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Salient features of Protochlorophyta

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Abstract

The Prochlorophytes are a varied group of photosynthetic prokaryotic organisms that belong to the cyanobacterial lineage, but they do not possess phycobilisomes as structures for the collection of light energy. Instead, the Prochlorophytes contain a light-harvesting mechanism that is made up of the pigments chlorophylls a and b, which are found in higher plants. In this overview, the antenna structures, photosynthetic characteristics, and evolutionary connections among these bacteria are discussed. The primary emphasis is placed on the part that photosynthesis plays in the environment in which these bacteria are found. The vast majority of the material that is now accessible comes from research conducted on Prochlorothrix, the model organism used to investigate this group in the laboratory. According to the results of our investigation, the thylakoid membrane in Prochloron and Prochlorothrix is arranged in a manner that is generally accepted by the scientific community. Because there have been no laboratory investigations carried out on Prochlorococcus, an abundant third Prochlorophyte, this species is not (yet) eligible for inclusion in the consensus. In general, we hypothesize that the structure of the light-harvesting complexes seen in Prochlorophytes is quite distinct from that of chloroplast systems, and that it is also very old in terms of evolutionary timescales. In both Prochlorothrix and Prochloron, the light-harvesting apparatus is thought to continue to retain a strong structural and functional relationship with Photosystem I. Photosystem In comparison to other photosynthetic systems, the donor and acceptor sides of the reaction center in Prochlorothrix have structural and functional features that are distinct from those of other photosynthetic systems. A demonstrated capacity for Photosystem I-dependent anoxygenic photosynthesis in Prochlorothrix may indicate that there is an increased dependence on cyclic photophosphorylation in these organisms. Speculation on the role that the photosynthetic apparatus plays in occupying, proliferating, and surviving in the ecological niches occupied by the Prochlorophytes has been based on a description of their natural habitats. It would seem that prochlorophytes thrive best in stable settings with a low light level, an adequate supply of nitrogen, and potentially the presence of necessary organic solutes.

Key words Bilin, Prochlorococcus, Prochloron, Prochlorothrix , Prochlorophyta , Prochlorococcus

Introduction

The photosynthetic prokaryotes known as prochlorophyta are included under the phytoplankton category known as picoplankton. Divinyl-chlorophyll is a special photosynthetic pigment that these oligotrophic organisms employ to take in light and convert it into usable energy. These organisms thrive in tropical seas that are deficient in nutrients. The absence of red and blue phycobilin pigments as well as the presence of impaled thylakoids are two characteristics that distinguish these species from Cyanophyta. Around the same time, in 1975, prochlorophytes were found for the first time off the coast of Mexico and close to the Great Barrier Reef. Ralph A. Lewin, of the Scripps Institution of Oceanography, designated them as a distinct algal sub-class the following year. Prochlorophytes are very minute microorganisms, typically ranging in size from 0.2 to 2 micrometers (Photosynthetic picoplankton). Members of the Prochlorophyta have been discovered in both coccoid (spherical) forms, such as Prochlorococcus, and filamentous shapes, such as Prochlorothrix. Their morphology is similar to that of Cyanobacteria.

Tineke Burger-Wiersma discovered subsequently in freshwater lakes in the Netherlands additional phytoplankton than Prochlorophyta that lacked Phycobilin pigments. These phytoplankton were found alongside Prochlorophyta. The name "Prochlorothrix" was given to these organisms. Chlorophylls a and b may be found in Prochloron, which is a marine symbiont, as well as in Prochlorothrix, which is found in freshwater plankton. Prochlorococcus, which is prevalent in marine picoplankton, includes divinyl-chlorophylls a and b. Sallie W. Chisholm and his colleagues made the discovery of the Prochlorococcus bacteria in 1986. It is possible that these creatures are accountable for a significant amount of the primary production that occurs on a worldwide scale. They are all obviously photosynthetic prokaryotes, much like cyanophytes; but, since they do not possess any blue or red bilin pigment, they have been placed in a distinct subclass of algae known as the Prochlorophyta. As a result of the fact that molecular biology does not provide any evidence to support the possibility of their evolutionary ties to the original chloroplasts of green plants, it is now more convenient to think of these organisms as aberrant cyanophytes.

