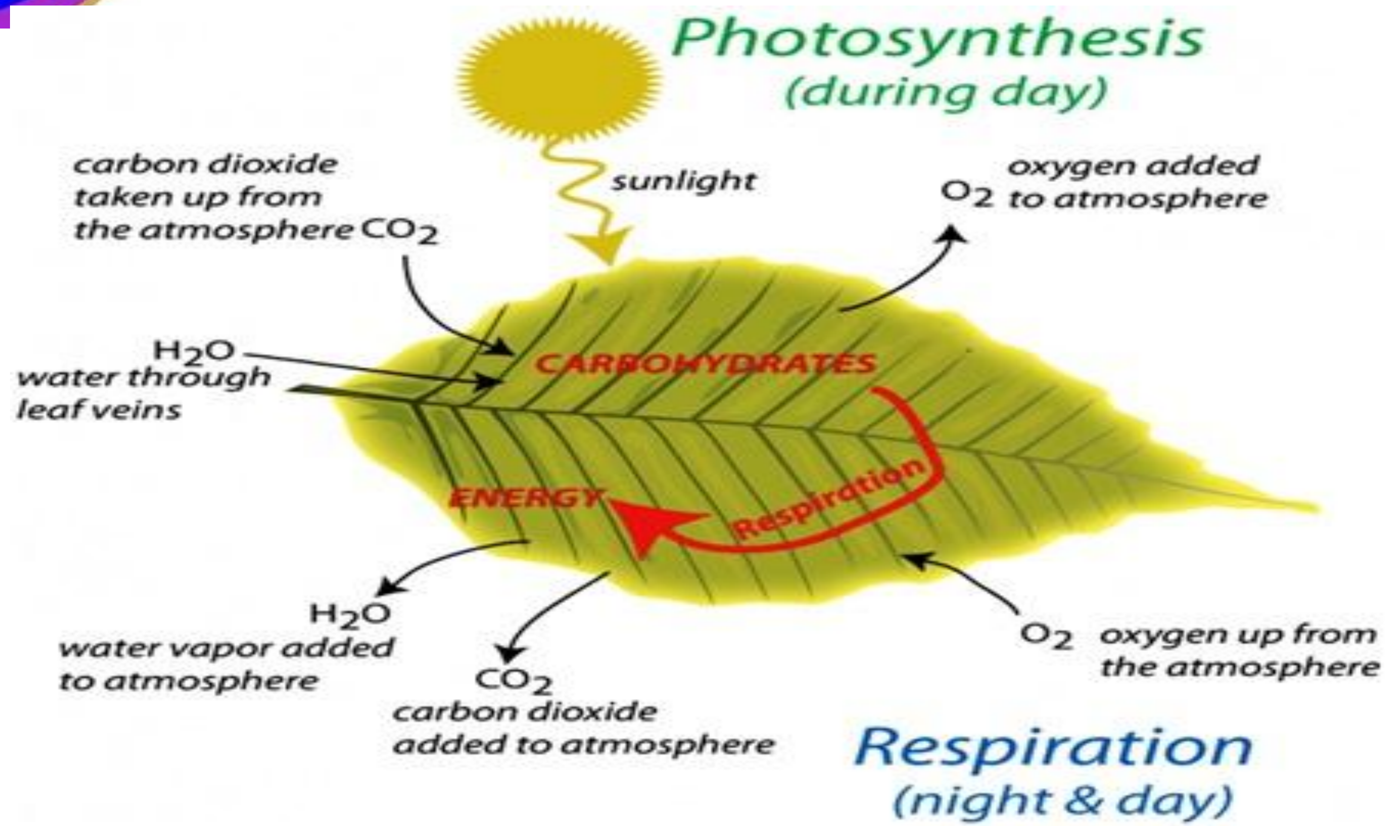
Bhagalpur National College, Bhagalpur

(A Constituent unit of Tilka Manjhi Bhagalpur University, Bhagalpur)

PPT Presentation- **Respiration (B.Sc.-III)**



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INTRODUCTION

- **Def.- Respiration** is the biochemical process in which the cells of an organism obtain energy by combining oxygen and glucose, resulting in the release of carbon dioxide, water, and **ATP** (the currency of energy in cells).

