

The Molecular Targets and Therapeutic Uses of Curcumin in Health and Disease

ADVANCES IN EXPERIMENTAL MEDICINE AND BIOLOGY

Editorial Board:

NATHAN BACK, *State University of New York at Buffalo*

IRUN R. COHEN, *The Weizmann Institute of Science*

DAVID KRITCHEVSKY, *Wistar Institute*

ABEL LAJTHA, *N. S. Kline Institute for Psychiatric Research*

RODOLFO PAOLETTI, *University of Milan*

Recent Volumes in this Series

Volume 587

NEW TRENDS IN CANCER FOR THE 21st CENTURY

Edited by Antonio Llombar-Bosch, Jose López-Guerrero and Vincenzo Felipe

Volume 588

HYPOXIA AND EXERCISE

Edited by Robert C. Roach, Peter D. Wagner, and Peter H. Hackett

Volume 589

NEURAL CREST INDUCTION AND DIFFERENTIATION

Edited by Jean-Pierre Saint-Jeannet

Volume 590

CROSSROADS BETWEEN INNATE AND ADAPTIVE IMMUNITY

Edited by Peter D. Katsikis, Bali Pulendran and Stephen P. Schoenberger

Volume 591

SOMATIC CELL NUCLEAR TRANSFER

Edited by Peter Sutovsky

Volume 592

REGULATORY MECHANISMS OF STRIATED MUSCLE CONTRACTION

Edited by Setsuro Ebashi and Iwao Ohtsuki

Volume 593

MICROARRAY TECHNOLOGY AND CANCER GENE PROFILING

Edited by Simone Mocellin

Volume 594

MOLECULAR ASPECTS OF THE STRESS RESPONSE

Edited by Peter Csermely and Laszlo Vigh

Volume 595

THE MOLECULAR TARGETS AND THERAPEUTIC USES OF CURCUMIN IN HEALTH AND DISEASE

Edited by Bharat B. Aggarwal, Young-Joon Surh and Shishir Shishodia

A Continuation Order Plan is available for this series. A continuation order will bring delivery of each new volume immediately upon publication. Volumes are billed only upon actual shipment. For further information please contact the publisher.

Bharat B. Aggarwal
Young-Joon Surh
Shishir Shishodia
Editors

The Molecular Targets and Therapeutic Uses of Curcumin in Health and Disease

With 77 Illustrations

 Springer

Editors

Bharat B. Aggarwal, Ph.D.
Ransom Horne, Jr., Professor of Cancer Research
Professor of Cancer Medicine (Biochemistry)
and Chief, Cytokine Research Section
Department of Experimental Therapeutics
The University of Texas M. D. Anderson Cancer Center
1515 Holcombe Boulevard, BOX 143, Houston, TX 77030, USA
aggarwal@mdanderson.org

Young-Joon Surh, Ph.D.
Chief and Professor
National Research Laboratory of Molecular Carcinogenesis
and Chemoprevention
College of Pharmacy
Seoul National University
Shillim-dong, Kwanak-gu, Seoul 151-742, South Korea
surh@plaza.snu.ac.kr

Shishir Shishodia, Ph.D.
Assistant Professor
Department of Biology
Texas Southern University
3100 Cleburne Street, Houston, TX 77004, USA
shishodia@gmail.com

Library of Congress Control Number: 2006938892

ISBN-13:978-0-387-46400-8 e-ISBN-13:978-0-387-46401-5

Printed on acid-free paper.

© 2007 Springer Science+Business Media, LLC

All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer Science+Business Media, LLC, 233 Spring Street, New York, NY 10013, USA), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden. The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

9 8 7 6 5 4 3 2 1

springer.com

Dedicated to our gurus and parents whose guidance continues to inspire us!

*Sarve bhavantu sukhinah sarve santu niramayah
Sarve bhadrani pasyantu ma kascid duhkhabhag bhavet*

“May all be happy; may all be healthy;
may all enjoy prosperity; may none suffer.”

