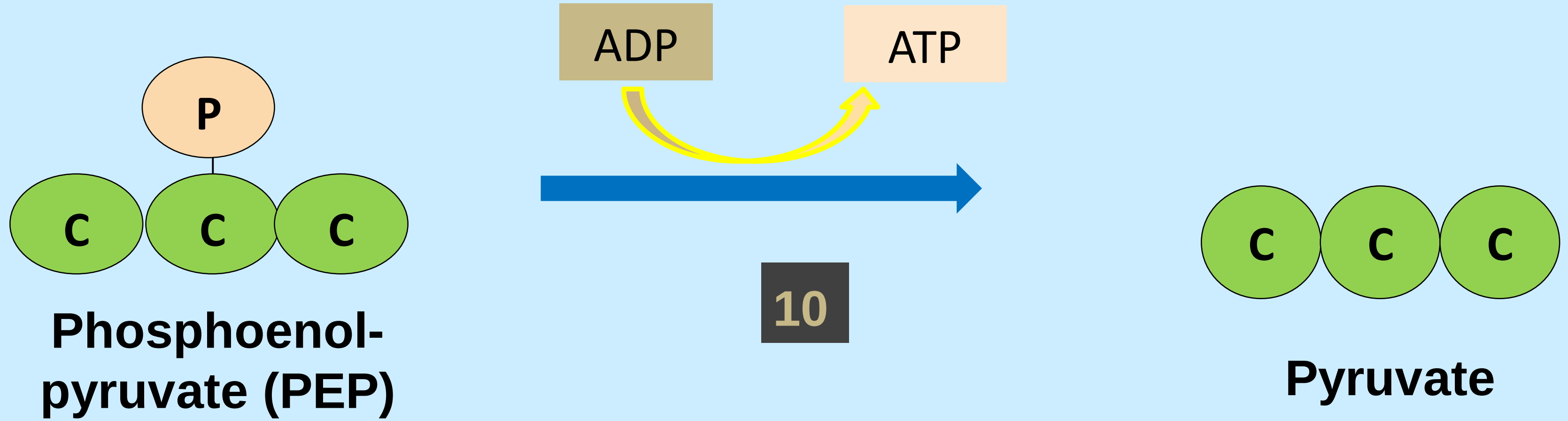
GLYCOLYSIS



09

- ✓ Water is removed from 2-phosphoglycerate to become phosphoenolpyruvate

GLYCOLYSIS



10

- ✓ Phosphate group of phosphoenolpyruvate is removed to become pyruvate.
- ✓ ATP is produced by substrate-level phosphorylation.

Summary of Glycolysis

Facts:

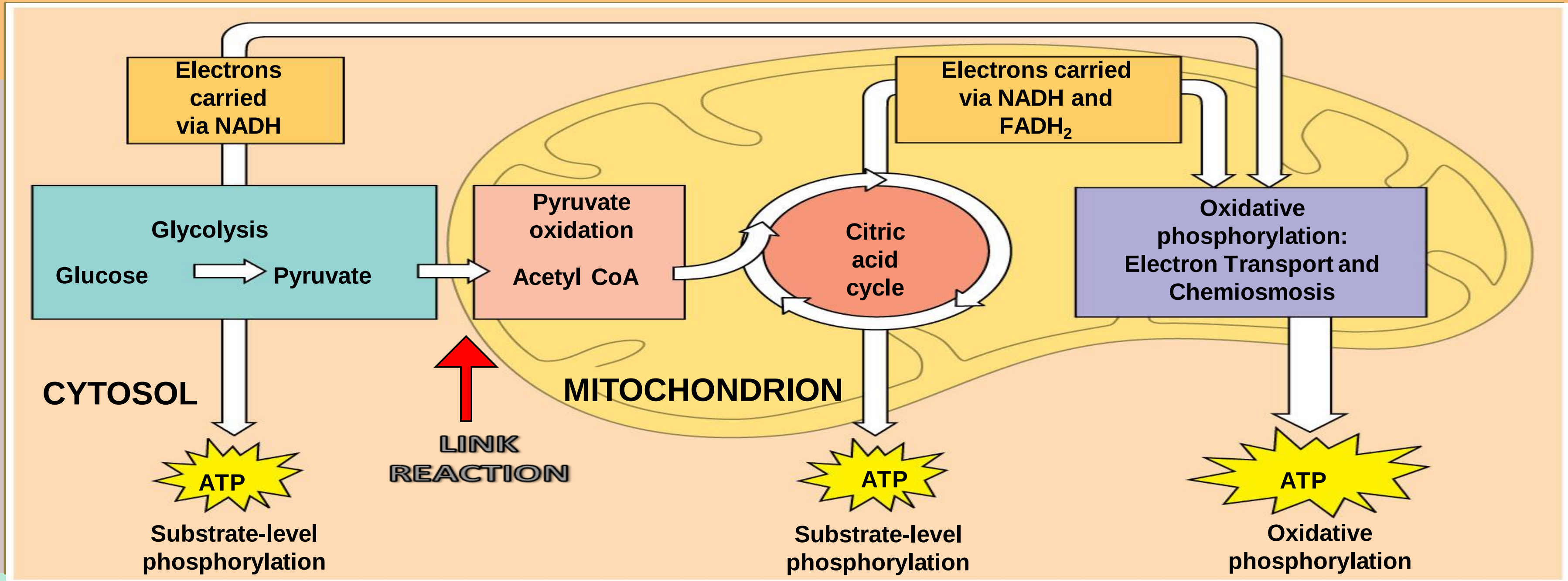
- ✓ 2 ATP used and 4 ATP produced
- ✓ Net ATP production : 2 ATP