Types of Respiration

Aerobic respiration (38 ATP)

Glucose ($C_6 H_{12} O_6$) + $6O_2$ → $6CO_2$ + $6H_2O$+38ATP

Glycolysis

Non-aerobic respiration (2ATP)

Alcohol Fermentation

Ethyl alcohol

Lactic acid Fermentation

Formaldehyde

MECHANISM OF EXCHANGE OF GASES

- Plants require O_2 for respiration- no specialized organs for gaseous exchange but have *Stomata & lenticels*

Reasons why plants don't need Respiratory organs:

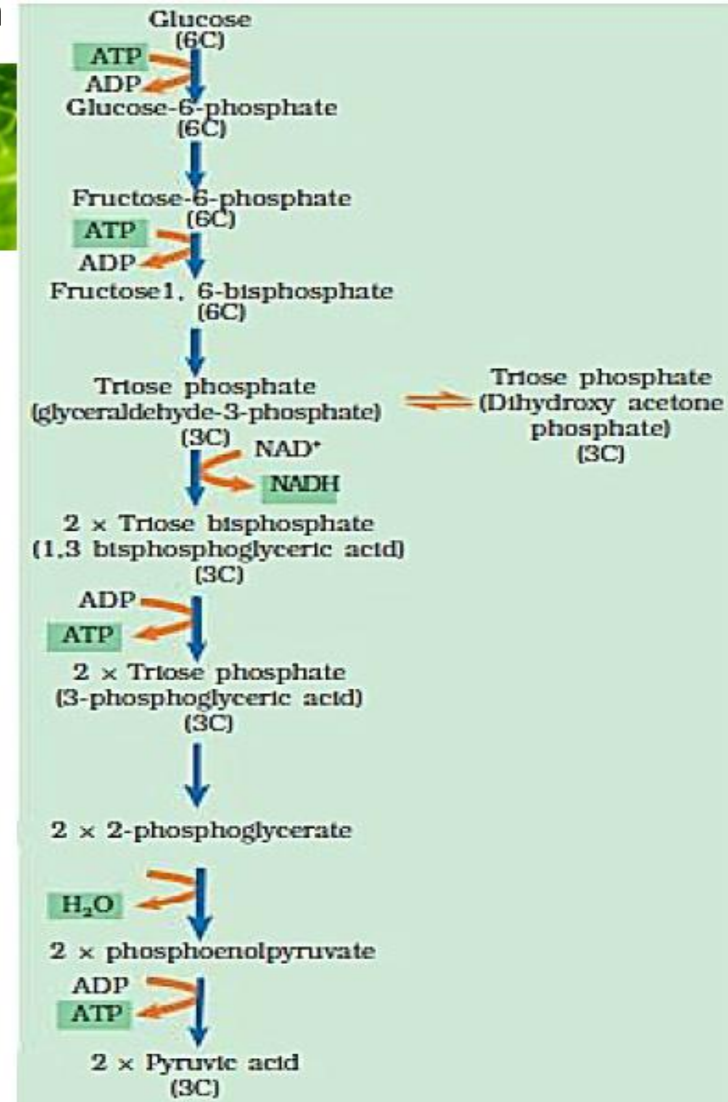
1. Each plant part takes care of its own gas-exchange needs. There is very little transport of gases from one plant part to another.
2. Plants do not present great demands for gas exchange. Respiration in plants is far low than animals. So O_2 requirement will be met by photosynthesis where O_2 will be directly released into cells
3. Diffusion of gases- less; living cells- located close to the surface of plants; Eg.- Thick woody stems- living cells are organised as thin layer beneath bark, opening- *lenticels*; Most cells or part- contact with air; loose packing of parenchyma cells in leaves, stems and roots- provide an interconnected network of air spaces.

Aerobic respiration

a) *Glycolysis (in Cytoplasm) — Kreb cycle — Electron Transport Chain

* Common to both aerobic and anaerobic respiration

1. Sucrose- converted to glucose & fructose- *invertase* & enters glycolytic pathway
2. Glucose phosphorylated to glucose- 6-phosphate- *hexokinase & ATP→ ADP*
3. Glucose- 6- phosphate isomerises to Fructose- 6- phosphate- *isomerase*
4. Fructose 6- phosphate converts to Fructose 1,6- diphosphate- *kinase & ATP→ ADP*
5. Fructose 1,6- diphosphate splits to Dihydroxy acetone phosphate (3C) & 3- phosphoglyceraldehyde (3C, PGAL) which isomerises between them



6. 3- phosphoglyceraldehyde converts to 1,3- diphosphoglyceric acid (DPGA)- *Dehydrogenase,* $NAD^+ \rightarrow NADH + H$

7. 1, 3 diphosphoglyceric acid converts to 3- phosphoglyceric acid (PGA)- *Kinase & ADP→ ATP*