PREFACE

The subject of this monograph, curcumin, which gives the yellow color to turmeric, best known as *Haridra* in Sanskrit (means dear to Hari or Lord Krishna). Turmeric is known by several synonyms related to its appearance or use, including *Pita* (yellow, leading to the name *Peethamber dhari* for Lord Krishna based on wearing only yellow clothes), *Gauri* (brilliant), *Kanchani* (looks like gold), *Nisha* (beautiful as a full moon night), *Krimighni* (antibacterial and antihelmenthic), *Mahaghni* (antidiabetic), and *Yoshit priya* (gynecological disorders). In Hindi, turmeric is known as *Haldi*, in Japanese as *Ukon* or *Gajyutsu*, and in Korean as *Ulgeum* or *Gangwhang*.

Turmeric is mentioned in the writings of the Italian explorer Marco Polo, who was introduced to it during his voyage to China and India around 1290 AD. Although he gets credit for bringing Far East spices to Europe, turmeric was actually introduced in Europe in the 13th century AD by Arab traders. The Portuguese explorer Vasco de Gama visited the Indian subcontinent during the 15th century and brought turmeric and other spices of the Orient to the West. It was only during the rule of the British in India that turmeric was combined with various other spices and renamed “curry powder,” as it is called in the West.

Turmeric became of special importance to man with the discovery that when added to various food preparations, its dried and powdered rhizome preserved their freshness and nutritive value and improved the palatability and presentation of food. The brilliant yellow color of turmeric, which persists even at very high dilutions, found its way to commercial use as a coloring agent for various items, including cotton, silk, paper, wood, foodstuffs, and cosmetics. In Ayurveda (science of long life), turmeric has been used internally as a stomachic, tonic, and blood purifier and topically in the prevention and treatment of skin diseases. Turmeric concoctions have been traditionally used for the treatment of flatulence, dyspepsia, liver disorder, jaundice, urinary tract diseases, cold, chronic otorrhea, parasitic skin infection, bruises, sprain, wound, infected wound, and inflammation.

We are currently living in an era when 80% of the world’s population cannot afford modern medicine. Even for those 20% who can, much of modern medicine is ineffective and has numerous side effects. It is a good time to revive the medicinal use of the ancient medicine curcumin. In this volume we bring together the contribution of modern science to one of the most ancient spices known to mankind. Curcumin’s beneficial role in health and disease and its molecular targets are the focus of this monograph. This volume is directed at clinicians and scientists working in the areas of experimental and molecular therapeutics, molecular medicine, translational cancer research, Ayurveda, herbal medicine, naturopathy, and biomedical sciences in general and, most importantly, to the end users of curcumin. We hope that this book will “add spice to everybody’s life.”

We would like to thank all of the contributors for their valuable contributions to this work. We would also like to thank those who have contributed significantly to curcumin research but could not, because of limitations on space, be invited to contribute.

Bharat B. Aggarwal, Ph.D.

Young-Joon Surh, Ph.D.

Shishir Shishodia, Ph.D.

FOREWORD

It is indeed a matter of pride and privilege to write the Foreword; to this scholarly contribution on curcumin—the major constituent of turmeric. The volume has been successful in seamlessly connecting the traditional knowledge available on turmeric to the findings of systematic modern research on turmeric and, based on this effort, building the possibilities of developing novel drugs to treat diverse diseases. Turmeric (*Curcuma longa*)—a widely cultivated tropical plant—has been used since ancient times as a spice, as a beauty care agent, and as a traditional medicine.

The rhizome of turmeric is highly aromatic and antiseptic. The medicinal properties of turmeric have been expounded in Ayurvedic and traditional Chinese medicine (TCM) texts. Turmeric is traditionally known as a stomachic, blood purifier and is useful for the common cold, leprosy, intermittent fevers, afflictions of the liver, indolent ulcer, pyogenic (forming pus) afflictions, wound-healing, and inflammation.

In recent years, the medicinal properties of turmeric have increasingly been recognized. It is being researched systematically even in the Western world. I remember fighting the “turmeric battle” on the wrong patent on the wound-healing properties of turmeric that was given by the US Patent Office almost a decade ago.

As per the US National Library of Medicine, 256 research papers were published last year on curcumin. The researchers have found in curcumin a near-perfect starting material for drug discovery. Thus, a variety of curcumin analogues have been prepared and evaluated biologically. Curcumin exhibits a wide range of activities [e.g., antibacterial, anti-inflammatory, hypolipidemic, hepatoprotective, lipoxigenase (LOX), cyclooxygenase (COX), protease inhibitory effects, in addition to being effective as an active oxygen scavenger and lipid peroxidase (a class of oxidoreductase enzymes) inhibitor]. Curcumin and the curcuminoids also lower cholesterol, reduce platelet aggregation, inhibit the proliferation of cancer cells, and improve digestion by increasing the flow of bile from the gallbladder. The desirable preventive or putative therapeutic properties of curcumin have been considered to be associated with its antioxidant and anti-inflammatory properties.

