Learning Module (in MCQ format) for **Botany Honours** students prepared on the basis of the proposed syllabus **(under CBCS system) of The University of Calcutta w.e.f. 2018-2019**

SEMESTER I

CORE COURSE 1: PHYCOLOGY AND MICROBIOLOGY- **BOTTA - I** (THEORETICAL)
PHYCOLOGY

Learning Module 1 on
5.6. Evolutionary significance of *Prochloron* (1 lecture)

Introduction:
The discovery of *Prochloron* was exciting as it was thought to be the ancestor of the chloroplasts of green algae and land plants, sharing with them the presence of chlorophyll a and b and stacked thylakoids but no phycobilins. This oxygenic photosynthetic cyanobacterium lives in obligate symbiosis with colonial ascidians inhabiting tropical/subtropical waters and free-living *Prochloron* cells have never been recorded so far.
The following are some multiple choice questions from which students will learn about the **Evolutionary significance of *Prochloron*.**

1. *Prochloron* (meaning 'primitive green thing') is a
a. blue-green Rhodophyte
b. green Rhodophyte
c. blue-green cyanophyte
d. green cyanophyte

2. Chief characteristics of *Prochloron* are
a. freshwater, filamentous Rhodophycean algae with chlorophyll a and chlorophyll c
b. freshwater, Rhodophycean algae with chlorophyll a and chlorophyll c
c. marine, coccoid Cyanophycean algae with pigments chlorophyll a and chlorophyll b (lacking any phycobilins) which live as extracellular symbionts within tropical and subtropical colonial ascidians (sea-squirts)
d. freshwater, coccoid Cyanophycean algae with pigments chlorophyll a, chlorophyll b and phycobillisomes

3. In the early development of the endosymbiotic theory, green and brown chloroplasts were often suggested to have been derived independently from 2 hypothetical photosynthetic prokaryotes: a green one with chlorophyll a and b and stacked thylakoids (Division Chlorophyta) and a brown one with chlorophyll a and c together with the brown accessory pigment fucoxanthin (Division Heterokontophyta). Thus when *Prochloron* was discovered it was thought to represent the missing link between
a. Chlorophyta and Heterokontophyta
b. prokaryotic algae and green chloroplasts
c. Cyanophyta and Glaucophyta
d. Cyanophyta and Heterokontophyta

4. Which of the following is **not** a technique adopted by the scientists to understand the evolutionary significance of *Prochloron*?
a. comparing microsatellites
b. DNA-DNA hybridization
c. analysis of the DNA-dependant RNA polymerase gene
d. comparing 16S rRNA gene

5. Which of the following is **not** an observation of evolutionary studies on *Prochloron* ?
a. Molecular phylogeny studies have not supported the close relationship between *Prochloron* and the chloroplasts of green plants nor the monophyly of the genera of the Prochlorophyta to which *Prochloron* belong.
b. *Prochloron* and the other prochlorophytes are usually attributed to the members of the division Cyanobacteria in recent years, supposing that chlorophyll *b* developed independently in each lineage.
c. The phylogeny inferred from genes for chlorophyll *b* synthesis implied a common ancestor of cyanobacteria, chlorophyll-*b* containing prokaryotes, and green algae and plants, assuming the subsequent multiple losses of chlorophyll *b* or phycobilins.
d. DNA-DNA hybridization data and the DNA-dependant RNA polymerase gene analysis concluded that *Prochloron* strains were not conspecific.

