



Nanobiomaterials

Applications in Drug Delivery

Editors

Anil K. Sharma | Raj K. Keservani | Rajesh K. Kesharwani

AAP | APPLE
ACADEMIC
PRESS



CRC Press
Taylor & Francis Group

NANOBIOMATERIALS

Applications in Drug Delivery



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>

NANOBIOMATERIALS

Applications in Drug Delivery

Edited By

Anil K. Sharma, MPharm

Raj K. Keservani, MPharm

Rajesh K. Kesharwani, PhD



Apple Academic Press Inc.
3333 Mistwell Crescent
Oakville, ON L6L 0A2
Canada

Apple Academic Press Inc.
9 Spinnaker Way
Waretown, NJ 08758
USA

© 2018 by Apple Academic Press, Inc.

No claim to original U.S. Government works

Printed in the United States of America on acid-free paper

International Standard Book Number-13: 978-1-77188-591-1 (Hardcover)

International Standard Book Number-13: 978-1-315-20491-8 (eBook)

All rights reserved. No part of this work may be reprinted or reproduced or utilized in any form or by any electronic, mechanical or other means, now known or hereafter invented, including photocopying and recording, or in any information storage or retrieval system, without permission in writing from the publisher or its distributor, except in the case of brief excerpts or quotations for use in reviews or critical articles.

This book contains information obtained from authentic and highly regarded sources. Reprinted material is quoted with permission and sources are indicated. Copyright for individual articles remains with the authors as indicated. A wide variety of references are listed. Reasonable efforts have been made to publish reliable data and information, but the authors, editors, and the publisher cannot assume responsibility for the validity of all materials or the consequences of their use. The authors, editors, and the publisher have attempted to trace the copyright holders of all material reproduced in this publication and apologize to copyright holders if permission to publish in this form has not been obtained. If any copyright material has not been acknowledged, please write and let us know so we may rectify in any future reprint.

Library of Congress Control Number: 2017952472

Trademark Notice: Registered trademark of products or corporate names are used only for explanation and identification without intent to infringe.

Library and Archives Canada Cataloguing in Publication

Nanobiomaterials : applications in drug delivery / edited by Anil K. Sharma, MPharm, Raj K. Keservani, MPharm, Rajesh K. Kesharwani, PhD.

Includes bibliographical references and index.

Issued in print and electronic formats.

ISBN 978-1-77188-591-1 (hardcover).--ISBN 978-1-315-20491-8 (PDF)

1. Drug delivery systems. 2. Nanobiotechnology. 3. Nanostructured materials. I. Sharma, Anil K., 1980-, editor II. Keservani, Raj K., 1981-, editor III. Kesharwani, Rajesh Kumar, 1978-, editor

RS199.5.N36 2017

615'.6

C2017-905673-5

C2017-905674-3

CIP data on file with US Library of Congress

Apple Academic Press also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic format. For information about Apple Academic Press products, visit our website at www.appleacademicpress.com and the CRC Press website at www.crcpress.com

CONTENTS

<i>Dedication</i>	<i>vii</i>
<i>Contributors</i>	<i>ix</i>
<i>Abbreviations</i>	<i>xiii</i>
<i>Preface</i>	<i>xvii</i>
<i>About the Editors</i>	<i>xxi</i>
PART I: AN OVERVIEW OF NANOBIMATERIALS	1
1. Nanoparticulate Nanocarriers in Drug Delivery	3
Raj K. Keservani, Anil K. Sharma, and Rajesh K. Kesharwani	
2. Nanoparticles: Formulation Aspects and Applications	23
Sushama Talegaonkar, Lalit Mohan Negi, Harshita Sharma, and Sobiya Zafar	
3. Physical and Chemical Properties of Nanobiomaterials	75
Sumitra Nain, Garima Mathur, Pragati Karana, and Hari Om Singh	
PART II: DRUG DELIVERY AND NANOTECHNOLOGY	89
4. Introduction to Drug Delivery	91
Mila A. Emerald	
5. Application of Nanobioformulations for Controlled Release and Targeted Biodistribution of Drugs	131
Josef Jampílek and Katarína Kráľová	
6. Targeted Delivery Systems Based on Polymeric Nanoparticles for Biomedical Applications	209
Sa Yang, Can Huang, Zhi-Ping Li, Qian Ning, Wen Huang, Wen-Qin Wang, and Cui-Yun Yu	
7. Smart Delivery of Nanobiomaterials	241
Mirza Sarwar Baig, Raj K. Keservani, Mohd Fasih Ahmad, and Mirza Ehtesham Baig	