Curcumin has been found to modulate the activity of several key transcription factors and, in turn, the cellular expression profiles. The effect of curcumin has been examined on most of the targets discovered within the last three decades. Curcumin modulates several different transcription factors, cytokines, growth factors, kinases and other enzymes. The research results have been elaborately covered in this book and explanations provided would add to knowledge pool.

The National Institutes of Health has four clinical trials in progress on curcumin treatment, namely for pancreatic cancer, multiple myeloma, Alzheimer's disease, and colorectal cancer. Curcumin has been found to possess potential

chemopreventive activities. It shows cytotoxic potential against tumor cells both *in vitro* and *in vivo*. Thus, curcumin fits well in the effort of chemoprevention by edible phytochemicals, which is now considered to be an inexpensive, readily applicable, and accessible approach to cancer management. The optimization of intervention trials of diet-derived putative chemopreventive agents is currently under development in normal populations as well as in high-risk groups. Curcumin is also a good immunomodulator. These biological activities warrant further studies of curcumin in the treatment and prevention of human neoplasia.

Curcumin has enormous potential as an antiangiogenic drug. It has been elaborately explained in the chapter discussing this. The property has been attributed to curcumin's ability to downregulate certain transcription factors and proangiogenic factors. Curcumin also has the necessary characteristics of a neuroprotective drug. The activity has been proven in a variety of disease models. Thus, it has great potential for the prevention of multiple neurological conditions for which current therapeutics are less than optimal. The chapter entitled "Neuroprotective Effects of Curcumin" embodies the research carried out on the subject and the existing necessity for further efforts. The curcumin-mediated regulation of COX and LOX enzymes for obtaining their beneficial effects in preventing diverse inflammatory diseases has been dwelt upon in another chapter. Interestingly, curcumin has an edge over conventional nonsteroidal anti-inflammatory drugs and selective COX-2 inhibitors. This might pave the way for path-breaking research in the domain.

This volume in fact covers the length and breadth of research undertaken on curcumin and research results thus far obtained. The diversity ranges from molecular targets, cell growth regulation, antioxidant and anti-inflammatory properties, chemosensitivity, radio protection, and radio sensitivity to immunomodulation, anticancer effects, cardioprotective effects, nephroprotective to hepatoprotective effects, protection from acute and chronic lung diseases to pharmacokinetics and pharmacodynamics and clinical studies undertaken with curcumin. The canvas thus covered is indeed brilliant.

As research advances, it poses newer challenges as well. Several questions in the light of the new drug development effort thus remain to be answered in order to put curcumin in a higher orbit. These pertain to the solubility and stability of curcumin, its optimum dose, pharmacokinetics, mechanism of action of curcumin for a given disease, bioavailability profile, and intricacies of prevention and cure of an identified disease. Further research is thus necessary on these aspects. There is also a need to find out whether other components of turmeric than curcumin have beneficial effects, either alone or in combination with curcumin.

I am happy to see that the contributions in this book have proven beyond doubt that curcumin—an ingredient of the traditional Indian spice turmeric—has enormous potential against a variety of malignant and nonmalignant diseases. I am confident that the state-of-the-art on curcumin research so nicely compiled and analyzed throughout this volume would provide an insight and learning not only to professionals in the field but also to budding researchers. I hope that they would be inspired to answer the unanswered questions on curcumin based on new research

endeavors. I congratulate the editors of the volume and the contributors of the various chapters for creating this unique and scholarly marvel.

