RED ALGAE IN THE GENOMIC AGE

Cellular Origin, Life in Extreme Habitats and Astrobiology

Volume 13

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Red Algae in the Genomic Age

Edited by

Joseph Seckbach
The Hebrew University of Jerusalem, Israel
and
David J. Chapman
University of California at Santa Barbara, CA, USA

Springer

Editors
Joseph Seckbach
The Hebrew University of Jerusalem
Israel
seckbach@huji.ac.il

David J. Chapman
University of California at Santa Barbara
CA
USA
chapman@lifesci.ucsb.edu

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Cover illustration: Top center: *Cyanidioschyzon merolae* (Cyanidioceae) cell. Artificial colors shows the chloroplast in green, mitochondrium in pink, peroxisome in dark brown, the nucleus in blue, and the Golgi Apparatus at the left of the nucleus colored light brown. Donated by **Dr. Shin Ya Miyagishima** (Research Unit in RIKEN, Japan).

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DEDICATION

We dedicate this volume to Professor Aharon Oren (The Hebrew University of Jerusalem) for all his contributions to the *Cellular Origin, Life in Extreme Habitats and Astrobiology* series, and his share for our understanding of algae over a wide spectrum of investigation.

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INTRODUCTION TO RED ALGAE IN THE GENOMIC AGE

Red algae (Rhodophyta) are mainly marine algae whose chlorophyll and carotenoids are masked by the red or purplish pigments, the phycobiliproteins, phycoerythrins and phycocyanins. Some groups of the Rhodophyta serve as a source of agar and carrageenan, used as an ingredient in food. *Porphyra*, is grown for production of Nori and Zicai (in Japan alone the total annual production of nori amounts to over billions of US dollars). Among other edible red seaweeds are dulse (*Palmaria*) and Irish moss (*Chondrus*).

The great majority of the Rhodophyta are macroscopic, multicellular, benthic marine algae, found in the intertidal and in the subtidal to depths of up to 40 m. and occasionally deeper. In addition there are some genera of single celled planktonic forms and some freshwater genera in addition to the thermophilic/acidophilic Cyanidiophyceae. The main Rhodophyta reserves are typically floridean starch, and floridoside while the unicellular Cyanidiophycea (see further) produce also glycogens. The walls of the red algae are made of cellulose, with the sulfated galactans agar, and carrageenans. The cell walls of the unicellular Cyanidiophyceae are mainly proteinaceous**.**

This volume is number thirteen in the series *Cellular Origins, Life in Extreme Habitats and Astrobiology* (COLE) see: www.springer.com/series/5775. The unicellular Rhodophyta are discussed from various aspects such as origins, evolution, ecology, habitats, and the genomic features. Among the unicellular rhodophytans are the thermo-acidophiles *Cyanidiophyceae* (*Cyanidium caldarium* group) which are discussed in detail in this book. Additional chapters deal with the current genomic aspects of some rhodophytes, such as *Porphyra* (*Bangiaceae*), *Cyanidioschyzon merolae,* and *Galdieria sulphuraria* (Cyanidiaceae), which have been recently sequenced.

In this volume we gathered contributors, authorities in their fields, from a dozen countries. It is hoped that this book will benefit a wide range of readers, from undergraduate students to professional scholars, in the fields of biology, microbiology, phycology, and ecology. We express our deep appreciation to the reviewers for their time and effort in evaluating and reviewing the chapters.