PART III: NANOBIMATERIALS AS CARRIERS IN CANCER THERAPEUTICS	289
8. Advances of Nanotechnology in Cancer Therapy	291
Urmila Jarouliya, Raj K. Keservani, and Rajesh K. Kesharwani	
9. Nanobiomaterials for Cancer Diagnosis and Therapy	329
Cecilia Cristea, Florin Graur, Ramona Gălătuș, Călin Vaida, Doina Pîslă, and Robert Săndulescu	
10. Nanobiomaterials for Cancer Therapy	377
Kevin J. Quigley and Paul Dalhaimer	
11. Nanotechnology in Hyperthermia-Based Therapy and Controlled Drug Delivery	395
Anamaria Orza and Christopher Clark	
PART IV: DIVERSE USES OF NANOBIMATERIALS.....	415
12. Nano Carrier Systems of Ubidecarenone (Coenzyme Q10) for Cosmetic Applications.....	417
N. K. Yadav, Rekha Rao, O. P. Katare, and Sanju Nanda	
13. Nanobased CNS Delivery Systems.....	441
Rahimeh Rasouli, Mahmood Alaei-Beirami, and Farzaneh Zaaeri	
14. Nanobiomaterial for Non-Viral Gene Delivery	475
Kirti Rani Sharma	
<i>Index.....</i>	<i>505</i>

DEDICATION

The Present Book is Dedicated to Our Beloved

Aashna, Atharva, and Vihaan



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>

CONTRIBUTORS

Mohd Fasih Ahmad

Barrocyte Pvt. Ltd., 105, First Floor, Block No-CHBS, Sukhdev Vihar CSC, Near Fortis-Escorts Hospital, New Delhi, 110025, India

Mirza Ehtesham Baig

Barrocyte Pvt. Ltd., 105, First Floor, Block No-CHBS, Sukhdev Vihar CSC, Near Fortis-Escorts Hospital, New Delhi, 110025, India

Mirza Sarwar Baig

Department of Biosciences, Jamia Millia Islamia (A Central University), New Delhi, 110025, India

Mahmood Alaei-Beirami

Drug Applied Research Center and Students' Research Committee, Tabriz University of Medical Science, Tabriz, Iran/Faculty of Pharmacy, Tabriz University of Medical Sciences, Tabriz, Iran

Christopher Clark

The Movement Group, Inc., Atlanta, Georgia, The United States of America

Cecilia Cristea

Analytical Chemistry Department, Faculty of Pharmacy, Iuliu Hațieganu University of Medicine and Pharmacy, 4 Pasteur St., 400012, Cluj-Napoca, Romania, E-mail: ccristea@umfcluj.ro

Paul Dalhaimer

Department of Chemical and Biomolecular Engineering, University of Tennessee, Knoxville, TN, 37996, USA, E-mail: pdalhaim@utk.edu/Department of Biochemistry, Cellular and Molecular Biology, University of Tennessee, Knoxville, TN 37996, USA

Mila A. Emerald

Phytoceuticals International™ and Novotek Global Solutions™, Ontario, Canada, E-mail: drmilaemerald@gmail.com

