Nutrition in Bacteria

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Introduction :

Nutrition is substances used in biosynthesis and energy production and therefore are required for all living things.

Bacteria, like all living cells, require energy and nutrients to build protein and structural membranes and drive biochemical processes.

Bacteria are devoid of chlorophyll and they perform heterotrophic mode of nutrition. However, there is a small group of bacteria which are autotrophic.

On the basis of nutrition bacteria can be grouped under following sub –headings:-

1. **Autotrophic Bacteria:**

- They can synthesise carbohydrate from CO_2 like that of autotrophs. They are of two types: Photosynthetic bacteria or photosynthetic autotrophs and chemosynthetic bacteria or non-photosynthetic autotrophs.

a) **Photosynthetic autotrophs:**

- They can build the carbohydrate in presence of sunlight and carbon- dioxide. They grow in light and are commonly found in sulphur springs where hydrogen sulphide is commonly available as electron donor.

- **They are of the following types:**:

(i) Green sulphur bacteria:

- They are anaerobic photoautotrophs.
- Their photosynthetic pigment, chlorobium chlorophyll, is located in the invagination of plasma membrane towards the cytoplasm.
- Hydrogen sulphide (H_2S) or reduced inorganic sulphur compounds used as the donor of hydrogen.
- Light splits H_2S, and forms hydrogen which combines with CO_2 to form CH_2O. Sulphur is deposited extra- cellularly, e.g., *Chlorobium*,etc.

$$2H_2S + CO_2 \xrightarrow[\text{chlorobium chlorophyll}]{\text{light}} CH_2O + 2S + H_2O$$

(ii) Purple sulphur bacteria:

- Anaerobes and the photosynthetic pigment bacteriochlorophyli is located in the invagination of plasma membrane.
- The H_2S is oxidised anaerobically via elemental sulphur to sulphate e.g., *Thiocystis, Thiospirillum, Rhodospirillum* etc.
- $$2CO_2 + H_2S + 2H_2O \xrightarrow[\text{bacteriochlorophyll}]{\text{light}} 2CH_2O + H_2SO_4$$
- Some sulphur bacteria can use sulphite, thiosulphate etc., instead of H_2S.:
- Other two groups of photosynthetic autotrophs such as non-sulphur purple and brown bacteria are grown in stagnant water and mud.
- They have bacteriochlorophyli as photosynthetic pigment. They use organic acid like malic acid, propionic acid etc. as hydrogen donor and light as the source of energy ,e.g.,*Rhodospirillum, Rhodopseudomonas e*tc.

$$\underset{\text{(Malic acid)}}{C_4H_6O_5} \xrightarrow[\text{bacteriochlorophyll}]{\text{light}} 3(CH_2O) + CO_2$$

$$\underset{\text{(Propionic acid)}}{2C_3H_6O_2} + H_2O + CO_2 \xrightarrow[\text{bacteriochlorophyll}]{\text{light}} 7(CH_2O)$$

(b) Chemosynthetic autotrophs:

- Chemosynthetic bacteria are more abundant in nature than that of photosynthetic bacteria and are non-photosynthetic

- Get energy by the oxidation of certain inorganic substances such as nitrates, nitrites, ferrous compound, hydrogen sulphide and many other metallic or non-metallic substances.
- This energy is used to combine CO_2 and water into food molecules. This process is called chemosynthesis. It is an exothermic reaction. This group of bacteria is independent of light and organic material.

Depending on the substrate specificity, they are of the following types:

(i) Sulphur bacteria:

These bacteria oxidise sulphur compounds, thus energy being released and is utilised for food synthesis. **e.g., Beggiatoa:**

$$H_2S + \frac{1}{2}O_2 \xrightarrow{\textit{Beggiatoa}} S + H_2O + \text{Energy}$$

Another type which utilises free sulphur and thereby produces sulphuric acid is *Thiobacillus thiooxidans.*

$$S + H_2O + 1\frac{1}{2}O_2 \longrightarrow H_2SO_4 + \text{Energy}$$

(ii) Iron bacteria:

- These bacteria oxidise ferrous compounds into ferric form and liberate energy.
- The energy is utilised in the synthesis of organic compounds, e.g., Gallionella, Leptothrix etc.
- Fe^{2+} ————————-> $Fe^{3+} + e^-$
- The ferric iron being deposited as insoluble ferric hydroxide
  $2Fe(HCO_3)_2 + O + H_2O$ —> $2Fe(OH)_3 + 4CO_2$ + Energy

(iii) Nitrifying bacteria:

- This group of bacteria helps in increasing the nitrogen source in nature.
- They oxidise ammonia to nitrate in two steps:
- Ammonia to nitrous acid and nitrous acid to nitric acid,
- Acids react with metal ions to produce the corresponding salts, i.e., nitrite and nitrate.