Joseph Seckbach
The Hebrew University of Jerusalem
Israel

David J. Chapman
The University of California
Santa Barbara, USA

June 2009

Biodata of **Joseph Seckbach**, editor (with **David J. Chapman**) of this volume and the author of the chapter ***"Overview of the Cyanidia"***

Professor Joseph Seckbach is the Founder and Chief Editor of book series ***Cellular Origins, Life in Extreme Habitats and Astrobiology*** **(COLE)**. See www.springer.com/sereis/5775. He is the author of several chapters in this series. Dr. Seckbach earned his Ph.D. from the University of Chicago, Chicago, IL (1965) and spent his postdoctoral years in the Division of Biology at Caltech (Pasadena, CA). Then he headed at the University of California at Los Angeles (UCLA) a team for searching for extraterrestrial life. He has been appointed to the faculty of the Hebrew University (Jerusalem, Israel) performed algal research and taught biological courses until his retirement. He spent his sabbatical periods in UCLA and Harvard University, and served at Louisiana State University (LSU), (1997/1998) as the first selected occupant Chair for the Louisiana Sea Grant and Technology transfer, and as a visiting Professor in the Department of Life Sciences at LSU (Baton Rouge, LA). He obtained two DAAD fellowships (German fellowships for exchange academicians) in Tübingen (1988) and in Ludwig Maximilians University in Munich (2006).

Among his publications are books, scientific articles in the lines of phytoferritin, cellular evolution, acidothermophilic algae, and life in extreme environments. He also edited and translated several popular books. Dr. Seckbach is the co-author (with R. Ikan) of the *Chemistry Lexicon* (1991, 1999) and a co-editor of *Proceeding of Endocytobiology VII Conference* (Freiburg, Germany, 1998) and the *Proceedings of Algae and Extreme Environments meeting* (Trebon, Czech Republic, 2000). His new edited volume (with Richard Gordon) entitled *Divine Action and Natural Selection: Science, Faith, and Evolution* has been published by World Scientific Publishing Company. His recent interest is in the field of enigmatic microorganisms and life in extreme environments.

E-mail: **seckbach@huji.ac.il**

Biodata of **David J. Chapman**, co-editor of this volume

Dr. David J. Chapman is a Professor of Marine Biology in the Department of Ecology, Evolution and Marine Biology and additionally the Graduate Marine Science Program at the University of California Santa Barbara. His main interest is in the broad spectrum of algal and protistan biology with an emphasis on the biochemical and physiological aspects and how these affect growth and survival in the environment. He received his Ph.D. from the Scripps Institution of Oceanography in 1965 and a D.Sc. from the University of Auckland (New Zealand) in 1979. His main research interests cover a broad spectrum of algal physiology and biochemistry, with an emphasis on pigments and natural products, applied uses of algae and the evolution of biochemical systems in the earliest algal life of the Archaean and Precambrian eras. In addition to his own published works, books, and papers, he has served in a number of editorial positions. Among his books are: *The Algae* (with V.J. Chapman) (1973); *Biochemical Phylogeny of the Protists* (with M.A. Ragan) (1978); *Seaweeds and Their Uses* (with V.J. Chapman) (1980). He edited the series of *Progress in Phycological Research* (with F.E. Round) Volume 1–13 (1982–1999); and the *Experimental Phycology. A Laboratory Manual*. (with C. Lobban and B. Kremer) (1988); *Handbook of Protoctista* (with L. Margulis, J.O. Corliss, M. Melkonian) (1990). Dr. Chapman has been awarded in UCLA (1989) a citation as the distinctive teacher and lecturer in the faculty of Life Science. He is also a Fellow of the Linnean Society of London and a member of a number of national and international phycological and plant biological societies.

E-mail: **chapman@lifesci.ucsb.edu**

FOREWORD

Red Algae in Genome Age Book

Most people reading this book have childhood memories about being enthralled at the beach with those rare and mysterious living forms we knew as seaweeds. We were fascinated at that time by their range of red hues and textures, and most of all, their exotic beauty. To a scientist, red algae represent much more than apparent features. Their complex forms have attracted morphologists for centuries; their intricate life cycles have brought more than one surprise to plant biologists familiar only with ferns and flowering plants; their unusual tastes have been appreciated for millennia, and their valuable chemical constituents have been exploited for nearly as long, most recently by biotech companies; their diversity in marine, freshwater, and terrestrial environments has offered centuries of engaging entertainment for botanists eager to arrange them in orderly classification systems; still, the red algae continue to teach us how many more challenges need to be overcome in order to understand their biodiversity, biological functions, and evolutionary histories.

