METABOLIC DIVERSITY AMONG MICRO-ORGANISMS

Presented By :-
Miss. Ashwini M. Devarshe
Assistant Professor
RSML Latur.

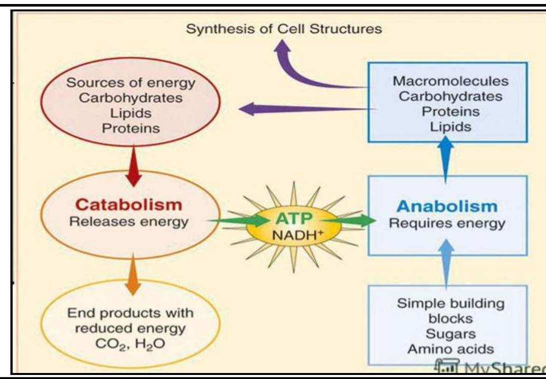
BACTERIAL METABOLISM

METABOLISM: The sum of the biochemical reactions required for energy generation and the use of energy to synthesize cell material from small molecules in the environment.

Metabolism → Catabolism + anabolism

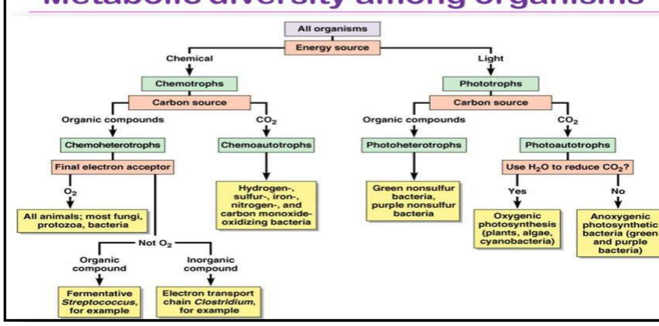
Catabolism :→ Chemical reactions that result in the breakdown of more complex organic molecules into simpler substances Release energy (ATP; stored and used to power anabolic chemical reactions)

Anabolism:→ Chemical reactions in which simpler substances are combined to form more complex molecules Require energy (ATP)



Carbon, Energy and Electron sources	
Carbon sources	
Autotrophs	CO_2 as sole carbon source
Heterotrophs	Organic substances from other organisms
Energy sources	
Phototroph	Light energy
Chemotrophs	Chemical energy source (Organic or Inorganic)
Electron sources	
Lithotrophs	Reduced inorganic substances
Organotrophs	Organic compounds

Bacterial metabolism
Metabolic diversity among organisms



Metabolic Diversity among Organisms

Nutritional Type	Energy Source	Carbon Source	Example
Photoautotroph	Light	CO_2	Oxygenic: Cyanobacteria plants Anoxygenic: Green, purple bacteria
Photoheterotroph	Light	Organic compounds	Green, purple nonsulfur bacteria
Chemoautotroph	Chemical	CO_2	Iron-oxidizing bacteria
Chemoheterotroph	Chemical	Organic compounds	Fermentative bacteria Animals, protozoa, fungi, bacteria.

Carbohydrate Catabolism

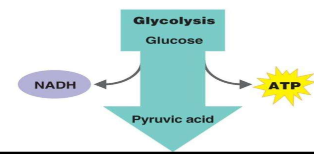
- The breakdown of carbohydrates to release energy
  - **Glycolysis**
  - **Krebs cycle**
  - **Electron transport chain**

A Summary of Respiration

- **Aerobic respiration**: The final electron acceptor in the electron transport chain is molecular oxygen (O_2).
- **Anaerobic respiration**: The final electron acceptor in the electron transport chain is not O_2 (rather an inorgainc molecules containing sulfate, nitrate, nitrite, carbonate, etc..).
  - Yields less energy than aerobic respiration because only part of the Krebs cycles operates under anaerobic conditions.

Glycolysis

- The oxidation of glucose to pyruvic acid produces ATP and NADH



Overall Result of Glycolysis

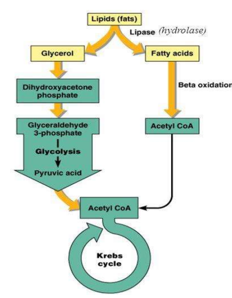
- Glucose + 2 ATP + 2 ADP + 2 PO_4^- + 2 NAD^+
  $\rightarrow$ 2 pyruvic acid + 4 ATP + 2 NADH + $2H^+$

Carbohydrate Catabolism

Pathway	Eukaryote	Prokaryote
Glycolysis	Cytoplasm	Cytoplasm
Intermediate step	Cytoplasm	Cytoplasm
Krebs cycle	Mitochondrial matrix	Cytoplasm
ETC	Mitochondrial inner membrane	Plasma membrane

Lipid Catabolism

- Lipases hydrolyze **lipids** into **glycerol** and **fatty acids.**
- Fatty acids and other hydrocarbons are catabolized by **beta-oxidation.**
- Catabolic products can be further broken down in **glycolysis** and the **Krebs cycle.**



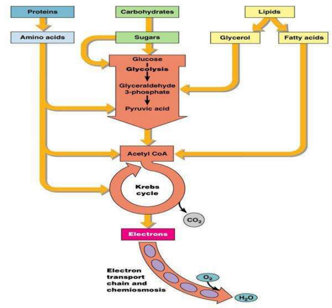
Protein Catabolism

Protein $\xrightarrow{\text{Extracellular proteases}}$ Amino acids

$\xrightarrow{\text{Deamination, decarboxylation, dehydrogenation}}$ Organic acid ⟶ **Krebs cycle**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Catabolism