8. 3- phosphoglyceric acid converts to 2- phosphoglyceric acid

9. 2- phosphoglyceric acid converts to Phosphoenolpyruvate, *Enolase,* H_2O

10. Phosphoenolpyruvate then form **pyruvic acid,** *Pyruvate kinase, ADP→ ATP*

- Fate of pyruvic acid depends on cellular need of cell:

i. Lactic acid fermentation- anaerobic, prokaryotes & uni. eukaryotes

ii. Alcoholic fermentation

iii. Aerobic respiration/ Kreb- Aerobic, complete oxidation to CO_2 & H_2O

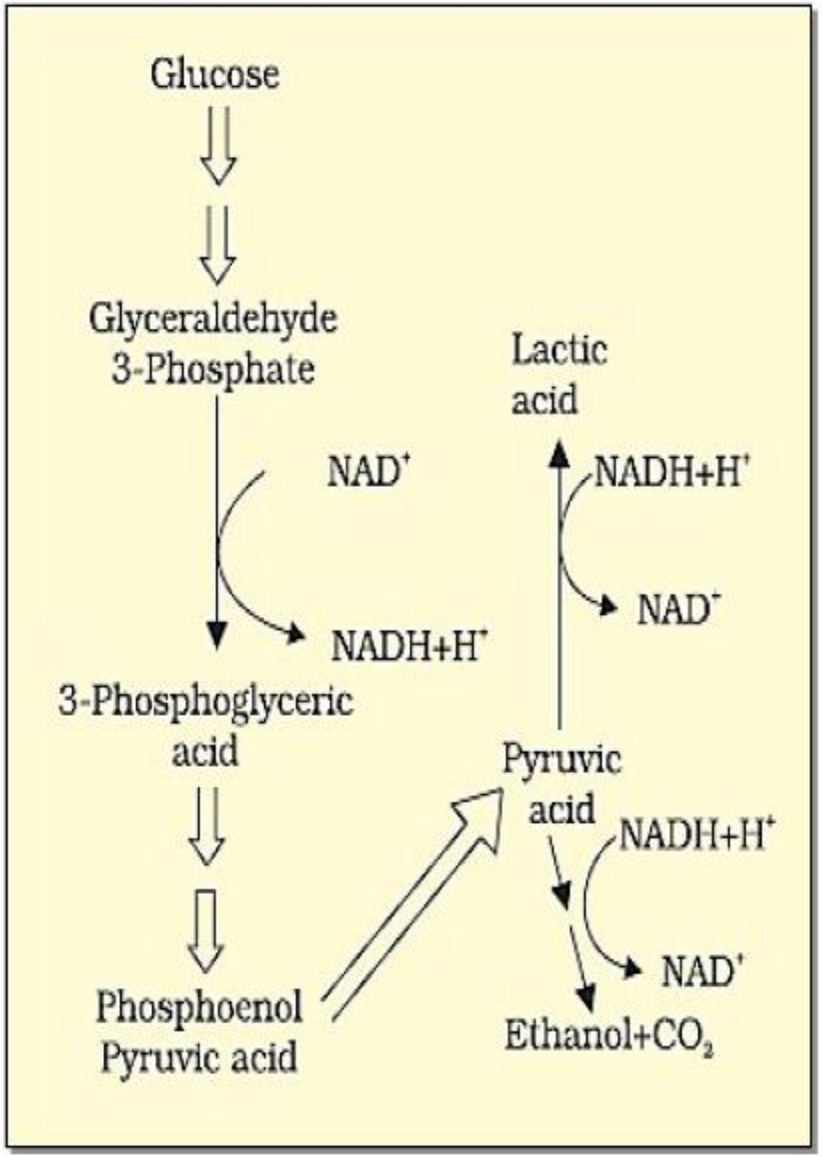
FERMENTATION

- There are three major ways in which different cells handle pyruvic acid produced by glycolysis:

1. Lactic acid fermentation.
2. Alcoholic fermentation.
3. Aerobic respiration.

LACTIC ACID FERMENTATION

- Pyruvic acid converted into lactic acid.
- It takes place in the muscle in anaerobic conditions.
- The reaction catalysed by lactate dehydrogenase.
- $NADH + H^+$ is reoxidised into NAD^+.



ALCOHOLIC FERMENTATION

- Incomplete oxidation of glucose- anaerobic
- Sets of reactions where pyruvic acid is converted into CO_2 and ethanol.
- The enzyme *pyruvic acid decarboxylase* and *alcohol dehydrogenase* catalyze these reactions.
- $NADH + H^+$ is reoxidised into NAD^+.