This book is about the genomics of red algae. The reader will not be dissatisfied to find that the rhodophytes provide a plethora of genomic surprises to keep us ever more interested in our never-ending biological pursuits. The red algae are one of the most ancient photosynthetic eukaryotes that, along with the green algae and glaucophytes, initiated long and rather complicated evolutionary pathways. Along the way, through further endosymbioses, they changed other life forms resulting in even more complex genomic lineages. Representatives of extant red algae found in our planet are the survivors of significant adventures. Their evolutionary histories may be understood if we decipher their stories. Genomics may provide the key to appreciating the problems these lineages have been confronting since their early appearance on our planet, and the elegant adaptive solutions that have insured their survival over millennia.

The editors of *Red Algae in Genome Age* have accomplished a remarkable task in bringing together a group of scientists with a wide range of expertise, including systematics, ecology, biotechnology, molecular biology and medicine, bioinformatics, extremophile biology, and evolutionary biology. The chapters in this volume have been organized into six parts preceded by an introductory section. The initial part corresponds to the Origin and Evolution of Red Algae (1) followed by General Studies of Rhodophyta (2). The majority of the chapters are assembled in parts (3) Genomic Studies and Biotechnology and (4) Cyanidia. Next follows (5) Biochemistry and Physiology, and a final part (6) comprising the Outlook and Summary.

Some books on the biology of red algae have had a profound affect on our understanding of these remarkable organisms. They have functioned as a conduit for learning at both undergraduate and graduate levels. These publications are also a mirror of the state of the art of the times, akin to milestones in the history of rhodophytan research. I fondly recall Kylin's monumental treatise published in 1956 on rhodophytan genera, *Die Gattungen der Rhodophyceen*; his ordinal morphology-based classification system endured for almost half a century. Seventeen years passed before the publication of Dixon's *Biology of the Rhodophyta* in 1973; this book introduced more dynamic features of the biology of red algae. Another seventeen-year gap preceded the 1990 publication of *Biology of Red Algae* edited by K. M. Cole and R. G. Sheath, which introduced the readers to a modern overview of rhodophytan biology, highlighting major advancements in molecular biology, DNA analysis, physiology, and genetics. Seventeen years later, J. Seckbach and D. Chapman began organizing the publication of this book, *Red Algae in Genome Age* – what a timely publication!

The preceding publication leaps have witnessed gigantic technological developments and remarkable algal discoveries that have re-invigorated our incessantly growing understanding of the tree of life. *Red Algae in Genome Age* will introduce phycologists and scientists in general to novel approaches to better understanding the rhodophtyes. Where terms such as gene expression, genome architecture, genome lineages, phylogenomics, to name just a few, are becoming an essential part of our research on the biology of red algae.

The red algae continue to fascinate us with their enigmatic beauty and well-kept secrets. Glimpses into future genomic rhodophytan research can be perceived from the stimulating chapters in this book. *Red Algae in Genome Age* represents a significant contribution to the field of algal genomics. It will be of great value to phycologists, scientists in general, university mentors and mentees, as well as to a wider audience interested in red algae and their uses.

The University of Alabama
Tuscaloosa, AL 35487, USA

Juan M. Lopez-Bautista

June 2009

Biodata of **Juan M. Lopez-Bautista**, author of the chapter ***"Red Algal Genomics: A Synopsis"***

Dr. Juan M. Lopez-Bautista is currently an Associate Professor in the department of biological sciences of The University of Alabama, Tuscaloosa, AL, USA and algal curator for The University of Alabama Herbarium (UNA). He received his Ph.D. from Louisiana State University, Baton Rouge, in 2000 (under the advisory of Dr. Russell L. Chapman). He spent 3 years as postdoctoral researcher at The University of Louisiana at Lafayette with Dr. Suzanne Fredericq. Dr. Lopez-Bautista's research interests include algal biodiversity, molecular systematics and evolution of red seaweeds and tropical subaerial algae.