For One molecule of Glucose

Products :

2 NADH
2 ATP
2 Pyruvate

LINK REACTION



LINK REACTION

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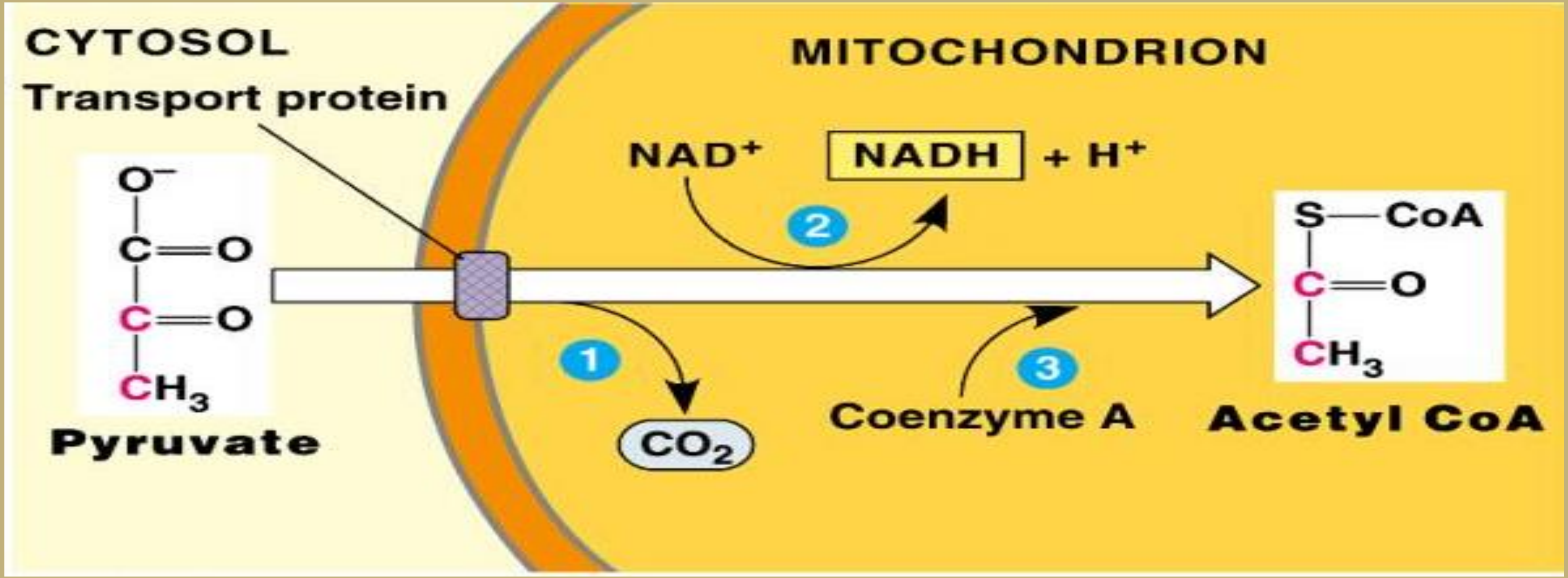
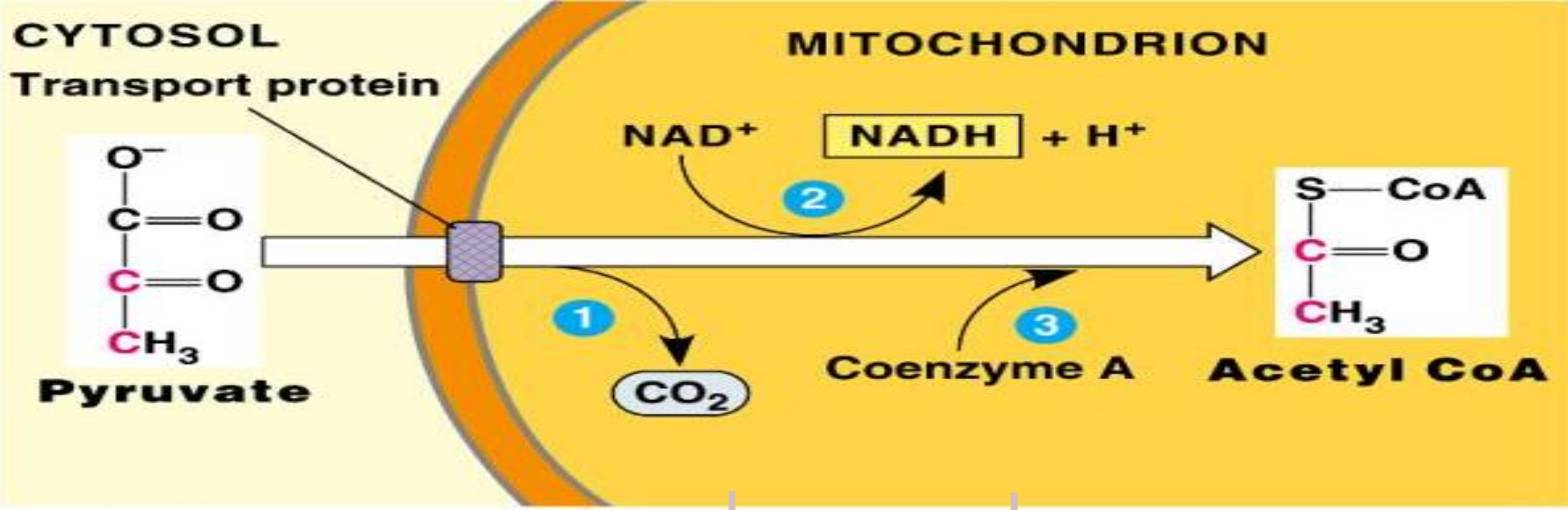


- In the presence of O_2.
- Pyruvate enters the mitochondrion by active transport.
- Occur TWICE per glucose molecule.