- Energy release- less than 7% of energy in glucose
- Yeast poisons to death when concentration of alcohol reaches about 13 peecent

Aerobic Respiration

- Complete oxidation of glucose & energy extraction- synthesize ATP
- Common in higher organisms & takes place within mitochondria
- requires O_2 and releases CO_2, water and a large amount of energy present in the substrate.

AEROBIC RESPIRATION

- Pyruvic acid enters into the mitochondria.
- Two main event of process:

i. Complete oxidation of pyruvate by the stepwise removal of all the hydrogen atoms, leaving three molecules of CO_2 - Matrix of mitochondria.

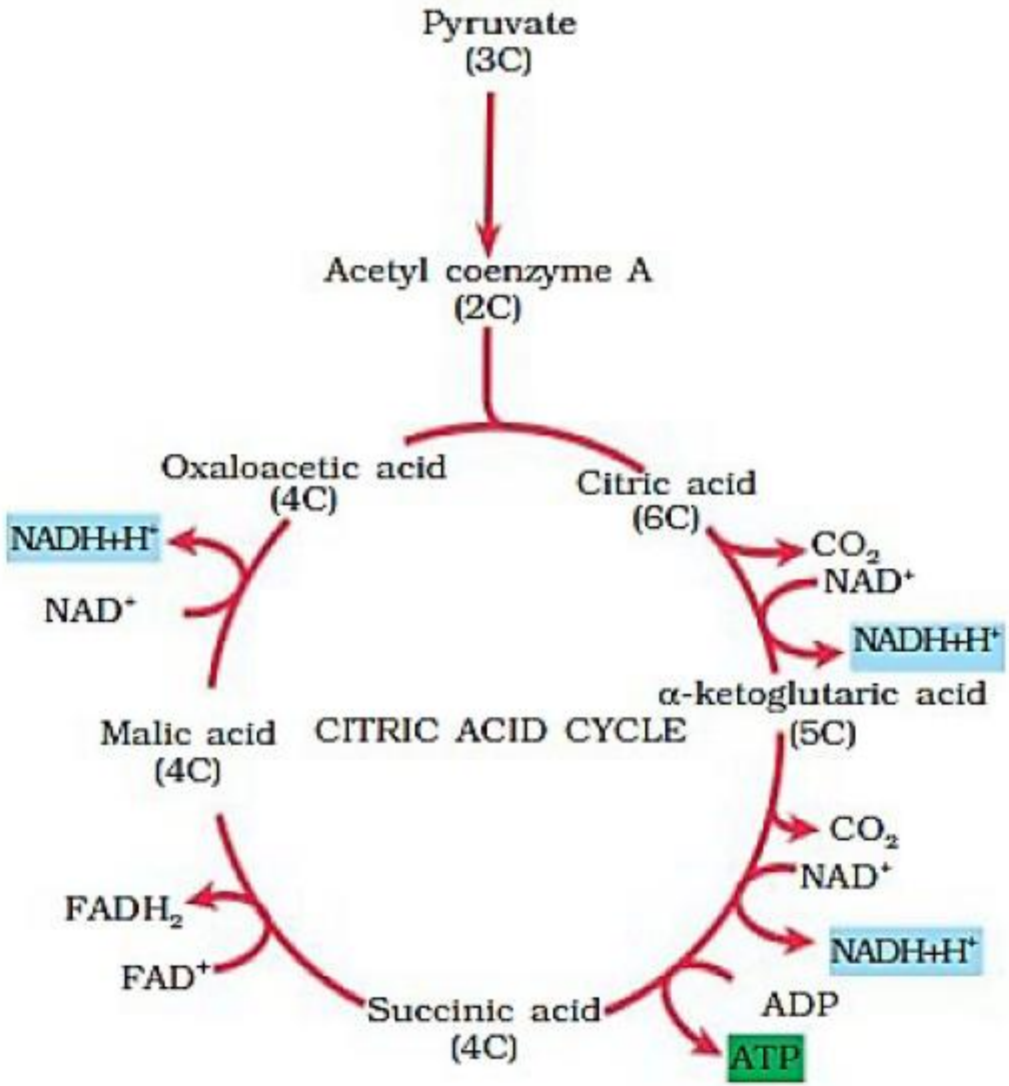
ii. The passing on the electrons removed as part of the hydrogen atoms to molecular oxygen (O_2) with simultaneous synthesis of ATP- inner membrane of mitochondria.