E-mail: **jlopez@ua.edu**

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We thank all our contributors for taking part in this volume, *Red Algae in Genome Age.* We are grateful to out external peer reviewers for the time and effort they expended in helping ensure the quality of the contributions: C. Amsler, R. Castenholz, R.L. Chapman, D. Cheney, C. Deatombes, P. Geigenberger, B. Green, T. Hase, E. Gantt, J. Huisman, I. Korf, G. Kraemer, A.W. Larkum, J. Lopez-Bautista, C. Maggs, Ch. McKay, C. Oesterhelt, G. Saunders, M. Verlaque, A. Weber, and J. Zertuche-Gonzalez. If any reviewers' name have been omitted, we apologize for the oversight. We wish also to acknowledge all colleagues who assisted us with their good advice for this volume. Special appreciations are due to Dr. Shin-Ya Miyagishima (Riken, Japan) for preparing the photo for this book's cover. Last but not least the senior editor (JS) is grateful to his wife, Fern Seckbach, for her patience, understanding and assistance during the compiling of this book (and other volumes in the series).

The Hebrew University of Jerusalem **Joseph Seckbach**
E-mail: seckbach@huji.ac.il

June 2009

LIST OF AUTHORS FOR *"RED ALGAE IN GENOMIC AGE"*

ADACHI HIDEYUKI
DIVISION OF BIOSCIENCE, GRADUATE SCHOOL OF NATURAL SCIENCE AND TECHNOLOGY, OKAYAMA UNIVERSITY, OKAYAMA 700-8530, JAPAN.

ARCHIBALD JOHN M.
THE CANADIAN INSTITUTE FOR ADVANCED RESEARCH, INTEGRATED MICROBIAL BIODIVERSITY PROGRAM, DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR BIOLOGY, DALHOUSIE UNIVERSITY, SIR CHARLES TUPPER MEDICAL BUILDING, 5850 COLLEGE STREET, HALIFAX, NS B3H 1X5, CANADA.

ARMANDO AZÚA-BUSTOS
DEPARTAMENTO DE GENÉTICA MOLECULAR Y MICROBIOLOGÍA, FACULTAD DE CIENCIAS BIOLÓGICAS, PONTIFICIA UNIVERSIDAD CATÓLICA DE CHILE, INSTITUTO MILENIO DE BIOLOGÍA FUNDAMENTAL Y APLICADA, SANTIAGO, CHILE.

BERG G. MINE
DEPARTMENT OF GEOPHYSICS, STANFORD UNIVERSITY, STANFORD, CA, USA.

BHATTACHARYA DEBASHISH
DEPARTMENT OF ECOLOGY, EVOLUTION AND NATURAL RESOURCES, RUTGERS UNIVERSITY, NJ 08901, USA.

BLOUIN NICOLAS A.
DEPARTMENT OF MARINE SCIENCES, UNIVERSITY OF MAINE, ORONO, ME, USA.

BRAWLEY SUSAN H.
DEPARTMENT OF MARINE SCIENCES, UNIVERSITY OF MAINE, ORONO, ME, USA.

BRODIE JULIET A.
DEPARTMENT OF BOTANY, THE NATURAL HISTORY MUSEUM, LONDON, UK.

CASTENHOLZ RICHARD W.
CENTER FOR ECOLOGY AND EVOLUTIONARY BIOLOGY, 5289, UNIVERSITY OF OREGON, EUGENE, OR 97403-5289, USA.

CHAN CHEONG XIN
UNIVERSITY OF IOWA, IOWA CITY, IA 52242, USA.

CHEN MIN
AUSTRALIAN CENTRE FOR ASTROBIOLOGY, UNIVERSITY OF NEW SOUTH WALES, NSW 2052, AUSTRALIA AND BIOLOGICAL SCIENCES, UNIVERSITY OF SYDNEY, NSW 2006, AUSTRALIA.

COLLÉN JONAS
CNRS, UNIVERSITXÉ PIERRE ET MARIE CURIE, STATION BIOLOGIQUE, ROSCOFF CEDEX, FRANCE.