Ramona Gălătuș

Basis of Electronics Department, Faculty of Electronics, Telecommunication and Information Technology, Technical University of Cluj-Napoca, 28 Memorandumului St., 400114 Cluj-Napoca, Romania

Florin Graur

Surgical Department, Faculty of Medicine, Iuliu Hațieganu University of Medicine and Pharmacy, 8 Victor Babes St., 400012, Cluj-Napoca, Romania

Can Huang

Hunan Province Cooperative Innovation Center for Molecular Target New Drug Study, University of South China, Hengyang, 421001, China, E-mail: yucuiyunusc@hotmail.com

Wen Huang

Learning Key Laboratory for Pharmacoproteomics of Hunan Province, Institute of Pharmacy and Pharmacology, University of South China, Hengyang, 421001, China

Josef Jampilek

Department of Pharmaceutical Chemistry, Faculty of Pharmacy, Comenius University, Odbojárov 10, 83232, Bratislava, Slovakia, E-mail: josef.jampilek@gmail.com

Urmila Jarouliya

School of Studies in Biotechnology, Jiwaji University, Gwalior (M.P.), 474011, India

Pragati Karana

Department of Pharmacy, Galgotia University, Gautam Budh Nagar, U.P., India

O. P. Katare

University Institute of Pharmaceutical Sciences, UGC Center of Advanced Studies, Punjab University, Chandigarh, 160-014, India

Raj K. Keservani

Faculty of Pharmaceutics, Sagar Institute of Research and Technology-Pharmacy, Bhopal-462041, India, E-mail: rajksops@gmail.com

Rajesh K. Kesharwani

Department of Biotechnology, NIET, Nims University, Jaipur-303121, India

Katarína Kráľová

Institute of Chemistry, Faculty of Natural Sciences, Comenius University, Ilkovičova 6, 84215, Bratislava, Slovakia

Zhi-Ping Li

Hunan Province Cooperative Innovation Center for Molecular Target New Drug Study, University of South China, Hengyang, 421001, China, E-mail: yucuiyunusc@hotmail.com

Garima Mathur

Department of Pharmacy, Galgotia University, Gautam Budh Nagar, U.P., India

Sumitra Nain

Department of Pharmacy, Banasthali University, Banasthali, Rajasthan, 304022, India, E-mail: nainsumitra@gmail.com

Sanju Nanda

Department of Pharmaceutical Sciences, Maharshi Dayanand University, Rohtak, 124001, India, E-mail: sn_mdu@rediffmail.com

Lalit Mohan Negi

Department of Pharmaceutics, Faculty of Pharmacy, Jamia Hamdard University, New Delhi, 110062, India, E-mail: stalegaonkar@gmail.com

Qian Ning

Hunan Province Cooperative Innovation Center for Molecular Target New Drug Study, University of South China, Hengyang, 421001, China, E-mail: yucuiyunusc@hotmail.com

Hari Om Singh

National AIDS Research Institute, Pune, India

Anamaria Orza

Department of Radiology and Imaging Sciences/Center for Systems Imaging, Emory University School of Medicine Atlanta, Georgia, The United States of America

Doina Pislă

Research Center for Industrial Robots Simulation and Testing, Technical University of Cluj-Napoca, 28 Memorandumului St., 400114 Cluj-Napoca, Romania

Kevin J. Quigley

Department of Chemical and Biomolecular Engineering, University of Tennessee, Knoxville, TN, 37996, USA, E-mail: pdalhaim@utk.edu

Contributors

Rekha Rao

Department of Pharmaceutical Sciences, Guru Jambheshwar University of Science and Technology, Hisar-125001, India

Rahimeh Rasouli

Department of Medical Nanotechnology, International Campus, Tehran University of Medical Sciences, Tehran, Iran, E-mail: r-rasouli@razi.tums.ac.ir

Robert Săndulescu

Analytical Chemistry Department, Faculty of Pharmacy, Iuliu Hațieganu University of Medicine and Pharmacy, 4 Pasteur St., 400012, Cluj-Napoca, Romania, E-mail: ccristera@umfcluj.ro