- Pyruvate enters from cytosol to mitochondrial matrix & undergoes oxidative decarboxylation- *Pyruvic dehydrogenase, coenzyme A & NAD^+* - 2 NADH produced from one molecule of glucose

$$\text{Pyruvic acid} + \text{CoA} + \text{NAD}^+ \xrightarrow[\text{Pyruvate dehydrogenase}]{\text{Mg}^{2+}} \text{Acetyl CoA} + CO_2 + \text{NADH} + H^+$$

Tricarboxylic acid cycle

- *Condensation* of acetyl group with oxaloacetic acid and water- citric acid- *citrate synthase.*
- *Isomerisation* of Citrate to form isocitrate.
- *Decarboxylation* for two successive steps, leading to formation of α-ketoglutaric acid and then succinyl-CoA.
- *Oxidation* of succinyl CoA into oxaloacetic acid.



- During conversion of succinyl CoA to succinic acid there is synthesis of one GTP molecule.
- In a coupled reaction GTP converted to GDP with simultaneous synthesis of ATP from ADP.
- During Krebs cycle there production of :
  - 2 molecule of CO_2, 3 $NADH_2$, 1 $FADH_2$, 1 GTP.

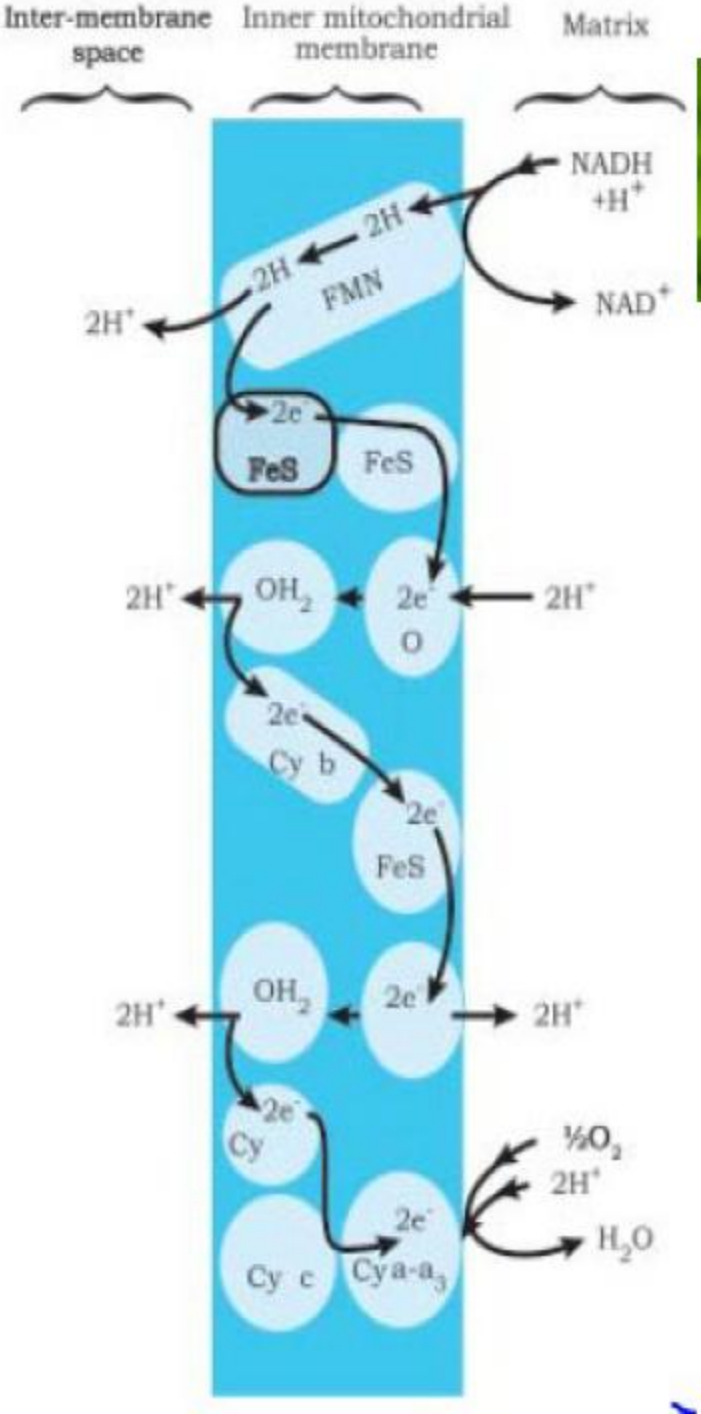
$$\text{Pyruvic acid} + 4NAD^+ + FAD^+ + 2H_2O + ADP + Pi \xrightarrow{\text{Mitochondrial Matrix}} 3CO_2 + 4NADH + 4H^+ + FADH_2 + ATP$$