R.A. Mashelkar, FRS
Director General
Council of Scientific & Industrial Research, New Delhi, India
October 19, 2006

CONTENTS

CURCUMIN: THE INDIAN SOLID GOLD	1
Bharat B. Aggarwal, Chitra Sundaram, Nikita Malani, and Haruyo Ichikawa	
HIGHLY ACTIVE ANTICANCER CURCUMIN ANALOGUES	77
Cara A. Mosley, Dennis C. Liotta, and James P. Snyder	
ANTIOXIDANT AND ANTI-INFLAMMATORY PROPERTIES OF CURCUMIN.....	105
Venugopal P. Menon and Adluri Ram Sudheer	
MODULATION OF TRANSCRIPTION FACTORS BY CURCUMIN.....	127
Shishir Shishodia, Tulika Singh, and Madan M. Chaturvedi	
CANCER CHEMOPREVENTIVE EFFECTS OF CURCUMIN	149
Young-Joon Surh and Kyung-Soo Chun	
ANTITUMOR, ANTI-INVASION, AND ANTIMETASTATIC EFFECTS OF CURCUMIN.....	173
Girija Kuttan, Kuzhuvelil B. Hari Kumar, Chandrasekharan Guruvayoorappan, and Ramadasan Kuttan	
CURCUMIN AS AN INHIBITOR OF ANGIOGENESIS	185
Sulochana S. Bhandarkar and Jack L. Arbiser	
NEUROPROTECTIVE EFFECTS OF CURCUMIN.....	197
Greg M. Cole, Bruce Teter, and Sally A. Frautschy	
REGULATION OF COX AND LOX BY CURCUMIN.....	213
Chinthalapally V. Rao	
MOLECULAR TARGETS OF CURCUMIN.....	227
Jen-Kun Lin	
CELL GROWTH REGULATION.....	245
Devarajan Karunakaran, Jeena Joseph, and Thankayyan R. Santhosh Kumar	

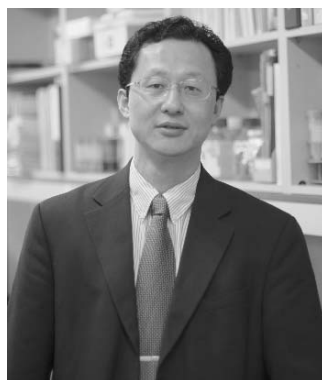
CURCUMIN AS CHEMOSENSITIZER.....	269
Pornngarm Limtrakul	
RADIOPROTECTION AND RADIOSENSITIZATION BY CURCUMIN	301
Ganesh C. Jagetia	
IMMUNOMODULATION BY CURCUMIN	321
Subhash C. Gautam, Xiaohua Gao, and Scott Dulchavsky	
BENEFICIAL ROLE OF CURCUMIN IN SKIN DISEASES	343
Rajesh L. Thangapazham, Anuj Sharma, and Radha K. Maheshwari	
CARDIOPROTECTIVE EFFECTS OF CURCUMIN	359
Sumitra Miriyala, Manikandan Panchatcharam, and Puvanakrishnan Rengarajulu	
PROTECTION FROM ACUTE AND CHRONIC LUNG DISEASES BY CURCUMIN	379
Narayanan Venkatesan, Durairaj Punithavathi, and Mary Babu	
NEPHROPROTECTIVE AND HEPATOPROTECTIVE EFFECTS OF CURCUMINOIDS	407
Toshihiko Osawa	
CURCUMIN AND AUTOIMMUNE DISEASE.....	425
John J. Bright	
PHARMACOKINETICS AND PHARMACODYNAMICS OF CURCUMIN.....	453
Ricky A. Sharma, William P. Steward, and Andreas J. Gescher	
CLINICAL STUDIES WITH CURCUMIN	471
Chih-Hung Hsu and Ann-Lii Cheng	
INDEX	481

EDITORS

Dr. Bharat B. Aggarwal received his Ph.D. in Biochemistry from the University of California, Berkeley, did his postdoctoral fellowship in endocrinology at the University of California Medical Center San Francisco, and then worked for a biotechnology company (Genentech Inc.) where he discovered two different TNFs, both essential components of the immune system. In 1989, Dr. Aggarwal accepted a position as a Professor and Chief of the Cytokine Research Section at the University of Texas M. D. Anderson Cancer in Houston. He currently holds the Ransom Horne Jr. Professorship in Cancer Research. He has published over 400 original peer-reviewed articles and reviews, edited 9 books, and been granted almost 35 patents. Since 2001, Dr. Aggarwal has been listed as one of the world's most highly cited scientists by the Institute of Scientific Information. Dr. Aggarwal received an Outstanding Scientists Award from Ranbaxy in 2005 and from the American Association of Indians in Cancer Research in 2006.