CUNNINGHAM FRANCIS X. JR.
DEPARTMENT OF CELL BIOLOGY AND MOLECULAR GENETICS, UNIVERSITY OF MARYLAND, COLLEGE PARK, MD 20742, USA.

DE OLIVEIRA MARIANA CABRAL
DEPARTMENT OF BOTANY, BIOSCIENCE INSTITUTE, UNIVERSITY OF SÃO PAULO, SÃO PAULO, BRAZIL.

DIXON JACK E.
DEPARTMENT OF MOLECULAR AND CELL BIOCHEMISTRY, UNIVERSITY OF KENTUCKY, COLLEGE OF MEDICINE, LEXINGTON, KY 40536-0509, USA AND DEPARTMENT OF PHARMACOLOGY AND THE HOWARD HUGHES MEDICAL INSTITUTE, UNIVERSITY OF CALIFORNIA-SAN DIEGO, LA JOLLA, CA 92093-0721, USA.

DUBINSKY ZVY
THE MINA AND EVERARD GOODMAN FACULTY OF LIFE SCIENCES, BAR-ILAN UNIVERSITY, 52900 RAMAT GAN, ISRAEL.

EGGERT ANJA
INSTITUTE OF BIOLOGICAL SCIENCES, APPLIED ECOLOGY, UNIVERSITY OF ROSTOCK, ROSTOCK D-18057, GERMANY.

ENAMI ISAO
DEPARTMENT OF BIOLOGY, FACULTY OF SCIENCE, TOKYO UNIVERSITY OF SCIENCE, SHINJUKU-KU, TOKYO 162-8601, JAPAN.

GANTT ELISABETH
DEPARTMENT OF CELL BIOLOGY AND MOLECULAR GENETICS, UNIVERSITY OF MARYLAND, COLLEGE PARK, MD 20742, USA.

GENTRY MATTHEW S.
DEPARTMENT OF MOLECULAR AND CELLULAR BIOCHEMISTRY, UNIVERSITY OF KENTUCKY, LEXINGTON, KY 40536-0509, USA.

GROSS JEFERSON
UNIVERSITY OF IOWA, IOWA CITY, IA 52242, USA.

GROSSMAN ARTHUR R.
DEPARTMENT OF PLANT BIOLOGY, THE CARNEGIE INSTITUTION, STANFORD, CA, USA.

GUPTA VISHAL
DISCIPLINE OF MARINE BIOTECHNOLOGY AND ECOLOGY, CENTRAL SALT AND MARINE CHEMICALS RESEARCH INSTITUTE, COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR), BHAVNAGAR 364002, INDIA.

HANAOKA MITSUMASA
LABORATORY OF MOLECULAR GENETICS, INSTITUTE OF MOLECULAR AND CELLULAR BIOSCIENCES, THE UNIVERSITY OF TOKYO, BUNKYO-KU, TOKYO 113-0032, JAPAN.

HOFFMAN RAZY
THE MINA AND EVERARD GOODMAN FACULTY OF LIFE SCIENCES, BAR-ILAN UNIVERSITY, 52900 RAMAT GAN, ISRAEL.

HOLTGREFE S.
DEPARTMENT OF PLANT PHYSIOLOGY, UNIVERSITY OF OSNABRUECK, OSNABRUECK D-49069, GERMANY.

HOPKINS JULIA F.
THE CANADIAN INSTITUTE FOR ADVANCED RESEARCH, INTEGRATED MICROBIAL BIODIVERSITY PROGRAM, DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR BIOLOGY, DALHOUSIE UNIVERSITY, SIR CHARLES TUPPER MEDICAL BUILDING, 5850 COLLEGE STREET, HALIFAX, NS B3H 1X5, CANADA.

ISRAEL ALVARO
ISRAEL OCEANOGRAPHIC & LIMNOLOGICAL RESEARCH, LTD., THE NATIONAL INSTITUTE OF OCEANOGRAPHY, TEL SHIKMONA, P.O. BOX 8030, HAIFA 31080, ISRAEL.

