

Rachapudi V. Sreeharsha
S. Venkata Mohan

Microbial Photosynthesis

From Basic Biology to Artificial Cell
Factories and Industrial Applications

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The Family*

Preface

In the intricate annals of biological processes, photosynthesis is one of the fascinating and scientifically captivating phenomena. *Microbial Photosynthesis: From Basic Biology to Artificial Cell Factories and Industrial Applications*, delve into the very essence of this remarkable phenomenon. This meticulously crafted book unfurls in three distinct parts, each encapsulating a facet of microbial photosynthesis. The chapters in Part I explore deep into the evolution, classification, and physiology of photosynthetic microbes. From the structural intricacies of microbial photosystem complexes to the elegant mechanisms of photosynthetic CO₂ fixation in unicellular organisms, these chapters serve as the foundation for applied photosynthesis. Part II ascends to the next level of comprehension, wherein the chapters investigate the practical applications of microbial photosynthesis. Techniques in photosynthetic physiology and innovative cultivation strategies are unveiled, laying the basis for sustainable resource utilization. The chapters dedicated to wastewater treatment and nutrient recovery, through cyanobacteria and microalgae, illuminate how these microorganisms can spearhead the charge towards a more sustainable future. Part III deals with the cutting-edge horizons of microbial photosynthesis. Genetic and metabolic engineering, as presented in Chap. 8, are the tools of the future to enhance the efficiency and potential of this biological process. The concept of industrial symbiosis, as elucidated in Chap. 9, sheds light on the circular economy forged by photosynthetic microbial biorefineries. And Chap. 10 ventures into the frontier of artificial photosynthesis—a complex interplay between photon energy and bioreactors that holds the promise of revolutionizing global energy landscape.

Throughout the book, the readers will encounter the findings and opinions of distinguished experts whose research contributions have provided valuable insights on photosynthesis and reflect a vision of the future. Our perspectives on the research topics of this book are helpful to transform industries and catalyze environmental sustainability. The contents of this book are highly useful to graduate students and scholars working in the areas of improving photosynthetic efficiency of microbes.

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Abbreviations

3HP-4HB	3-hydroxypropionate-4-hydroxybutyrate
ABS/RC	Absorption Flux per Reaction Center
ACCase	Acetyl-CoA carboxylase
AEM	Anion exchange membrane
ALRs	Airlift reactors
ARDS	Acute respiratory distress syndrome
ARE	Antioxidant responsive element
ASFV	African swine fever virus
ATP	Adenosine triphosphate
BBES	Balanced Bioenergy System
BBNC	Bioprocess and Biorefinery Nexus Consortium
BESs	Bioelectrochemical systems
BET	Bioelectrochemical treatment
BOD	Biochemical oxygen demand
C ₁₀	Geranyl diphosphate
C ₁₅	Farnesyl diphosphate
C ₂₀	Geranylgeranyl diphosphate
CAM	Crassulacean acid metabolism
Car	Carotenoids
CBCRs	Cyanobacteriochromes
CCA	Chromatic acclimation
CCM	CO ₂ concentrating mechanism
CEF	Cyclic electron flow
CEM	Cation exchange membrane
Chl	Chlorophyll
Chlide	Chlorophyllide
COD	Chemical oxygen demand
Copro	Coproporphyrinogen
CpSRP	Chloroplast signal recognition particle
CRISPR	Clustered regularly interspaced short palindromic repeats
Cyt	Cytochrome

DAO	Direct anodic oxidation
DCMU	(3-(3,4-dichlorophenyl)-1,1-dimethylurea)
DHA	Docosahexaenoic acid
DI0/RC	Dissipated Energy Flux per Reaction Center
DMAPP	Dimethylallyl pyrophosphate
DOE	Department of Energy
DPA	Docosapentaenoic acid
DSA	Dimensionally stable anodes
EAB	Electrochemically active bacteria
EFCs	Enzymatic fuel cells
EMCV	Encephalomyocarditis RNA virus
EPA	Eicosapentaenoic acid
EPS	Exopolysaccharides
ETC	Electron transfer chain
ETC/RC	Electron Transport Flux per Reaction Center
F ₀	Initial fluorescence
F ₀ /F _m	Fluorescence parameter
FACE	Free air CO ₂ enrichment
FAD	Flavin adenine dinucleotide
FADGDH	Flavin adenine dinucleotide-dependent glucose dehydrogenases
FaRLip	Far red-light photoacclimation
FBPase	Fructose 1,6-bisphosphatase
Fd	Ferredoxin
FDPs	Flavodiiron proteins
F _J	Fluorescence value
FLIM	Fluorescence lifetime imaging microscopy
F _m	Measure maximum fluorescence
FNR	Ferredoxin-NADH ⁺ reductase
FP	Peak fluorescence level
Ft	Measure steady-state fluorescence yield during light exposure
Fv	Fluorescence
F _x , F _A , F _B	Iron sulfur clusters
G ₃ P	Glyceraldehyde-3-phosphate
GAG	Glycosaminoglycans
GAPDH	Glyceraldehyde-3-phosphate dehydrogenase
GLA	γ-linolenic acid
Glu-R	Glutamyl-tRNA reductase
GOGAT	Glutamate synthase
GS	Glutamine synthetase
GSA	Glutamic acid 1-semialdehyde
GST-α1	Glutathione-S-transferase-α1
HBV	Hepatitis B virus
HHV-3	Human α herpesvirus 3
H ₂ S	Hydrogen sulfide