Dr. Young-Joon Surh is a Professor of Biochemistry and Molecular Toxicology, College of Pharmacy, Seoul National University, South Korea and Chief of National Research Laboratory of Molecular Carcinogenesis and Chemoprevention. Professor Surh earned a Ph.D. degree at the McArdle Laboratory for Cancer Research, University of Wisconsin–Madison and completed postdoctoral training at the Massachusetts Institute of Technology. In 1992, he was appointed as a tenure-track assistant professor at Yale University School of Medicine. Since relocating to Seoul National University in 1996, he has been leading the Chemoprevention Working Group, investigating the molecular mechanisms of cancer prevention by edible phytochemicals, with emphasis on intracellular signaling molecules as prime targets.



He is currently a member of the editorial boards of more than 10 international journals, including *Carcinogenesis*, *Molecular Carcinogenesis*, *Cancer Letters*, *Mutation Research*, *Food and Chemical Toxicology*, and *Biofactors*. He is also

co-editor of the book *Oxidative Stress, Inflammation and Health* published by CRC Press in 2005. Dr. Surh has published more than 120 papers in peer-reviewed international journals and about 50 invited editorials, reviews, and book chapters. Dr. Surh has recently published a seminal article, entitled “Chemoprevention with Dietary Phytochemicals,” in *Nature Reviews Cancer*.

Dr. Shishir Shishodia earned his Ph.D. in Biotechnology from Banaras Hindu University, Varanasi, India and did his postdoctoral fellowship at the University of Texas M. D. Anderson Cancer Center. Before joining M. D. Anderson Cancer Center, he served as an Assistant Professor at Patna University, Patna, India. He is currently an Assistant Professor at the Texas Southern University, Houston. Dr. Shishodia’s research interests include cytokine signaling, the role of transcription factors in tumorigenesis, and regulation of transcription by natural products. He has identified several natural compounds that exhibit anticancer properties. He has published over 50 peer-reviewed papers and co-edited the book *Resveratrol in Health and Disease*. Dr. Shishodia is a recipient of the BHU Gold Medal and the Theodore N. Law Odyssey Award for outstanding scientific achievements.



CONTRIBUTORS

Bharat B. Aggarwal

Ransom Horne, Jr., Professor of
Cancer Research
Professor of Cancer Medicine
(Biochemistry) and
Chief, Cytokine Research Section
Department of Experimental
Therapeutics
The University of Texas M.D.
Anderson Cancer Center
1515 Holcombe Boulevard
BOX 143
Houston, TX 77030, USA
aggarwal@mdanderson.org

Jack L. Arbiser

Associate Professor
Department of Dermatology, Emory
University School of Medicine
Winship Cancer Institute
1639 Pierce Drive WMB 5309
Atlanta, GA 30322, USA
jarbise@emory.edu

Mary Babu

Deputy Director and Head
Bio-Materials Laboratory
CLRI, Chennai-600020, India
marybabu@hotmail.com

Sulochana S. Bhandarkar

Department of Dermatology
Emory University School of
Medicine
Winship Cancer Institute
1639 Pierce Drive WMB 5309
Atlanta, GA 30322, USA
ssbhand@emory.edu

John J. Bright

Senior Investigator and Director of
Neuroscience Research Laboratory
Methodist Research Institute
Clarian Health, 1800 N Capital Avenue
Noyes Building, Suite E504
Indianapolis, IN 46202, USA
jbright1@clarian.org

Madan M. Chaturvedi

Professor
Department of Zoology
Delhi University
Delhi 110007, India
mchaturvedi@zoology.du.ac.in

Ann-Lii Cheng

Professor
Department of Internal Medicine and
Oncology, National Taiwan University
Hospital
Cancer Research Center, National
Taiwan University College of Medicine
7 Chung-Shan S. Rd., Taipei, Taiwan
andrew@ha.mc.ntu.edu.tw

Kyung-Soo Chun

Laboratory of Molecular
Carcinogenesis
National Institute of Environmental
Health Sciences
Research Triangle Park, NC 27709,
USA
chunkyungsoo@yahoo.co.kr

Gregory M. Cole

Professor of Medicine and Neurology
Greater Los Angeles Veterans Affairs
Healthcare System

Geriatric Research, Education, and
Clinic Center 11E
16111 Plummer Street
Sepulveda, CA 91343, USA
gmcole@ucla.edu