- Because 2 pyruvate produced from one molecule of glucose (Glycolysis).



01

- Oxidative decarboxylation
- Pyruvate (3C) undergoes oxidative decarboxylation to produce 2C sugar
- CO2 is released

02

- NADH is produced

03

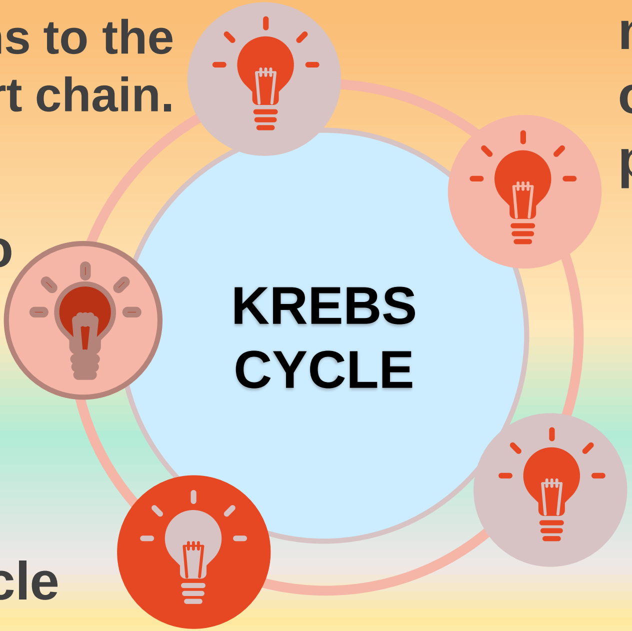
- Coenzyme A (CoA) attaches on 2C sugar to form Acetyl CoA.
- Acetyl CoA enters the Krebs cycle.

