SHORT REVIEW

Respiration and Photosynthesis in Energy-Transducing Membranes of Cyanobacteria

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Abstract

Cyanobacteria are photolithotrophic organisms exhibiting oxygenic photosynthesis. In the dark they satisfy their need for energy with respiration. These reactions occur in the same compartment and probably on the same energy-transducing membranes. The characterization of the electron transport chain in the light and in the dark, photophosphorylation and oxidative phosphorylation, as well as possible common pathways in photosynthesis and respiration, are discussed.

Key Words: Respiration; photosynthesis; cyanobacteria; thylakoids; energy-transducing membranes.

Introduction

This review concentrates on light-driven and oxidative events and their relationship in energy-transducing membranes of cyanobacteria. So far the vast majority of investigations have been carried out with the photosynthetic system, and there exist a number of excellent reviews to which I will refer. On the other hand, very little work has been done on respiration although recently there is a rapidly growing interest in this subject.

1Abbreviations: DCMU, 3-(3,4-dichlorophenyl)-1,1-dimethylurca; LDAO, lauryldimethylamine oxide; SDS-PAGE, Na-dodecyl sulfate polyacrylamide gel electrophoresis; DBMIB, 2,5-dibromo-3-methyl-6-isopropyl-p-benzoquinone; TTFA, 5-thenoxyltrifluoroacetone; m-CLAM, m-chlorobenzhydroxamic acid; DCCD, N,N'-dicyclohexylcarbodiimide. Systematical Notes: Plectonema boryanum = Phormidium luridum; Anacystis nidulans = Synechococcus sp.; Mastigocladus laminosus = Fischerella sp.

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Cyanobacteria, formerly called cyanophytae or blue green algae, are a distinct type of photosynthetic organism: they are the only prokaryotes with oxygenic photosynthesis of the higher plant type. Cyanobacteria are physiologically and structurally a heterogeneous group of organisms. A revised classification has been published by Rippka et al. (1979). This diversity has to be considered when experiments done with different species are compared.

Since cyanobacteria are prokaryotes, the energy-transducing membranes are not located in mitochondria nor chloroplasts as in higher plants. Instead cyanobacterial cells contain a densely packed membrane system (thylakoids) in the cytoplasm. In addition, the plasmalemma can serve as an energy-transducing membrane system like in other bacteria.

There is a fair amount of evidence today that chloroplasts of higher plants with their cyanobacterial-like genome structure and photosynthesis are endosymbiotic ancient prokaryotes (Gray and Doolittle, 1982). There are two recent reviews on the evolution of cyanobacteria and their relation to other photosynthetic organisms (Whatley et al., 1979; Krogmann, 1981). Another report describes more generally the evolution of energy-transducing membranes and their functions (Wilson and Lin, 1980). Books about cytology, physiology, and biochemistry of cyanobacteria have been published by Carr and Whitton (1973) and by Fogg et al. (1973).

Structure of the Membranes

Thylakoid membranes of cyanobacteria are similar to those of chloroplasts of higher plants. Neverthelss there are two obvious structural differences: the lack of phycobilisomes in chloroplast thylakoids of higher plants and the absence of the typical chloroplast grana stacks in cyanobacteria. The prokaryotic origin of cyanobacteria is suggested by the rather high content of saturated or mono-unsaturated fatty acids in many lipids.

Whether the cell membrane (plasmalemma) is linked to the thylakoids is still a subject of controversy (Bisalputra, 1974). On electron micrographs the plasmalemma appears smoother than thylakoid membranes and does not have attached phycobilisomes (Holt and Edwards, 1972). Furthermore, cells deprived of carbon dioxide (Miller and Holt, 1977) or photobleached under extreme conditions (Schmetterer and Peschek, 1981) lose their thylakoids while the plasmalemma remains intact and the cells turn colorless. These results indicate that in general the plasmalemma does not possess photosynthetic activities. Cell envelopes with attached plasmalemma have been separated from thylakoids of Anacystis nidulans (Murata et al., 1981), but functions of the cell envelopes have not been determined; thus the activities of the plasmalemma alone are not known yet.