Prochlorophytes are very minute microorganisms, typically ranging in size from 0.2 to 2 micrometers (photosynthetic picoplankton). They have a similar appearance to that of cyanobacteria. Both coccoid (spherical) (Coccus) and filamentous forms of Prochlorophyta members have been discovered. One example of the former is Prochlorococcus, while the latter is Prochlorothrix. Several different scientists have stated that they are associated with ascidians that live on the tropical Pacific coastlines. Electron microscopy has shown that the cells that were discovered linked with the surfaces of Didemnum colonies on the Pacific coast of Mexico are prokaryotic. This finding strongly implies that the cells in question are cyanophytes, which are also known as blue-green algae. However, despite the fact that all known blue-green algae (with the exception of a few apochlorotic varieties) contain phycoerythrin, phycocyanin, or both, these ascidian symbionts are apple green in color and do not contain any identifiable bilin pigments. In addition, just like the eukaryotic algae in the divisions Chlorophyta and Euglenophyta, they contain two chlorophyll components that can be separated using chromatography and are provisionally identified as chlorophylls a and b. On the other hand, it is known that cyanophytes do not contain chlorophyll b. The prochlorophytes are a varied group of photosynthetic prokaryotes that belong to the cyanobacterial lineage, but they lack phycobilisomes as light gathering structures. Although they are related to cyanobacteria, prochlorophytes cannot produce their own chlorophyll. “Instead, prochlorophytes contain a light-harvesting mechanism that is made up of the pigments chlorophyll a and chlorophyll b, which are found in higher plants. In this review, the evolutionary connections between these bacteria are discussed, with a particular emphasis on the composition and operation of the photosynthetic apparatus. This investigation reaches a conclusion that is in line with the findings of research conducted on Prochloron sp. as well as Prochlorothrix hollandica regarding the organization of the thylakoid membrane.

The internal structure of the algae, which is similar to that of blue-green algae, is made up of two distinct zones that are separated by a multilayered cell wall that is very thin (30–50 nm). The cytoplasm and photosynthetic lamellae both call the outer zone of the plant their home. The center zone is see-through to electrons and may sometimes host lamellae whose origin cannot be determined. The photosynthetic lamellae of algae, on the other hand, are made up of two-appressed thylakoids, in contrast to the single non-appressed thylakoids seen in Cyanophyta. Before cytokinesis to take place, the central zone must first go through binary division.

Cells of Prochloron

Taxonomy of Prochlorophytes

Although the type genus Prochloron was validly published under the Botanical Code in the family Prochloraceae, order Prochlorales, and division Prochlorophyta when it was first described, their prokaryotic nature suggests that preference should be given to schemes that comply with the code of nomenclature applied to bacteria. advocated that the order Prochlorales be put in the class Photobacteria, while placing the Prochlorales in a group that would subsequently be designated the Oxychlorobacteria and placing that group inside the class Oxygenic Photosynthetic Bacteria. It was suggested, during the process of properly defining Prochlorothrix hollandica, that it be placed in the order Prochlorales, but in the new family Prochlorotrichaceae (on the grounds of its filamentous morphology). It is challenging to square the common presence of chlorophyll b in chloroplasts and prochlorophytes with the phylogenetic studies, which has led to the hypothesis that the ability to use chlorophyll b as a light-harvesting pigment evolved independently more than once and that the organisms in question turned out to be members of an entirely different family. The Prochlorophyta are a type of photosynthetic bacteria that make up an essential part of picoplankton. Divinyl-chlorophyll is a special photosynthetic pigment that these oligotrophic organisms employ to take in light and convert it into usable energy. These organisms thrive in tropical seas that are deficient in nutrients. Although Prochlorophyta are clearly distinguishable from Cyanobacteria due to the absence of red and blue phycobilin pigments and the presence of stacked thylakoids, some writers believe them to be a component of the Cyanobacteria, namely in the form of the group Prochlorales.

The biomass and composition of phytoplankton are crucial criteria for understanding marine ecology. Changes in phytoplankton assemblages are connected to differences in the assemblages of higher-trophic marine organisms. Phytoplankton assemblages are also known to have an impact on the biogeochemical cycles of elements. For example, diatoms transform dissolved Si into particulate Si. Although evidence regarding changes in the phytoplankton community is limited, Lorrain et al. suggested that diatoms are decreasing in the oceans based on the trend of carbon stable isotope ratio of tuna. This conclusion was reached despite the fact that there is little evidence regarding changes in the phytoplankton community. As a result, monitoring phytoplankton assemblages is necessary on both a global and a local scale, and there is a need for techniques of analysis that are consistent. The most fundamental approach to determining the composition of phytoplankton assemblages is to see them using a microscope. Identification by chemotaxonomy, which makes use of photosynthesis and photoprotective marker pigments, is an approach that is considered to be more convenient.

Chemical investigations during the identification of plant pigments using high-performance liquid chromatography (HPLC) take thirty minutes, and plant pigment markers deteriorate fast, which makes it impossible to conduct regular or high-resolution observations. Ultra-HPLC only needed a short run time of seven minutes, but high-resolution observations of HPLCs are still challenging to carry out when shipboard procedures like as water sampling and filtering are taken into consideration.

Review of literature

(Choe 1986) studied prochlorophyta: a sub-class of chlorophyta It was discovered that the photosynthetic prokaryotes known as Prochlorophyta are members of the phytoplankton group known as Picoplankton. Divinyl-chlorophyll is a special photosynthetic pigment that these oligotrophic organisms employ to take in light and convert it into usable energy. These organisms thrive in tropical seas that are deficient in nutrients. The absence of red and blue phycobilin pigments as well as the presence of impaled thylakoids are two characteristics that distinguish these species from Cyanophyta. Around the same time, in 1975, prochlorophytes were found for the first time off the coast of Mexico and close to the Great Barrier Reef. Ralph A. Lewin, of the Scripps Institution of Oceanography, designated them as a distinct algal sub-class the following year. Prochlorophytes are very minute microorganisms, typically ranging in size from 0.2 to 2 micrometers (Photosynthetic picoplankton). Members of the Prochlorophyta have been discovered in both coccoid (spherical) forms, such as Prochlorococcus, and filamentous shapes, such as Prochlorothrix. Their morphology is similar to that of Cyanobacteria.