Kirti Rani Sharma

Amity Institute of Biotechnology, Amity University Uttar Pradesh, Noida, Sector 125, Noida-201303 (UP), India, E-mail: krsharma@amity.edu, Kirtisharma2k@rediffmail.com

Anil K. Sharma

Delhi Institute of Pharmaceutical Sciences and Research, University of Delhi, New Delhi, 110017, India

Harshita Sharma

Department of Pharmaceutics, Faculty of Pharmacy, Jamia Hamdard University, New Delhi, 110062, India, E-mail: stalegaonkar@gmail.com

Sushama Talegaonkar

Department of Pharmaceutics, Faculty of Pharmacy, Jamia Hamdard University, New Delhi, 110062, India, E-mail: stalegaonkar@gmail.com

Călin Vaida

Research Center for Industrial Robots Simulation and Testing, Technical University of Cluj-Napoca, 28 Memorandumului St., 400114 Cluj-Napoca, Romania

Wen-Qin Wang

Hunan Province Cooperative Innovation Center for Molecular Target New Drug Study University of South China, Hengyang, 421001, China

N. K. Yadav

Department of Pharmaceutical Sciences, Maharshi Dayanand University, Rohtak, 124001, India, E-mail: sn_mdu@rediffmail.com

Sa Yang

Hunan Province Cooperative Innovation Center for Molecular Target New Drug Study, University of South China, Hengyang, 421001, China, E-mail: yucuiyunusc@hotmail.com/Changsha Medical University Affiliated People's Hospital of Xiangxiang City, Hunan Province, 411400, *China*

Cui-Yun Yu

Hunan Province Cooperative Innovation Center for Molecular Target New Drug Study, University of South China, Hengyang, 421001, China, E-mail: yucuiyunusc@hotmail.com/Learning Key Laboratory for Pharmacoproteomics of Hunan Province, Institute of Pharmacy and Pharmacology, University of South China, Hengyang, 421001, China

Farzaneh Zaaeri

Department of Pharmaceutics, Faculty of Pharmacy, Tehran University of Medical Sciences, Tehran, Iran

Sobiya Zafar

Department of Pharmaceutics, Faculty of Pharmacy, Jamia Hamdard University, New Delhi, 110062, India, E-mail: stalegaonkar@gmail.com



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>

ABBREVIATIONS

AC NP	amorphous chitin nanoparticles
ASGPR	asialoglycoprotein receptor
BAC	bisacryloylcystamine
BBB	brain blood barrier
BC	bacterial cellulose
CA	cellulose acetate
CCNT	collagen/carbon nanotube
CD	cyclodextrins
CFD	computational fluid dynamics
CFNTs	covalently functionalized nanotubes
CLIJ	confined liquid impinging jets
CLS	cellulose
CM	carboxymethyl
CMC	carboxymethyl cellulose
CMCS	carboxymethyl chitosan
CMCT	carboxymethyl chitin
CNH	carbon nanohorns
CNS	central nervous system
CNTs	carbon nanotubes
CPP	cell-penetrating peptides
CRM	controlled-release mechanisms
CRS	controlled release systems
CRT	controlled-release technology
CTH	camptothecin
DDS	drug delivery systems
DNR	daunorubicin
DOX-HA-SPION	doxorubicin-hyaluronan conjugated super-paramagnetic iron oxide nanoparticles
DTT	dithiothreitol
ECs	endothelial cells
EGCG	epigallocatechin gallate
EGF	epidermal growth factor
EGFR	epidermal growth factor receptor