Scott Dulchavsky

Department of Surgery
Henry Ford Health System
2977 West Grand Boulevard
Detroit, MI 48202, USA
sdulchal1@hfhs.org

Sally A. Frautschy

Associate Professor of Neurology
Department of Medicine and
Neurology
University of California,
Los Angeles
Greater Los Angeles Healthcare
System
(Veteran's Affairs Medical Center)
16111 Plummer St. North Hills,
CA 91343, USA
frautsch@ucl.edu

Xiaohua Gao

Department of Surgery
Henry Ford Health System
2977 West Grand Boulevard
Detroit, MI 48202, USA
tgao1@hfhs.org

Subhash C. Gautam

Department of Surgery
Henry Ford Health System
2977 West Grand Boulevard
Detroit, MI 48202, USA
sgautam1@hfhs.org

Andreas J. Gescher

Professor of Biochemical Toxicology
Cancer Biomarkers and Prevention
Group

Department of Cancer Studies and
Molecular Medicine
University of Leicester
Leicester LE2 7LX, UK
ag15@leicester.ac.uk.

Chandrasekharan**Guruvayoorappan**

Department of Immunology
Amala Cancer Research Centre
Amala Nagar, Thrissur Kerala 680555,
India
guruappa2003@yahoo.co.in

Chih-Hung Hsu

Department of Oncology
National Taiwan University Hospital
7, Chung-Shan S. Rd., Taipei, Taiwan
chih@ha.mc.ntu.edu.tw

Haruyo Ichikawa

International Research and Educational
Institute for Integrated Medical
Sciences
Tokyo Women's Medical School
8-1 Kawada-cho, Shinjuku
Tokyo 162-8666, Japan
haruyo.ichikawa@gmail.com

Ganesh C. Jagetia

Professor & Head
Department of Radiobiology
Kasturba Medical College
Manipal—576 104, India
gc.jagetia@gmail.com

Jeena Joseph

Department of Cancer Biology
Rajiv Gandhi Centre for
Biotechnology
Thiruvananthapuram-695 014, India
josephjeena@gmail.com

Devarajan Karunakaran

Professor
Department of Biotechnology

Indian Institute of Technology Madras
Chennai - 600 036, India
karuna@iitm.ac.in

Kuzhuvelil B. Hari Kumar

Department of Biochemistry
Amala Cancer Research Centre
Amala Nagar, Thrissur Kerala, India
kbharikumar@gmail.com

Thankayyan R. Santhosh Kumar

Department of Cancer Biology
Rajiv Gandhi Centre for Biotechnology
Thiruvananthapuram-695 014, India
santhaltr@yahoo.com

Girija Kuttan

Professor
Department of Immunology
Amala Cancer Research Centre
Amala Nagar, Thrissur Kerala, India
amalaresearch@rediffmail.com

Ramadasan Kuttan

Research Director
Amala Cancer Research Centre
Amala Nagar, Thrissur
Kerala, India
amalaresearch@rediffmail.com

Pornngarm Limtrakul

Chairperson, Department of
Biochemistry
Faculty of Medicine
Chiang Mai University
Chiang Mai, Thailand 50200
plimtrak@mail.med.cmu.ac.th

Jen-Kun Lin

Professor
Institute of Biochemistry and
Molecular Biology
College of Medicine
National Taiwan University

No. 1, Section 1, Jen-ai Road
Taipei, Taiwan
jclin@ha.mc.ntu.edu.tw

Dennis C. Liotta

Professor of Organic Chemistry
Department of Chemistry
Emory University
Atlanta, GA, 30322, USA
dliotta@emory.com

Radha K. Maheshwari

Professor of Pathology
Director, Center for Combat Casualty
and Life Sustainment Research
Coordinator Indo-US activities
Uniformed Services University of the
Health Sciences
Bethesda, MD 20814, USA
rmaheshwari@usuhs.mil

Nikita Malani

Cytokine Research Laboratory
Department of Experimental
Therapeutics - Box 143
University of Texas M. D. Anderson
Cancer Center
1515 Holcombe Boulevard
Houston, Texas, USA
nmalani@sas.upenn.edu

Venugopal P. Menon

Professor and Chairman
Department of Biochemistry &
Center for Micronutrient Research
Annamalai University
Annamalai Nagar-608 002
Chidambaram, Tamilnadu, India
biocmr@sify.com