JHA BHAVANATH
DISCIPLINE OF MARINE BIOTECHNOLOGY AND ECOLOGY, CENTRAL SALT AND MARINE CHEMICALS RESEARCH INSTITUTE, COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR), BHAVNAGAR 364002, INDIA.

KAMIYA MITSUNOBU
DEPARTMENT OF MARINE BIOSCIENCE, FUKUI PREFECTURAL UNIVERSITY, GAKUENCHO, FUKUI, OBAMA FUKUI 917-0003, JAPAN.

KARPOWICZ STEVEN
DEPARTMENT OF CHEMISTRY, UNIVERSITY OF CALIFORNIA, LOS ANGELES, CA, USA.

KARSTEN ULF
INSTITUTE OF BIOLOGICAL SCIENCES, APPLIED ECOLOGY, UNIVERSITY OF ROSTOCK, ROSTOCK D-18057, GERMANY.

KITADE YUKIHIRO
DEPARTMENT OF ALGAL GENETICS AND CHEMISTRY, FISHERIES SCIENCES, HOKKAIDO UNIVERSITY, HAKODATE, HOKKAIDO, JAPAN.

KLEIN ANITA S.
DEPARTMENT OF BIOLOGICAL SCIENCES, UNIVERSITY OF NEW HAMPSHIRE, DURHAM, NH, USA.

KÖNIG NICOLAS
DEPARTMENT OF PLANT PHYSIOLOGY, UNIVERSITY OF OSNABRUECK, OSNABRUECK D-49069, GERMANY.

KUMANO SHIGERU
BIODIVERSITY AND PHYLOGENETIC STUDY SECTION, ENVIRONMENTAL BIOLOGY DIVISION, NATIONAL INSTITUTE FOR ENVIRONMENTAL STUDIES, TSUKUBA 305-8506, JAPAN.

LAPIDOT MIRI
DEPARTMENT OF BIOTECHNOLOGY ENGINEERING, BEN-GURION UNIVERSITY OF THE NEGEV, BEER-SHEVA 84105, ISRAEL.

LEVINE IRA A.
UNIVERSITY OF SOUTHERN MAINE, LEWISTON, ME, USA.

LIN SENJIE
DEPARTMENT OF MARINE SCIENCES, UNIVERSITY OF CONNECTICUT, GROTON, CT, USA.

LOPEZ-BAUTISTA JUAN M.
DEPARTMENT OF BIOLOGICAL SCIENCES,
THE UNIVERSITY OF ALABAMA, TUSCALOOSA, AL 35487, USA.

LU SHAN
SCHOOL OF LIFE SCIENCES, NANJING UNIVERSITY,
NANJING, CHINA.

LYNCH MICHAEL D. J.
DEPARTMENT OF BIOLOGY, UNIVERSITY OF WATERLOO,
WATERLOO, ON N2L 3G1, CANADA.

MATTOO SEEMA
DEPARTMENT OF PHARMACOLOGY AND THE HOWARD HUGHES MEDICAL INSTITUTE, UNIVERSITY OF CALIFORNIA-SAN DIEGO, LA JOLLA, CA 92093-0721, USA.

McDERMOTT TIMOTHY R.
THERMAL BIOLOGY INSTITUTE AND DEPARTMENT
OF LAND RESOURCES, ENVIRONMENTAL SCIENCES MONTANA STATE UNIVERSITY, BOZEMAN, MT 59717, USA.

MINOCHA SUBHASH C.
UNIVERSITY OF SOUTHERN MAINE, LEWISTON, ME, USA.

MIYAGISHIMA SHIN-YA
MIYAGISHIMA INITIATIVE RESEARCH UNIT, FRONTIER RESEARCH SYSTEM, RIKEN, 2-1 HIROSAWA, WAKO,
SAITAMA 351-0198, JAPAN.

MÜLLER KIRSTEN M.
DEPARTMENT OF BIOLOGY, UNIVERSITY OF WATERLOO,
WATERLOO, ON N2L 3G1, CANADA.

