CHAPTER 05: STUDY of the MAJOR BACTERIAL GROUPS

5.2. AUTOTROPHIC BACTERIA

1. Introduction

Autotrophy is a life style in which inorganic compounds provide for all nutritional needs of an organism. Implicit in this definition is the capacity of an organism to derive all cell carbon from carbon dioxide.

Autotrophs are capable of growth exclusively at the expense of inorganic nutrients and they are vital in the cycling of inorganic compounds. Such autotrophs not only completely satisfied their own needs for reduced carbon monomers from inorganic matter but could also feed the already existing heterotrophs. Thus, autotrophic organisms are also called *primary producers*. Carbon dioxide that is fixed into organic compounds as a result of autotrophic activity is available for consumption or respiration by animals or heterotrophic microorganism. The end products of respiration in heterotrophic organism are carbon dioxide and this way the carbon cycle is completed. Now it is accepted that autotrophy is an extremely important process on Earth and autotrophic microorganisms, as primary producers, support the growth of non-autotrophic organisms.

Few bacteria possess photosynthetic pigment bacteriochlorophyll other than normal chlorophyll found in higher plants are called photosynthetic bacteria. Thus, autotrophic bacteria are of two types based on the energy sources: (1) Photoautotrophs (Photosynthetic bacteria) are photosynthetic and obtain energy from sunlight. (2) Chemoautotrophs (Chemosynthetic bacteria) obtain energy by the oxidation of other substances.

2. Divers type of autotrophic bacteria

2.1. Photoautotrophs bacteria

A large number of bacteria, as well as the green plants and algae, are photoautotrophs. They use light as energy source and CO_2 as unique source of carbon to synthesize carbohydrate in the process called *photosynthesis*. The result of this mechanism is the generation of a proton motive

force (PMF) that can be used in the synthesis of ATP and the synthesis of reducing power (e.g., NADPH).

The **photosynthetic bacteria** possess a special type of pigment called *bacteriochlorophyll*. Along with this other pigment viz. Bacteriviridin (type of bacteriochlorophyll) or chlorobium chlorophyll (green sulfur bacteria) is also found. These pigments are found on spiral structures called chromatophores. Generally, the CO_2 fixation process occur in the presence of sulphur compounds which is mainly H_2S (hydrogen sulphide) (anoxygenic photosynthetic bacteria). Therefore, it can be said that hydrogen sulphide is main hydrogen source in photosynthesis in bacteria and here sulphur is produced as byproduct in place of oxygen (produced in higher plants and oxygenic photosynthetic bacteria, *Cyanobacteria*) in the chemical reaction.

The chemical reaction of photosynthesis is as follows

$$CO_2 + H_2S \rightarrow (CH_2O)n + 2S + H_2O + \text{energy}$$

e.g. *Chromatium, Chlorobium* and *Chlorobacterium* (anoxygenic photosynthetic bacteria).

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

e.g. *Cyanobacteria* (oxygenic photosynthetic bacteria)

2.2. Chemoautotrophs

Many bacteria, called **chemosynthetic bacteria**, uses the energy released from different type of chemical reactions for the conversion of carbon dioxide into carbohydrate (because they cannot utilize the photo energy due to lack of chlorophyll). In the 1880s, Sergei Winogradsky (1856–1953) proposed the concept of ***chemolithotrophy***, the oxidation of inorganic compounds as a source of energy and electrons for the autotrophic growth. The discovery of autotrophy in chemolithotrophic bacteria was of major significance in the advance of our understanding of cells physiology because it showed that CO_2 could be converted to organic carbon without photosynthesis.

These bacteria use the energy released from the oxidation of certain substances such as sulphur and its compound. Ammonia, Nitrites, Iron, Hydrogen, Carbon monoxide, methane are certain chemical substances whose oxidation is carried out by certain bacteria and the energy released is used by these bacteria for the synthesis of food. The important chemosynthetic bacteria are as follows:

a. Sulphur bacteria: These bacteria utilize the energy released by the oxidation of Sulphur and its compounds. For example, *Thiothrix* oxidizes the hydrogen sulphide or mineral sulphides into sulphur. This sulphur get stored inside the bacteria and later get converted into sulphate.

$$2H_2S + O_2 \rightarrow 2S + 2H_2O + 122.2 \text{ kcal}$$
$$2S + 2H_2O + 3O_2 \rightarrow 2H_2SO_4 + 248.4 \text{ kcal}$$

e.g. *Thiobacillus, Beggiatoa* and *Thiothrix.*

b. Iron bacteria: These bacteria generally oxidize the ferrous ion into ferric ion and releases energy.

$$4FeCO_3 + O_2 + 6H_2O \rightarrow 4Fe(OH)_3 + 4CO_2 + 81 \text{ Kcal}$$

e.g. *Leptothrix, Ballionella* and *Ferrobacillus.*

c. Hydrogen bacteria: These bacteria convert the molecular hydrogen into water utilize the energy released during chemical reaction.

$$2H_2 + O_2 \rightarrow 2H_2O + 137 \text{ Kcal}$$

e.g. *Bacillus, Pantrotrophus* and *Hydromonas*

d. Nitrifying bacteria: These bacteria utilize the energy released from nitrogen compound. They are generally of two types:

(i) Who oxidize ammonia into Nitrous, e.g. *Nitrosomonas* and *Nitrobacter*.

(ii) Who convert nitrite into nitrate, e.g. *Nitrococcus* and *Bactoderma.*

Along with this some chemo-organotroph bacteria are found who utilizes the carbon and its compound as a source of energy they are of following types:

- **Methane bacteria:** These bacteria convert and oxidize methane into carbon dioxide gas and water, e.g. *Methanococcus, Lactobacillus* and *Acetobacter.*

- **Carbon bacteria:** These bacteria use the energy released by the oxidation of carbon monoxide, e.g. *Bacillus oligocarbophilus.*

$$2CO + O_2 \rightarrow 2CO_2 + \text{Energy.}$$