The steps are bacteria specific and occurs in two steps:-

<u>First step:-</u>

- Involves the oxidation of ammonia to nitrous acid by nitrosifying bacteria like *Nitrosomonas*, *Nitro coccus* and *Nitrospira and process* is called **nitrosification**. The process is catalysing by the enzyme, ammonia dehydrogenase.

Second step:-

- Involves oxidation of nitrous acid to nitric acid by *Nitrobacter, Nitrococcus* and *Nitrospira* is called **nitrification**. The reaction is carrying out by nitrous acid dehydrogenase enzyme.
- Step-I : $2NH_4^+ + 30, ——> 2NOf + 4H^+ + 2H_2O$
- Step-II : $2NO_2 + O_2 ————> 2NO^-_3$

(iv) Hydrogen bacteria:

- This group of bacteria oxidises molecular hydrogen and produces water and energy, e.g., *Pseudomonas facilis*, *Alcaligenes eutrophs*.

$$H_2 + ½O_2 ——> H_2O$$

2. Heterotrophic Bacteria:

These bacteria obtain their food from any organic source.

They are of two types:

a. **Saprophytic,**
b. **Parasitic.**

a. **Saprophytic (Saprobic) bacteria:**

- These bacteria grow on decaying organic matters . By secreting enzymes -they break complex organic compound into simpler forms. These simpler forms are rendered into soluble form and are absorbed by the bacteria as food.

The breakdown of compounds may be of two types:

1.Fermentation
2.Putrefaction.

1. **Fermentation:**

- The breakdown of carbohydrate is known as fermentation.
- Some bacteria (*Escherichia coli*) are able to ferment glucose and galactose, thereby CO_2 is released.
- On the other hand, some bacteria like *Lactobacillus* ferment milk and produce an organic acid, the lactic acid, which causes the souring and curding of milk.
- Carbon dioxide is not evolved in this process.

2. **Putrefaction:**

- The breakdown of protein material is known as **putrefaction.**
- The earlier stage takes place in absence of oxygen by some anaerobic bacteria, where peptone, peptide, polypeptide and amino acids are produced.
- The later stages of breakdown require oxygen where substances like amino acids are further decomposed into sulphur substance such as methane, nitrogen, hydrogen, ammonia etc.
- A few species are able to degrade fats into fatty acids and glycerine.

b. Parasitic bacteria:

- They grow on or within living organisms like plants and animals.
- They draw the organic food from their host.
- These are of two types: **Symbiotic and Pathogenic**:

(i) Symbiotic bacteria:

- These bacteria are useful to the host on one hand and receive food and shelter in return.
- e.g., different types of *coli bacteria* inhabiting the intestine of man and other organisms, which help in the digestion of cellulose by various enzymes secreted by them and also deposite vitamins used by host and they take shelter and food from host.
- In leguminous plants, the bacterium *Rhizobium* develops root nodules. *Rhizobium* possesses nitrogenase enzyme and fix atmospheric nitrogen useful to the plants and, in return, it also takes shelter and food from its host.
- *Frankia spp*. of Actinomyceteous fungi develop root nodules in about 178 species of non-leguminous plants like Casuarina, Alnus, Myrica; Elaeagnus, Coriaria, Ceanothus etc. They also fix atmospheric N_2 with the help of nitrogenase enzyme.

(ii) Pathogenic bacteria:

- These bacteria cause diseases of plants and animals including man.
- They cause diseases on the host either by direct attack or by liberation of toxic substances which affect directly or indirectly.
- Some common human diseases caused by pathogenic bacteria are Cholera (Vibrio cholerae), Diphtheria (Corynebacterium diphtheriae), Tuberculosis (Mycobacterium tuberculosis), Typhoid (Salmonella typhi), Pneumonia (Mycoplasma pneumoniae) etc.
- The plant diseases caused by bacteria are citrus canker (*Xanthomonas axonopodis* pv. citri), Bacterial blight of rice (*Xanthomonas campestris pv*. oryzae), Tundu disease of wheat (*Clavibacter tritici*)Bacterial blight of cotton (*Xanthomonas malvacearum*), etc.

Conclusion:

Bacteria can survive in areas having low oxygen density. Instead of water, hydrogen is used as source of reducing power. Bacteria require source of carbon, nitrogen, P, Fe and a large number of other molecules for nutritional requirements

Some types of bacteria consume pre formed organic molecules to obtain energy while other generate their own energy from inorganic sources.