HMF	Hydroxymethylfurfural
HO-1	Heme oxygenase
HRAP	High-rate algal pond
HRT	Hydraulic retention time
HSV	Herpes simplex virus
HTA	Hexadecatrienoic acid
IPP	Isopentenyl diphosphate
IRGA	Infrared gas analyzer
LER	Light-enhanced respiration
LET/CET	Linear/Cyclic electron transfer
LHC	Light-harvesting complex
LHCR	LHC receptors
LPS	Lipopolysaccharide
MAAs	Mycosporine-like amino acids
MAP	Mitogen-activated protein
MDCs	Microbial desalination cells
MECs	Microbial electrolysis cells
MEP	Methyl erythritol 4-phosphate
MES	Microbial electrosynthesis
METs	Manufacturing of bio-based goods
MFCs	Microbial fuel cells
MMe	Monomethyl ester
MRSA	Methicillin-resistant <i>Staphylococcus aureus</i>
MSCs	Microbial solar cells
MUFA	Mono-unsaturated fatty acids
MuLV	Murine leukemia virus
MVA	Mevalonate
NADH/NADPH	Nicotinamide adenine dinucleotide/phosphate hydrogen
NF-KB	Nuclear transcription factor-KB
NIR	Near-infrared fluorescence
NPQ	Non-photochemical chlorophyll fluorescence quenching
NQO-1	Quinone oxidoreductase
NSAIDs	Non-steroidal anti-inflammatory drugs
OEC	Oxygen-evolving complex
OMBRs	Osmotic membrane bioreactors
PA	Palmitoleic acid
PAM	Pulse amplitude modulation
PBG	Porphobilinogen
PBS	Phycobilisomes
PC	Plastocyanin
Pchilde	Protochlorophyllide
PHA	Polyhydroxyalkanoate
PHB	Polyhydroxy butyrate
Pi	Phosphate
PI	Performance index

PI _{ABS}	Performance index
PMBC	Peripheral blood mononuclear cells
PMFCs	Plant microbial fuel cells
PPFD	Photosynthetic photon flux density
PQQ-ADH	Pyroquinoline quinone-dependent alcohol dehydrogenase
PRK	Phosphoribulokinase
Proto	Protoporphyrin
Protogen	Protoporphyrinogen
PS	Polysaccharides
PS I	Photosystem I
PS II	Photosystem II
PsaA	PSI protein A
PsaB	PSI protein B
PTOX	Plastoquinone (plastid) terminal oxidase
PUFA	Poly-unsaturated fatty acids
PVC	Polyvinyl chloride
Q _A	Quinone acceptor
Q _B	Plastoquinone B
QBH ₂	Reduced hydroquinone
ROS	Reactive oxygen species
RPP	Reductive pentose phosphate cycle
RSV-A/B	Respiratory syncytial virus
RuBISCO	Ribulose-1,5-bisphosphate carboxylase/oxygenase
RuBP	Ribulose-1,5 bisphosphate
SBPase	Sedoheptulose-1,7-bisphosphate
SCP	Single cell protein
TAG	Triacylglycerols
TALENs	Transcription activator like endonucleases
TR ₀ /RC	Trapped Energy Flux per Reaction Center
UM	Urban metabolism
Uro	Uroporphyrinogen
VACV	Vaccinia virus
VEGF	Vascular endothelial growth factor
VHSV	Hemorrhagic septicemia virus
VSV	Vesicular stomatitis virus
ZFN	Zinc-finger nuclease
ΔpH	Trans-thylakoid proton gradient
φD0	Quantum Yield of Non-Radiative Energy Dissipation
φE0	Quantum Yield of Electron Transport
φP0	Quantum Yield of Primary Photochemistry