Rajesh Prasad Rastogi *Editor*

Ecophysiology and Biochemistry of Cyanobacteria

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Preface

Cyanobacteria are the most dominant prokaryotic floras on the Earth's surface and are of great importance in terms of ecological, economical and evolutionary perspectives. They are oldest groups of photosynthetic autotrophs, which create oxygenic atmosphere for the development and sustainability of ecosystems with different life forms. Recently, cyanobacteria have been employed in space research, bioremediation, as well as an efficient source of ecofriendly and alternative source of renewable energy in connection with photosynthesis—the most important life-supporting biological phenomena of the planet.

This book emphasizes and establishes the emerging information on ecophysiology and biochemistry of cyanobacteria with special emphasis on their biodiversity, molecular mechanisms of some important biological processes and survival mechanisms under myriad of environmental conditions as well as bioremediation. Also included is an integrative approach to their possible biotechnological application in the field of bioenergy and various aspects of biochemistry, biophysics and structural biology of photosynthesis.

This book has attempted to span the depth of cyanobacterial biology from the perspective of its basic ecophysiology and biochemistry starting with more general information about cyanobacteria such as evolution, distribution, taxonomy and photosynthesis in Chaps. 1–3. Chapters 4–7 focus on the impacts of environmental stress on physiology and biochemistry of cyanobacteria along with UV stress response and molecular mechanisms of stress tolerance in cyanobacteria. Chapter 8 presents an overview on stress proteins and signal transduction in cyanobacteria, whereas Chapter 9 focuses on molecular chaperones and their involvement in maintaining the cellular protein homeostasis under normal and stress conditions. Chapters 10 and 11 describe the chromatic acclimation in response to light quality and phenomenon of allelopathy in cyanobacteria, respectively. In Chapter 12, assembly of nitrogen-fixing machinery and role of key enzymes in nitrogen metabolism of cyanobacteria have been discussed. Chapters 13 and 14 address cyanobacteria-based phycoremediation for effective removal of numerous pollutants from waste effluents. Chapters 15–20 all deal with biochemistry of cyanobacteria uncovering their potential applications towards biotechnological values. Chapter 15 discusses antioxidant, anti-ageing and neuroprotective potential of various cyanobacterial biomolecules, while Chapter 16 describes the engineering

challenges of carbon dioxide capture and sequestration by cyanobacteria to reach a better and greener world. Chapter 17 reviews the significant development and the recent progress in engineering cyanobacteria for photosynthetic production of sucrose and sucrose-synthesis mechanisms. Chapters 18–20 highlight the concept of cyanobacterial bio-refineries for future bio-energy/bio-fuel demand.

I believe that this book will be helpful to a great extent for the academicians and researchers in the field of cyanobacterial research. Certainly, the contents incorporated in this book can be used as a textbook by undergraduate and post-graduate students, teachers and researchers in the most interesting fields of physico-chemical ecology and biochemistry of cyanobacteria.

It is very sad to mention here that Mr. Mukesh Ghanshyam Chaubey, first author of the Book Chapter 15 passed away on 23rd November, 2020 due to Covid-19. We pray that his soul rests in peace and may God give enough strength to the bereaved family to bear the irreparable loss.

I am highly thankful to all the peer-reviewers for their thoughtful assistance in reviewing the manuscripts. I thank Dr. Madhurima Kahali, Editor (Book), Springer, India, for her assistance in seeing it through to completion. I am sincerely grateful to the entire team of Springer Nature for the coordination, support and implementation of this book project. Last but not least, I express my sincere gratitude to all the authors for their kind collaboration and scientific contributions towards completion of this book successfully.

New Delhi, Delhi, India Rajesh P. Rastogi
January 2021

Contents

Nitrogen Metabolism in Cyanobacteria

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Kunal Seth, Geetanjali Kumawat, Mukesh Kumar, Vishambhar Sangela, Nitika Singh, Amit Kumar Gupta, and Harish

Abstract

Cyanobacteria are known to have unique capability of nitrogen fixation in their specialized cell known as heterocyst. However, differentiation of vegetative cell toward heterocyst reduces competitive ability of cyanobacteria because it led to a shift of energy allocation from carbon to nitrogen metabolism. Therefore, heterocyst formation is regulated to avoid the differentiation commitment due to short-term nitrogen fluctuation. Once nitrogen deficiency signal is sensed by the cyanobacteria, pattern of heterocyst formation is determined that ensures equidistance formation of heterocyst cells with about one heterocyst per ten vegetative cells. After differentiation, heterocyst provides anaerobic condition that is prerequisite for the nitrogenase complex to fix the atmospheric dinitrogen. Microoxic condition inside the heterocyst is attained by elimination of oxygen-producing photosystem II activity, increasing respiration rate, and by formation of thick heterocyst-specific exopolysaccharide and glycolipid layer. Nitrogen-fixing machinery is assembled and activated during heterocyst differentiation. The nitrogenase complex is encoded by *nif* gene family. Many of these genes are interrupted in the vegetative cells by interruption elements and these are excised during differentiation of heterocyst by a site-specific recombinase, leading to the activation of genes. In this chapter, we have outlined the molecular circuit of heterocyst differentiation and discussed the assembly of nitrogen-fixing machinery and role of key enzymes in the nitrogen metabolism in the cyanobacteria.

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