MURRAY SHAUNA
SCHOOL OF BIOTECHNOLOGY AND BIOMOLECULAR SCIENCE AND THE AUSTRALIAN CENTRE FOR ASTROBIOLOGY,
UNIVERSITY OF NEW SOUTH WALES, NSW 2052, AUSTRALIA.

NAKANISHI HIROMITSU
MIYAGISHIMA INITIATIVE RESEARCH UNIT,
FRONTIER RESEARCH SYSTEM, RIKEN, 2-1 HIROSAWA,
WAKO, SAITAMA 351-0198, JAPAN.

NEEFUS CHRISTOPHER D.
UNIVERSITY OF SOUTHERN MAINE, LEWISTON, ME, USA.

NEILAN BRETT A.
SCHOOL OF BIOTECHNOLOGY AND BIOMOLECULAR SCIENCE
AND THE AUSTRALIAN CENTRE FOR ASTROBIOLOGY,
UNIVERSITY OF NEW SOUTH WALES,
NSW 2052, AUSTRALIA.

POTIN PHILIPPE
STATION BIOLOGIQUE, UNIVERSITÉ PIERRE ET MARIE CURIE-
PARIS6 CNRS UMR 7139 AND LIA'DIAMS', BP74, F-29682 ROSCOFF,
FRANCE.

RAFAEL VICUÑA
DEPARTAMENTO DE GENÉTICA MOLECULAR Y MICROBIOLOGÍA,
FACULTAD DE CIENCIAS BIOLÓGICAS, PONTIFICIA UNIVERSIDAD
CATÓLICA DE CHILE, INSTITUTO MILENIO DE BIOLOGIA
FUNDAMENTAL Y APLICADA, SANTIAGO, CHILE.

RAVEN JOHN A.
DIVISION OF PLANT SCIENCES, UNIVERSITY OF DUNDEE AT SCRI,
SCOTTISH CROP RESEARCH INSTITUTE, INVERGOWRIE,
DUNDEE DD2 5DA, UK.

REDDY C.R.K.
DISCIPLINE OF MARINE BIOTECHNOLOGY AND ECOLOGY,
CENTRAL SALT AND MARINE CHEMICALS RESEARCH INSTITUTE,
COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR),
BHAVNAGAR 364002, INDIA.

REEB VALERIE
DEPARTMENT OF BIOLOGICAL SCIENCES AND THE ROY J. CARVER
CENTER FOR COMPARATIVE GENOMICS,UNIVERSITY OF IOWA,
IOWA CITY, IA 52242, USA.

RYMARQUIS LINDA
UNIVERSITY OF DELAWARE, BIOTECHNOLOGY INSTITUTE,
NEWARK, DE, USA.

SCHEIBE R.
DEPARTMENT OF PLANT PHYSIOLOGY, UNIVERSITY
OF OSNABRUECK, 49069 OSNABRUECK, GERMANY.

SECKBACH JOSEPH
HEBREW UNIVERSITY OF JERUSALEM, HOME:
20 MEVO HADAS, P.O. BOX 1132 EFRAT, 90435, ISRAEL.

SHEATH ROBERT G.
DEPARTMENT OF BIOLOGICAL SCIENCES, CALIFORNIA STATE
UNIVERSITY SAN MARCOS, SAN MARCOS, CA 92096, USA.

SHEN JIAN-REN
DIVISION OF BIOSCIENCE, GRADUATE SCHOOL OF NATURAL
SCIENCE AND TECHNOLOGY, OKAYAMA UNIVERSITY,
OKAYAMA 700-8530, JAPAN.

ARAD SHOSHANA (MALIS)
DEPARTMENT OF BIOTECHNOLOGY ENGINEERING,
BEN-GURION UNIVERSITY OF THE NEGEV,
BEER-SHEVA 84105, ISRAEL;
PRESENT ADDRESS:
SCRIPPS INSTITUTION OF OCEANOGRAPHY,
UNIVERSITY OF CALIFORNIA,
SAN DIEGO, LA JOLLA CA 92037.