- During the whole process of oxidation of glucose produce:
- CO_2, 10 $NADH_2$, 2 $FADH_2$, 2 GTP.(2 ATP)

ELECTRON TRANSPORT SYST
OXIDATIVE PHOSPHORYLATI

- The metabolic pathway, through which the carrier to another, is called **Electron trans**
- it is present in the inner mitochondrial mem
- ETS comprises of the following:
  - Complex I – NADH Dehydrogenase.
  - Complex II – succinate dehydrogenase.
  - Complex III – cytochromes bc1
  - Complex IV – Cytochromes a-a_3(cytoch
  - Complex V – ATP synthase.

1. $NADH_2$ produced in citric acid cycle oxidize *Dehydrogenase*- electrons are then transfe in the inner membrane.
2. $FADH_2$ is oxidized by *succinate dehydroger* electrons to ubiquinone

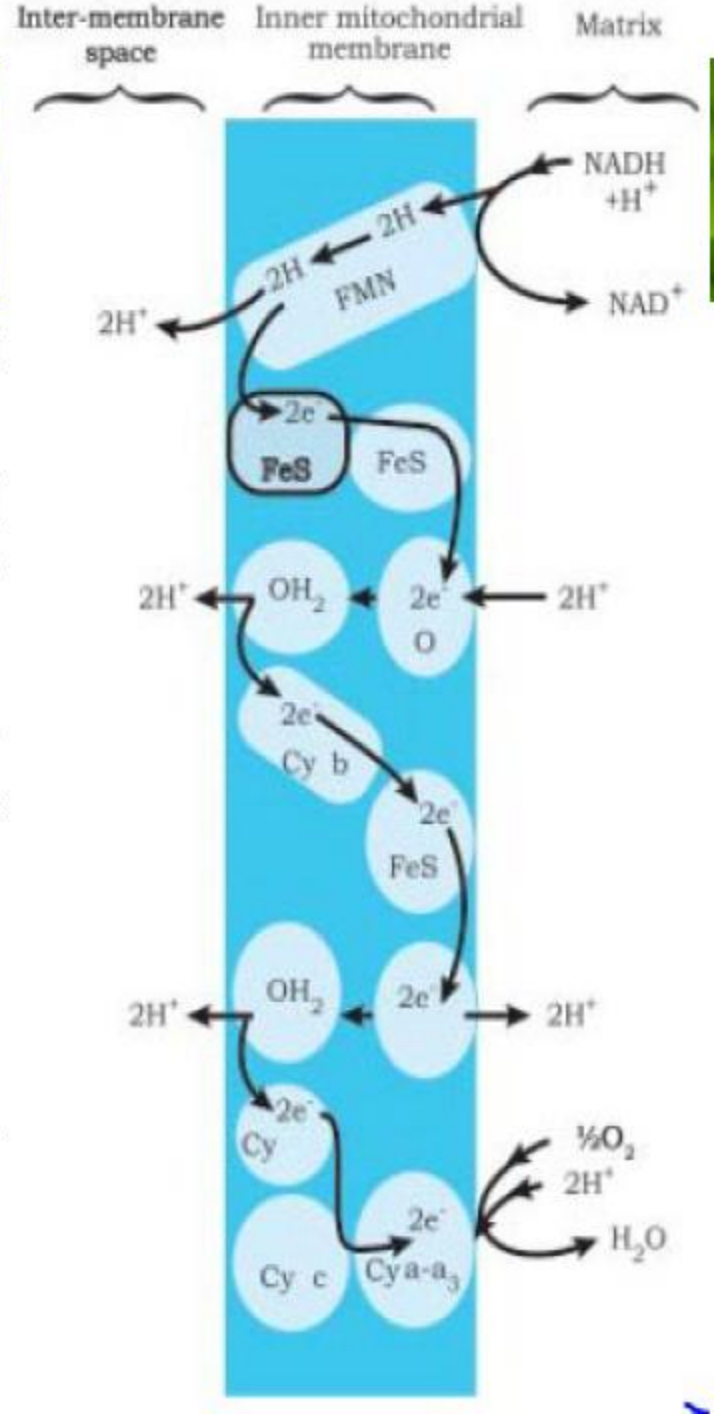


3. The reduced ubiquinone is then oxidized wi
cytochrome *c* via cytochromes *bc1* complex.

4. Cytochrome c is small protein attached to tl
inner membrane and acts as a mobile carrier
complex III and complex IV.

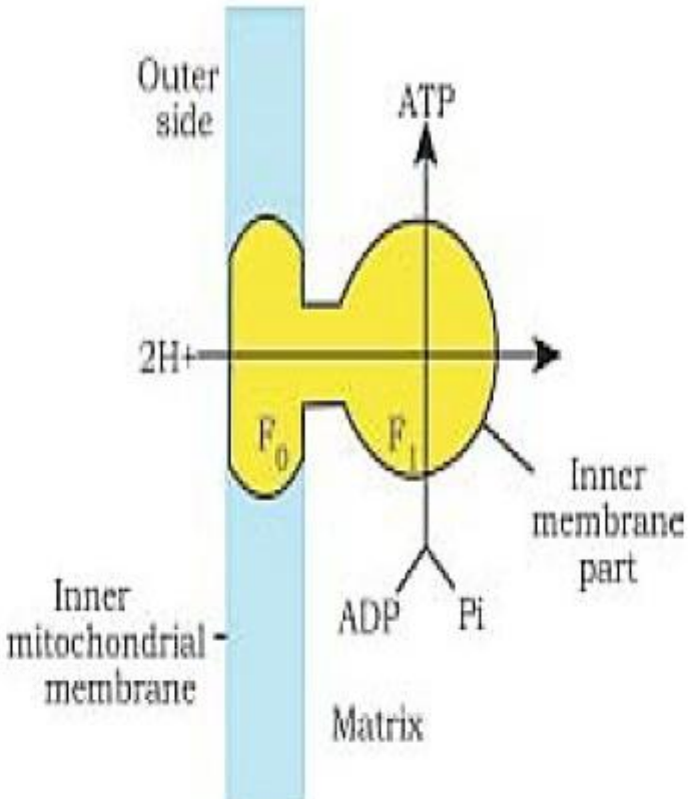
5. When electrons transferred from one carrie
to IV in the electron transport chain, they are
(complex V) for the synthesis of ATP from AD

- One molecule of $NADH_2$ gives rise to 3 ATP.
- One molecule of $FADH_2$ gives rise to 2ATP.
- Oxygen plays a vital role in removing electror
production of H_2O.
- Phosphorylation in presence of oxygen is cal
phosphorylation.



STRUCTURE OF ATP SYNTHASE

- Energy released utilised in synthesising ATP with the help of ATP synthase (complex V).
- Complex consists of two major components, F1 and F0; F1 headpiece is a peripheral membrane protein complex and contains the site for synthesis of ATP from ADP & Pi.
- F0 is an integral membrane protein complex that forms the channel through which protons cross the inner membrane.
- The passage of protons through the channel is coupled to the catalytic site of the F1 component for the production of ATP.
- For each ATP produced, 2H+ passes through F0 from the intermembrane space to the matrix down the electrochemical proton gradient



RESPIRATORY BALANCED SHEET

- These calculations can be made only on certain assumptions that:

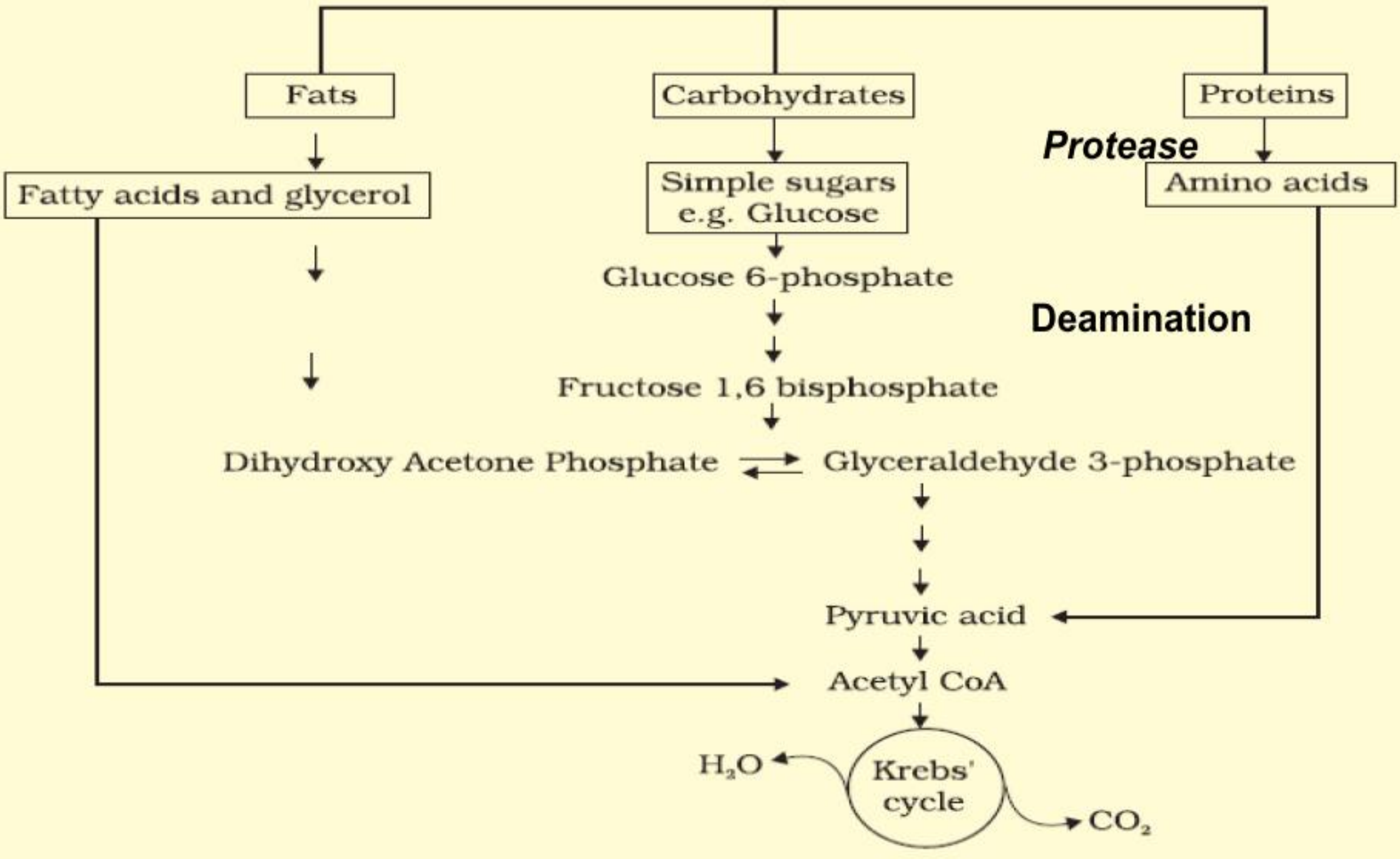
1. There is a sequential, orderly pathway functioning, with one substrate forming the next and with glycolysis, TCA cycle and ETS pathway following one after another.
2. The NADH synthesised in glycolysis is transferred into the mitochondria and undergoes oxidative phosphorylation.
3. None of the intermediates in the pathway are utilised to synthesise any other compound.
4. Only glucose is being respired – no other alternative substrates are entering in the pathway at any of the intermediary stages.

- Net gain of 36 ATP molecules during aerobic respiration of one molecule of glucose.

Fermentation and Aerobic Respiration

1. Fermentation accounts for only a partial breakdown of glucose whereas in aerobic respiration it is completely degraded to CO2 and H2O.
2. In fermentation there is a net gain of only two molecules of ATP for each molecule of glucose degraded to pyruvic acid whereas many more molecules of ATP are generated under aerobic conditions.
3. NADH is oxidised to NAD+ rather slowly in fermentation, however the reaction is very vigorous in case of aerobic respiration.

AMPHIBOLIC PATHWAY



RESPIRATORY QUOTIENT

- The ratio of the volume of CO2 evolved to the volume of O2 consumed in respiration is called the **respiratory quotient** (RQ) or respiratory ratio.

$$RQ = \frac{\text{volume of } CO_2 \text{ evolved}}{\text{volume of } O_2 \text{ consumed}}$$

- Depends on respiratory substrates
- Carbohydrate: Completely oxidised, RQ= 1, CO2 & O2- equal amount evolved & consumed

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

$$RQ = \frac{6CO_2}{6O_2} = 1.0$$

- Fats: RQ= less than 1

$$\underset{\text{Tripalmitin}}{2(C_{51}H_{98}O_6)} + 145O_2 \longrightarrow 102CO_2 + 98H_2O + \text{energy}$$

$$RQ = \frac{102CO_2}{145O_2} = 0.7$$

- Proteins: RQ= 0.9

Thank you