KREBS CYCLE

KREBS CYCLE

NADH and $FADH_2$ produced relay electrons to the electron transport chain.

Occur in mitochondrial matrix of eukaryotic cells or in the cytosol of prokaryotes.

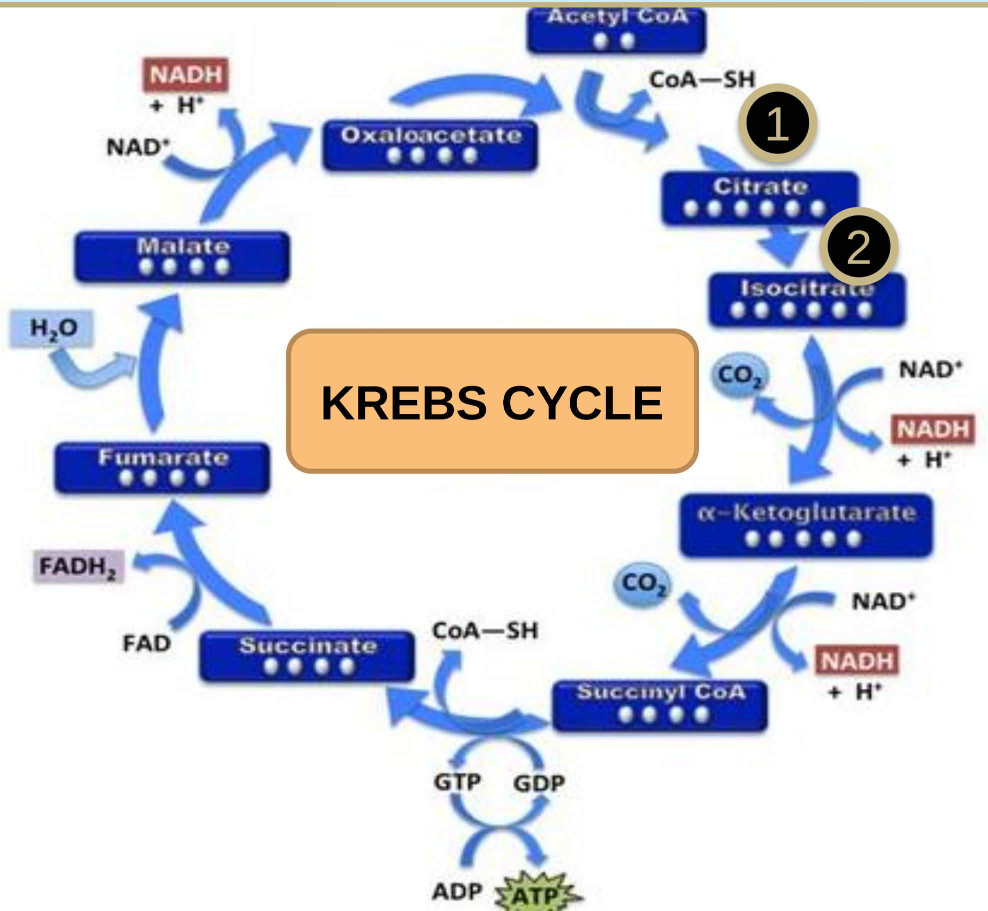


Oxidize acetyl CoA to carbon dioxide

Citric acid cycle/ Tricarboxylic acid cycle