SHRESTHA ROSHAN PRAKASH
DEPARTMENT OF BIOTECHNOLOGY ENGINEERING,
BEN-GURION UNIVERSITY OF THE NEGEV,
BEER-SHEVA 84105, ISRAEL.

SMITH ALISON
DEPARTMENT OF PLANT SCIENCES, UNIVERSITY CAMBRIDGE,
CAMBRIDGE, UK.

STANKE MARIO
UNIVERSITÄT GÖTTINGEN, INSTITUT FÜR MIKROBIOLOGIE
UND GENETIK, ABTEILUNG FÜR BIOINFORMATIK,
GOLDSCHMIDTSTR. 1, 37077 GÖTTINGEN, GERMANY.

STILLER JOHN W.
DEPARTMENT OF BIOLOGY, EAST CAROLINA UNIVERSITY,
GREENVILLE, NC, USA.

TANAKA KAN
GRADUATE SCHOOL OF HORTICULTURE, CHIBA UNIVERSITY,
648 MATSUDO, CHIBA 271-8510, JAPAN.

WEINBERGER FLORIAN
BENTHIC ECOLOGY DEPARTMENT, LEIBNIZ-INSTITUT FÜR
MEERESWISSENSCHAF-TEN, DÜSTERNBROOKER WEG 20,
KIEL D-24105, GERMANY.

WEINSTEIN YACOB
DEPARTMENT OF MICROBIOLOGY AND IMMUNOLOGY,
FACULTY OF HEALTH SCIENCES, BEN-GURION
UNIVERSITY OF THE NEGEV, BEER SHEVA 84105, ISRAEL.

WEST JOHN A.
SCHOOL OF BOTANY, UNIVERSITY OF MELBOURNE,
PARKVILLES, VIC 3010, AUSTRALIA.

WU WEN-KAI
COLLEGE OF FISHERIES AND LIFE SCIENCE,
SHANGHAI OCEAN UNIVERSITY, SHANGHAI, CHINA.

YARISH CHARLES
UNIVERSITY OF CONNECTICUT, STAMFORD, CT, USA.

YOON HWAN SU
BIGELOW LABORATORY FOR OCEAN SCIENCES,
180 MCKOWN POINT ROAD, WEST BOOTHBAY HARBOR,
ME 04575, USA.

ZHUANG YUN YUN
DEPARTMENT OF MARINE SCIENCES,
UNIVERSITY OF CONNECTICUT, GROTON, CT, USA.

ZUCCARELLO GIUSEPPE C.
SCHOOL OF BIOLOGICAL SCIENCES, VICTORIA UNIVERSITY
OF WELLINGTON, P.O. BOX 600, WELLINGTON 6140, NEW ZEALAND.

PART 1:
ORIGIN AND EVOLUTION

Miyagishima
Nakanishi
Yoon
Zuccarello
Bhattacharya

Biodata of **Shin-Ya Miyagishima** and **Hiromitsu Nakanishi**, authors of ***"The Chloroplast Division Machinery: Origin and Evolution"***

Dr. Shin-Ya Miyagishima is currently the Unit leader of Miyagishima Initiative Research Unit in RIKEN, Japan. He obtained his Ph.D. from the University of Tokyo in 2002 and continued his studies and research at Michigan State University. His scientific interests are in the areas of mechanism of chloroplast and mitochondrial division, evolution of chloroplasts, and mechanism of endosymbiosis.

E-mail: **smiyagi@riken.jp**

Dr. Hiromitsu Nakanishi is currently the Research Scientist of Miyagishima Initiative Research Unit in RIKEN, Japan. He obtained his Ph.D. from the Shinshu University in 2006. His scientific interests are in the areas of mechanism of chloroplast division and morphogenesis of chloroplast.

E-mail: **h_nakanishi@riken.jp**

Shin-Ya Miyagishima

Hiromitsu Nakanishi

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