Highly reduced complex molecules

Oxidized

$NAD^+ \rightarrow NADH$

Energy

ADP ⟶ **ATP**

BACTERIAL PHOTOSYNTHESIS

Photosynthesis

- Photosynthesis :→ Is the conversion of light energy into chemical energy in the form of ATP.
- Prokaryotes that can convert light energy into chemical energy include the photosynthetic cyanobacteria, the purple and green bacteria, halobacteria etc.
- Net equation:
  6CO 2 +12H2O+LightEnergy →C6H12O6+6O2+6H20

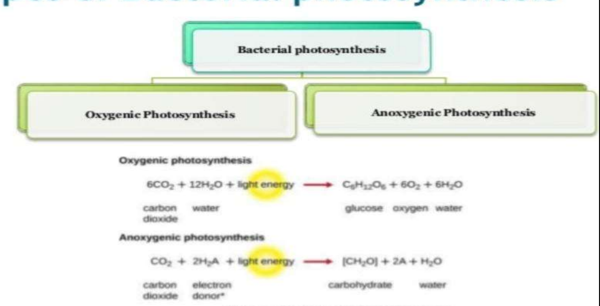
Photosynthetic reactions divided into two stages:

1} Light reaction – light energy is absorbed and converted to chemical energy such as ATP and NADPH.

2} Dark reaction- carbohydrates made from CO2 is stored in ATP & NADPH.

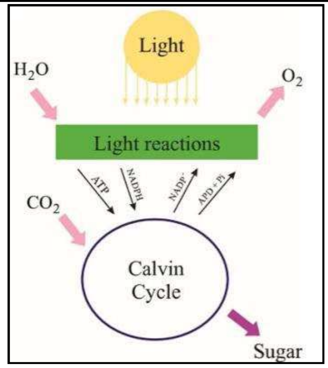
- Photosynthetic bacteria contain light absorbing pigments and reaction centres and capable of converting light energy into chemical energy.
- **Photosynthetic pigments**: Bacteriochlorophyll, carotenoids, bacteriorhodopsin, phycobilins.

Types of Bacterial photosynthesis



1. Oxygenic Photosynthesis :→

- Oxygenic photosynthetic bacteria are unicellular or multicellular and possess chlorophyll a.
- They perform photosynthesis in a similar manner to plants.
- They contain light-harvesting pigments (such as phycobilins, phycoerythrin), absorb CO2, and release oxygen.
- Eg. Cyanobacteria or Cyanophyta and prochlorophytes .
- The synthesis of carbohydrates results in release of molecular O2 and removal of CO2 from atmoshphere.

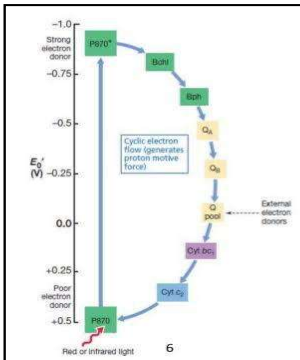


- It occurs in lamellae which house thylakoids containing chlorophyll a/b and phycobilisomes pigments to gather light energy.
- This process involves two photosystems (PS):
- PS II- which generates a proton-motive force for making ATP.
- PS I- which generates low potential electrons for reducing power.

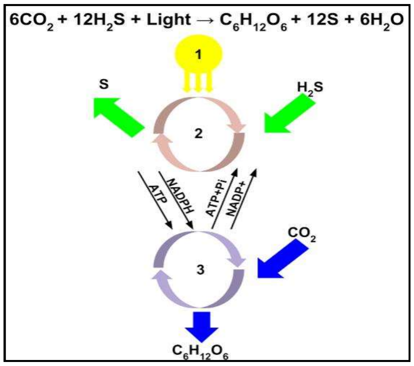
- Cyanobacteria perform photosynthesis using water as an electron donor in a similar manner to plants. This results in the production of oxygen and is known as oxygenic photosynthesis.
- Cyanobacteria are mostly found in water but can survive on land, in rocks, and even in animal shells (or fur), and in coral. They are also endosymbiont- they can live within the cells or body of another organism in a mutually beneficial way.

2. Anoxygenic Photosynthesis :→

- Anoxygenic photosynthetic bacteria consume CO2, light energy to create organic compounds, sulfur or fumarate compounds instead of O2.
- It occurs in purple bacteria, green sulfur bacteria, green gliding bacteria, Filamentous Anoxygenic Phototrophs (FAPs), Phototrophic Acidobacteria, and Phototrophic Heliobacteria.
- It uses bacteriochlorophyll instead of chlorophyll and involves one photosystem (PS I) to generate ATP in "cyclic" manner.



Electron flow in anoxygenic photosynthesis in a purple bacterium. Only a single light reaction occurs. Note how light energy converts a weak electron donor, P870, into a very strong electron donor, P870*. Bph, bacteriopheophytin; QA, QB, intermediate quinones; Q pool, quinone pool in membrane; Cyt, cytochrome.



- Purple bacteria can be divided into two main types –
1. Chromatiaceae :→ which produce sulfur particles inside their cells, and
2. Ectothiorhodospiraceae:→ which produce sulphur particles outside their cells.

- They cannot photosynthesize in places that have an abundance of oxygen.
- They are found in either stagnant water or hot sulfuric springs.
- Purple sulfur bacteria use hydrogen sulfide as their reducing agent(instead of using water to photosynthesize), releasing

- Green sulfur bacteria are generally non-motile and occurs in multiple shapes such as spheres, rods, and spirals.
- They are found in deep ocean and can survive in extreme conditions, like the other types of photosynthetic bacteria.
-

Applications of Photosynthetic Bacteria

- Water purification, bio-fertilizers, animal feed and bioremediation of chemicals among many others.
- They are used in the treatment of polluted water since they can grow and utilize toxic substances such as H2S or H2S203.