ELPs	elastin-like polypeptides
EMA	European Medicine Agency
EPR	enhanced permeability and retention
FA	folic acid
FB	flurbiprofen
FDA	Food and Drug Administration
Fe	iron
FNP	flash nanoprecipitation
FR	folate receptor
FRET	fluorescence resonance energy transfer
GA	glycyrrhetic acid
GA	gum arabic
GC	galactosylated chitosan
GDL	gadoteridol
GEP	gastroenteropancreatic
GG	gellan gum
GPCR	G-protein coupled receptors
GRAS	generally recognized as safe
GRDDS	gastro retentive drug delivery system
GTC	galactosylated trimethyl chitosan-cysteine
HA	hyaluronic acid
HES	hydroxyethyl starch
HPMC	hydroxypropyl methylcellulose
IEC	intestinal epithelial cells
IND	indomethacin
IONPs	iron oxide nanoparticles
LBL	layer-by-layer
LCST	lower critical solution temperature
LDC	lipid drug conjugates
LLC	lewis lung carcinoma
LPD	liposome polycation pDNA
MB	methylene blue
MDDS	multiple drug delivery systems
MMT	montmorillonite
MN	manganese
MNP	magnetic nanoparticles
MRI	magnetic resonance imaging
MSN	mesoporous silica nanoparticles

MTP	membrane transduction peptides
MTX	methotrexate
NCS	nanotoxicological classification system
NIPAAm	nisopropylacrylamide
NIR	near infrared
NLC	nanostructure lipid carriers
NM	nanobiomaterial
NNI	National Nanotechnology Initiative
NP	nanoparticles
NRPs	neuropilins
PACA	polyalkyl cyanoacrylates
PCL	polycaprolactone
PDT	photo-dynamic therapy
PEG	poly ethylene glycol
PEI	polyethylenimine
PET	positron emission tomography
PGA	polyglycolide
PGLA	poly(lactic-co-glycolic) acid
PHDFDA	poly(heptadecafluorodecylacrylate)
PLA	polylactic acid
PLGA	poly lactic-co-glycolic acid
PNIPAM	poly(N-isopropylacrylamide)
PPy	polypyrrole
PR	plasmon resonance
PS	polysacchride
PTX	paclitaxel
PVMMA	poly(vinyl methyl ether-co-maleic anhydride)
PVP	poly(vinylpyrrolidone)
QD	quantum dots
QSAR	quantitative structure–activity relationship
RES	reticuloendothelial system
RESS	rapid expansion of supercritical solutions
RIF	rifampicin
ROS	reactive oxygen species
SAS	solvent to antisolvent
SCF	supercritical fluid
SCO ₂	carbon dioxide
SELPs	silk-elastin-like protein polymers

SERS	surface enhanced Raman scattering
SF	silk fibroin
SLN	solid lipid nanoparticles
SPION	super paramagnetic iron oxide nanoparticles
SPR	surface plasmon resonance
SPs	surface plasmons
SSTA	synthetic somatostatin analogs
SWCNTs	single-walled carbon nanotubes
TC	trimethyl chitosan-cysteine
TDD	transdermal drug delivery
TDS	transdermal delivery systems
TEG	tetraethylene glycol
TfR	transferrin receptor
TOAB	tetraoctylammonium bromide
TOPO	trioctylphosphine oxide
TRS	The Royal Society
UCST	upper critical solution temperature
VEGF	vascular endothelial growth factor
VEGFRs	vascular endothelial growth factor receptors
XG	xanthan gum

PREFACE

The field of nanotechnology has been a constantly evolving arena of science and technology. In recent times diversified applications of nanotechnology-based products have definitely helped human beings. Nanotechnology has been observed to uplift the level of sophistication through a variety of ways. The uses of nanotechnology embrace materials science, engineering, medical, dentistry, drug delivery, etc. The utilities relevant to drug delivery are of interest to pharmaceutical manufacturers, healthcare personnel, and researchers. The last few decades have witnessed enormous developments with respect to the delivery of active pharmaceutical ingredients to the target sites, thereby sparing the normal functioning biological systems. The nanomaterials purported to be used in biological systems are termed ‘nanobiomaterials.’