6. Which of the following is false regarding the recent phylogenetic studies on Prochloron?
a. Phylogenetic analysis demonstrated that the prochlorophytes are a polyphyletic group within the cyanobacterial radiation, supporting the view that the ability to synthesize chlorophyll *b* evolved several times separately with consequent loss of the ability to synthesize phycobilins.
b. Due to the low genetic diversity amongst *Prochloron* strains, this genus could be a relatively recent lineage thus contradicting the view that these prochlorophytes are descendants of the ancient organisms that gave rise to chloroplasts.
c. In contrast, studies of the chlorophyll *b* synthesis genes from *P. didemni, Prochlorothrix hollandica* and several green chloroplasts indicated a common origin for these genes in prochlorophytes and chloroplasts. However, considering mounting biochemical and molecular evidence it seems likely that horizontal gene transfer may account for the similarity between the chlorophyll *b* synthesis genes in these organisms.
d. Carefully isolated cells of *Prochloron* retained low activity of photosynthetic oxygen evolution comparable to that of free-living algae and plants.

7. Coevolutionary characteristics are demonstrated by *Prochloron* by the following except
a. Some scientists observe that the vertical transmission of *Prochloron* cells by the ascidian larvae poses the possibility of co-evolution between the symbiont and its host.
b. The ascidian-*Prochloron* symbiosis system is probably maintained by both vertical and horizontal transmission of the photosymbionts, and the vertical transmission should is more important for the young colonies.
c. The 16S rRNA structures from four *Prochloron* strains from different hosts found they were not identical and a distant phylogenetic relationship amongst these strains was demonstrated.
d. Due to their pigment composition, the *Prochloron* members were proposed to descend from the protoendosymbiont that gave rise to chloroplasts . For this reason the symbiotic

cyanobacterium, *Prochloron*, can be considered a veritable "missing link" between ancestral plastids and modern day chloroplasts.

Instructor would conclude:

The life and evolution of *Prochloron* and related symbiotic cyanobacteria are being explored by genetic, physiological, biochemical, and morphological studies and these cyanophytes probably has complex evolutionary process of symbiogenesis and diversification.

Students will learn the summary of evolutionary significance of *Prochloron*:

1. *Prochloron* is an oxygenic photosynthetic cyanobacterium which lives in obligate symbiosis with colonial ascidians inhabiting tropical/subtropical waters

2. *Prochloron* (meaning 'primitive green thing') is a green cyanophyte and it has chlorophyll a and b and stacked thylakoids but no phycobilins

3. It is a marine, coccoid Cyanophycean alga with pigments chlorophyll a and chlorophyll b (lacking any phycobilins) which live as extracellular symbionts within tropical and subtropical colonial ascidians (sea-squirts)

4. *Prochloron* was thought to represent the missing link between prokaryotic algae and green chloroplasts

5. To understand the evolutionary significance of *Prochloron* DNA-DNA hybridization, analysis of the DNA-dependant RNA polymerase gene and comparing 16S rRNA gene were done.

6. Molecular phylogeny studies have not supported the close relationship between *Prochloron* and the chloroplasts of green plants nor the monophyly of the genera of the Prochlorophyta to which *Prochloron* belong. *Prochloron* and the other prochlorophytes are usually attributed to the members of the division Cyanobacteria in recent years, supposing that chlorophyll *b* developed independently in each lineage. The phylogeny inferred from genes for chlorophyll *b* synthesis implied a common ancestor of cyanobacteria, chlorophyll-*b* containing prokaryotes, and green algae and plants, assuming the subsequent multiple losses of chlorophyll *b* or phycobilins.

7. Phylogenetic analysis demonstrated that the prochlorophytes are a polyphyletic group within the cyanobacterial radiation, supporting the view that the ability to synthesize chlorophyll *b* evolved several times separately with consequent loss of the ability to synthesize phycobilins. However, considering mounting biochemical and molecular evidence it seems likely that horizontal gene transfer may account for the similarity between the chlorophyll *b* synthesis genes in these organisms

8. Some scientists observe that the vertical transmission of *Prochloron* cells by the ascidian larvae poses the possibility of co-evolution between the symbiont and its host. The ascidian-*Prochloron* symbiosis system is probably maintained by both vertical and horizontal transmission of the photosymbionts, and the vertical transmission should is more important for the young colonies.

Answers: 1.d, 2. c, 3. b, 4. a, 5. d, 6. d, 7. c

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