Sumitra Miriyala

Department of Medicine
Carolina Cardiovascular Biology
Center
University of North Carolina

Chapel Hill, North Carolina-27599,
USA
sumishree@hotmail.com

Cara A. Mosley
Department of Chemistry
Emory University
Atlanta, GA, 30322, USA
camosle@emory.edu

Toshihiko Osawa
Professor
Laboratory of Food and Biodynamics
Nagoya University Graduate School of
Bioagricultural Sciences
Furo-cho, Chikusa-ku, Nagoya
464-8601, Japan
osawat@agr.nagoya-u.ac.jp

Manikandan Panchatcharam
Department of Medicine
Carolina Cardiovascular Biology
Center
University of North Carolina
Chapel Hill, North Carolina 27599,
USA
spmani5@gmail.com

Durairaj Punithavathi
Bio-materials Laboratory
CLRI, Adyar, Chennai-600020, India
punithavathid@yahoo.com

Chinthalapally V. Rao
Professor of Medicine
Kerley-Cade Endowed Chair in Cancer
Research
Hematology-Oncology Section
Director, Chemoprevention Program
University of Oklahoma Cancer
Institute
OUHSC, P.O. Box 26901
975 NE 10th Street, BRC 1203
Oklahoma City, OK 73104, USA
cv-rao@ouhsc.edu

Puvanakrishnan Rengarajulu
Deputy Director and Head
Department of Biotechnology
CLRI, Chennai-600 020
India
puvanakrishnan@yahoo.com

Adluri Ram Sudheer
Department of Biochemistry &
Biotechnology
Faculty of Science
Annamalai University
Annamalai Nagar-608002, Tamilnadu,
India
biosudheer99@yahoo.co.in

Anuj Sharma
Uniformed Services University of
Health Sciences,
Bethesda, MD, USA
Birla Institute of Technology and
Science
Pilani 333031, Rajasthan, India
asharma@usuhs.mil

Ricky A. Sharma
Senior Fellow & Honorary Consultant
Radiation Oncology & Biology,
University of Oxford, Churchill
Hospital, Oxford OX3
7LJ, UK
ricky.sharma@rob.ox.ac.uk

Shishir Shishodia
Assistant Professor
Department of Biology
Texas Southern University
3100 Cleburne Street
Houston, TX 77004, USA
shishodia@gmail.com;
shishodias@tsu.edu

Tulika Singh
Department of Biology
Texas Southern University

3100 Cleburne Street
Houston, TX 77004, USA
tsshishodia@gmail.com

James P. Snyder

Director of Biostructural
Research
Department of Chemistry
Emory University
1515 Dickey Drive
Atlanta, GA 30322, USA
jsnyder@emory.edu

William P. Steward

Professor of Oncology
Cancer Biomarkers and Prevention
Group
Department of Cancer Studies and
Molecular Medicine
University of Leicester
Leicester Royal Infirmary
Leicester LE1 SWW, UK
wps1@leicester.ac.uk

Chitra Sundaram

Cytokine Research Laboratory
Department of Experimental
Therapeutics - Box 143
University of Texas M. D. Anderson
Cancer Center
1515 Holcombe Boulevard
Houston, Texas, USA
chitra_1964@yahoo.com

Young-Joon Surh

Chief and Professor
National Research Laboratory of

Molecular Carcinogenesis and
Chemoprevention
College of Pharmacy
Seoul National University
Shillim-dong, Kwanak-gu
Seoul 151-742, South Korea
surh@plaza.snu.ac.kr

Bruce Teter

Department of Medicine and
Neurology
University of California, Los Angeles
Greater Los Angeles Healthcare
System
(Veteran's Affairs Medical Center)
16111 Plummer St. North Hills, CA
91343, USA
bteter@ucla.edu

Rajesh L. Thangapazham

Uniformed Services University of
Health Sciences
Bethesda, MD, USA
Birla Institute of Technology and
Science
Pilani 333031, Rajasthan, India
rlthangapazham@usuhs.mil

Narayanan Venkatesan

Associate Professor
Faculte de Medecine
UMR-7561 CNRS UHP; B.P. 184
54505 Vandoeuvre lès Nancy
France
vnar12@yahoo.com