Every acetyl CoA generate 1 ATP, 3 NADH and 1 $FADH_2$

KREBS CYCLE



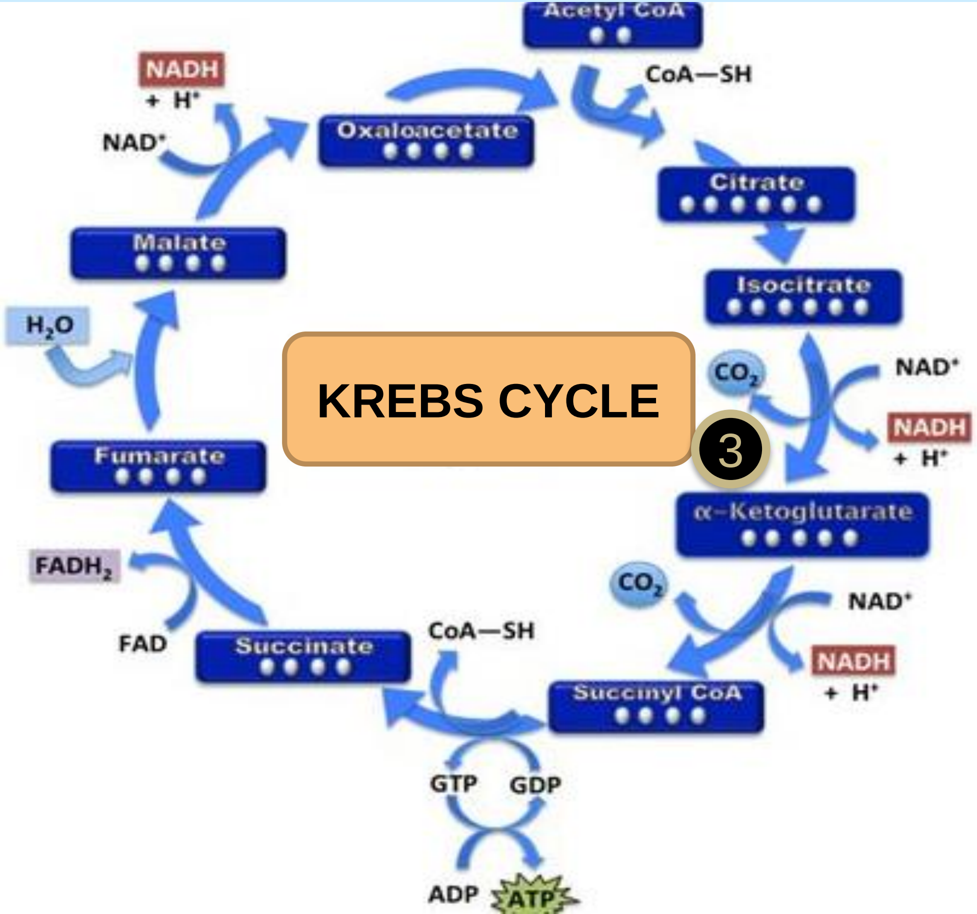
1

- The acetyl group (2C) of acetyl CoA combine with oxaloacetate (4C) to form citrate (6C).

2

- Citrate (6C) is converted to its isomer, isocitrate (6C).