(Ma, Jacoby, and Johnson 2021) studied High Densities of a Prochlorophyte **(**Unresolved Species) Inhibit Grazing by the Herbivorous Copepod Parvocalanus crassirostris discovered that both Harmful algal blooms (HABs) are rising in frequency and intensity, highlighting how important it is to explore possible top-down management of blooms. [Citation needed] One damaging bloom was co-dominated by an unresolved prochlorophyte of the Family Prochlorothricaceae in the Indian River Lagoon (IRL), which is a shallow subtropical estuary. This prochlorophyte reached densities of > 106 cells ml1, giving rise to the name Superbloom. On the prochlorophyte, experiments were carried out to examine grazing rates and the possibility for top-down management by an abundant herbivorous copepod called Parvocalanus crassirostris. When both algal species were provided in monocultures with the same density, those grazing rates were lower than the rates on a pleasant alternative algal meal called Isochrysis galbana. When the cell density reached more than 4.8 x 105 cells ml-1, grazing on the prochlorophyte either slowed down or stopped entirely. Both species were devoured when the prochlorophyte and the palatable alternative each represented half of the total density. However, grazing on I. galbana was decreased in comparison to the grazing rates that were seen in a monoculture of this species, particularly at higher cell densities. The treatments that included mucilage and had significant amounts of the prochlorophyte caused the death of the copepods that were tested. The findings of the studies that simulated the viscosities created by prochlorophyte mucilage were compatible with the results of the trials that were done with grazing (i.e., copepods showed lower grazing rates and higher mortality rates in higher viscosity treatments). The results indicate that there may be possible limits to the top-down control that this grazer exerts on HABs that generate mucilage and prochlorophyte blooms.

(Kodama et al. 2022) studied Empirical estimation of marine phytoplankton assemblages in coastal and offshore areas using an in situ multi-wavelength excitation fluorometer discovered that Phytoplankton assemblages are important for understanding the quality of primary production in marine environments, and this was confirmed by their findings. The fluorescence that was excited by nine light-emitting diodes was recorded by the MEX, together with the temperature and sensor depth. We created reference datasets that included MEX fluorescence and phytoplankton assemblages based on plant pigments, and they were comprised of nine different chemotaxonomy groups (diatoms, dinoflagellates, cryptophytes, chlorophytes, haptophytes type 3, hapto- phytes type 4, prasinophytes, cyanophytes, and prochlorophytes). Two different procedures were used in order to make the transition from the MEX fluorescence to the phytoplankton assemblages. The fluorescence of the target MEX was first decomposed by using a linear inverse model for the purpose of determining coefficients. In the second step of the process, the pigment-based chemotaxonomy of the target MEX fluorescence was rebuilt by making use of the coefficients and the chemotaxonomy assemblages that were found in the reference data. When chloro-phytes, haptophytes, and prasinophytes were summarized as other eukaryotes, a positive correlation was seen between proportions estimated with MEX and pigments as same as other five chemotaxonomy groups. Cross-validation analyses indicated that MEX provided a good estimation of the proportion of diatoms, dino- flagellates, cryptophytes, cyanophytes, and prochlorophytes. In the Kuroshio, the Sea of Japan, the Oyashio, and the Okhotsk Sea, many MEX observations were carried out. Diatoms were found to be a major primary producer in both the Oyashio and the Okhotsk Sea, according to the water-column integrated biomass. On the other hand, eukaryotes were found to be important in the Sea of Japan, while prochlorophytes were found to be important in the Kuroshio. Our approach, which makes use of the MEX", will prove to be an effective instrument for understanding and estimating the chemotaxonomy-level assemblages and biomass found in the ocean.

Conclusion

we detailed an approach that, when combined with the MEX, enables accurate assessment of the phytoplankton community structure. The results of two validation studies and one sensitivity study indicated that our conversion method is reliable and accurately estimated the proportions of six phytoplankton chemotaxonomy groups, which are as follows: diatoms, dinoflagellates, cryptophytes, cyanophytes, prochlorophytes, and other eukaryotes (chlorophytes, haptophytes, and prasinophytes). The field application revealed that the vertical distributions of phytoplankton assemblages are very variable, and the water-column integrated compositions of the phytoplankton community revealed the spatial patterns that may be found in the waters near Japan. According to this, MEX is a useful technique for gaining a knowledge of the productivities of the ocean. We thought that our methodology may be a useful way for future global observations. Specifically, this was our thinking. Because both our database and our computer program are public, and because our computer program is built in open-source R, our approaches contribute to a better understanding of the phytoplankton assemblages that are found in the world's oceans. Because of global warming, primary production is falling across the board, but our understanding of how the phytoplankton population is changing is limited. The measurements from the MEX will be a potential answer to the problem of understanding how the phytoplankton ecosystem in the ocean as a whole is changing.

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