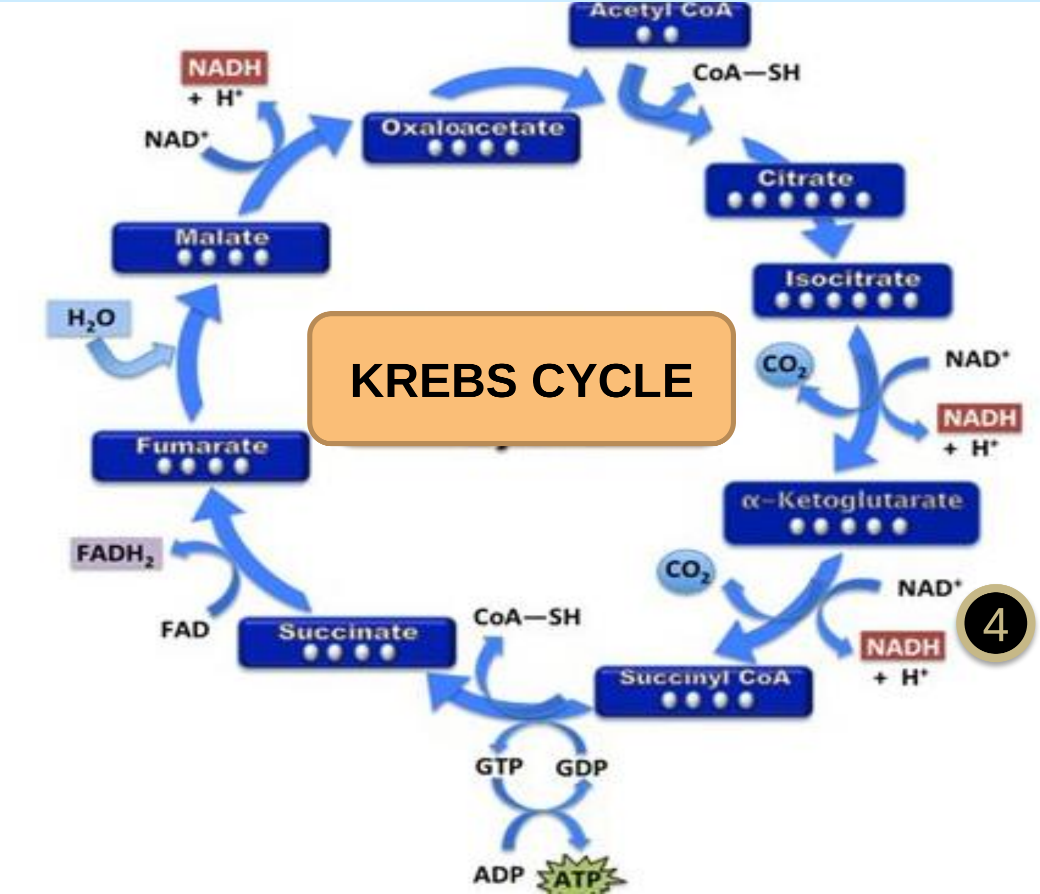
KREBS CYCLE



3

- Oxidative decarboxylation
- Isocitrate (6C) is oxidized and undergoes decarboxylation to become α-ketoglutarate (5C).
- NADH is produced.
- CO^2 is produced.

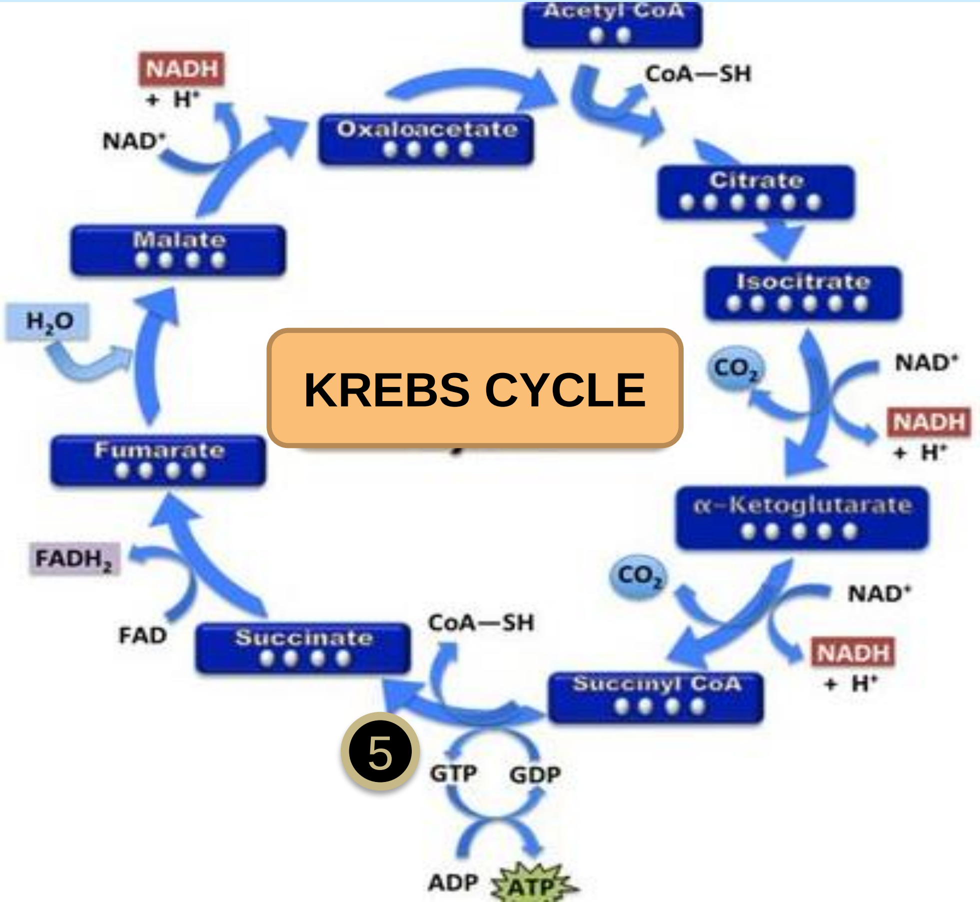
KREBS CYCLE



4

- Oxidative decarboxylation
- α-ketoglutarate (5C) is oxidized, undergoes decarboxylation and added with CoA to become succinyl CoA.
- NADH is produced.
- CO^2 is produced.

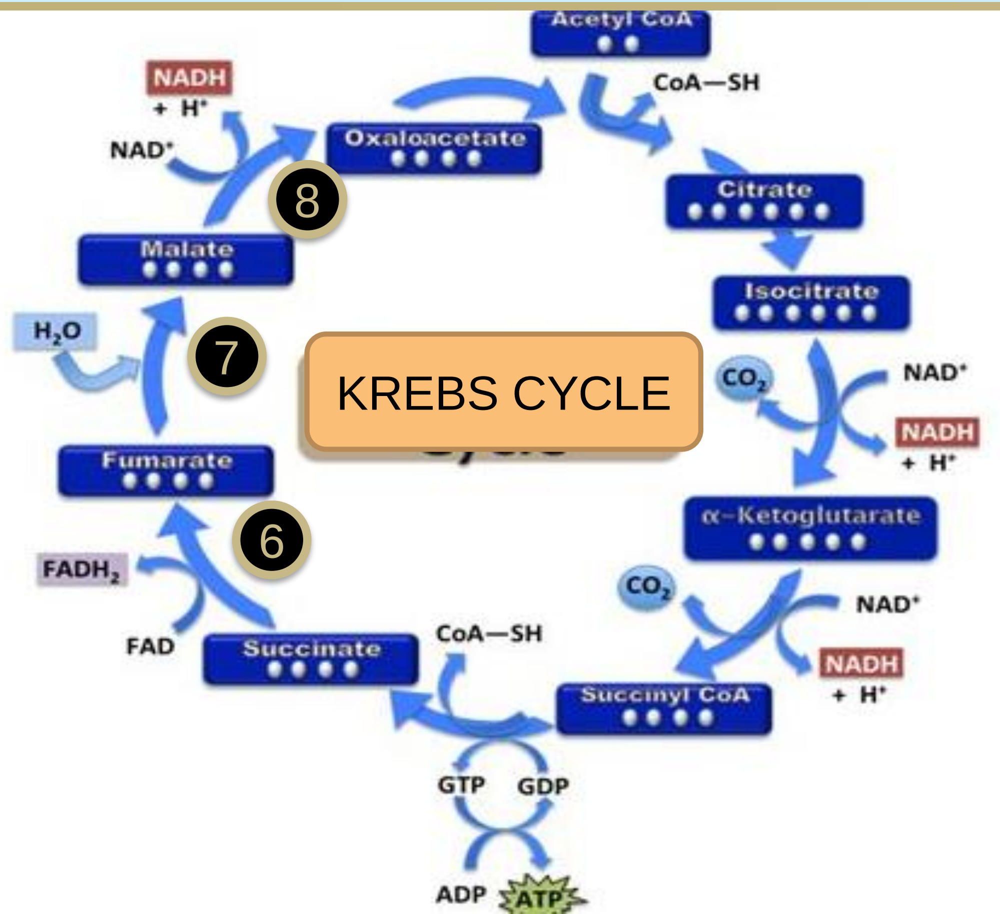
KREBS CYCLE



5

- CoA of succinyl CoA is replaced by a phosphate group, which is then transferred to ADP forming ATP. Succinate (4C) is produced.
- ATP is produced by substrate-level phosphorylation

KREBS CYCLE



6

- Succinate (4C) is oxidized to become fumarate (4C).
- $FADH_2$ is produced.

7

- Water is added to fumarate (4C), to produce malate (4C).

8

- Malate (4C) is oxidized to produce oxaloacetate (4C).
- NADH is produced.

Summary of Krebs Cycle

One turn of the Krebs Cycle yields:

- $2\ CO_2$
- $1\ FADH_2$
- 3 NADH
- 1 ATP

NADH and $FADH_2$ will feed into the electron transport chain

NEXT LECTURE :