Keeping the drug delivery aspect of nanobiomaterials under consideration, this volume is an endeavor to furnish the requisite information to readers. The content of this book is written by highly skilled, experienced and renowned scientists and researchers from all over the world. They provide updated knowledge to provide drug delivery information to readers, researchers, academician, scientists and industrialists around the globe.

The book *Nanobiomaterials: Applications in Drug Delivery* is comprised of 14 chapters that provide an introduction to nanobiomaterials, their physicochemical features, their generalized and specific applications dealing with drug delivery in particular. The materials used as well as formulation and characterization have been discussed in detail. The emphasis of certain chapters is to provide specific input regarding treatment of a disease/disorder causing the highest mortality.

Chapter 1, *Nanoparticulate Nanocarriers in Drug Delivery*, written by Raj K. Keservani and colleagues, introduces the terminology prevailing in nanoscience. Further, it provides an overview of various nano-systems used for the delivery of drug molecules. The authors have summarized the nanocarriers with their key characteristics.

The details of general principles, classification, and methods of preparation of nanoparticles have been presented in **Chapter 2**, *Nanoparticles: Formulation Aspects and Applications*, written by Sushama Talegaonkar and

associates. The authors have discussed metallic and non-metallic nanoparticles with suitable instances. In addition, they provide a thorough coverage of polymeric nanoparticles. The polymers of natural origin as well as synthetic ones are adequately described.

Chapter 3, *Physical and Chemical Properties of Nanobiomaterials*, written by Sumitra Nain and colleagues, gives a brief account of physico-chemical attributes of nanoparticles. The last section of chapter summarizes applications of nanobiomaterials in tabular form.

Different aspects of drug delivery are described in **Chapter 4**, *Introduction to Drug Delivery*, written by Mila A. Emerald. The author has provided information regarding controlled release drug delivery systems with examples of polymers exploited for this purpose. The various routes by which the drug could be delivered have been discussed. The biosafety issue has also been addressed in this chapter.

The description of biodegradable polymers is provided by **Chapter 5**, *Application of Nanobioformulations for Controlled Release and Targeted Bio-distribution of Drugs*, written by Josef Jampílek and Katarína Kráľová. Nanoparticles-based preparations made up of biodegradable natural and synthetic polymers have been discussed following a brief introduction of nanotechnology-based products and their pros and cons. The studies having mention of bio-distribution of drug molecules have been chosen in order to offer the reader accurate information regarding targeting aspects of nanotechnology.

The uses of nanoparticles for drug delivery and other fields of medicine have been discussed in **Chapter 6**, *Targeted Delivery Systems-Based on Polymeric Nanoparticles for Biomedical Applications*, written by Sa Yang and associates. The authors have provided information relevant to tumor targeting. The drugs as well as genes that have been incorporated in polymeric nanoparticles have been prominently described. The details of polymers covered both of natural origin and synthetic ones.

The customized applications of nanobiomaterials-based on specific requirements are given by **Chapter 7**, *Smart Delivery of Nanobiomaterials in Drug Delivery*, written by Mirza Sarwar Baig and associates. The authors have strived to provide an overall preview of nanobiomaterials (NMs) or nanoparticles (NPs) and their applications in life sciences and medicine, insight into the drug delivery system (DDS) plus most recent developments in this field. Finally they discuss the limitations and future of NMs.

An overview of nanoscience-based preparation for the treatment of cancer has been presented in [Chapter 8](#), *Advances of Nanotechnology in Cancer Therapy*, written by Urmila Jarouliya and colleagues. The authors have discussed a number of preparations having relevance in tumor treatment. The targeting to the cancerous tissues the core of this chapter. Moreover, the clinical and preclinical status of nanocarriers has been described covering future prospects.

[Chapter 9](#), *Nanobiomaterials for Cancer Diagnosis and Therapy*, written by Cecilia Cristea and associates, deals with testing protocols and treatment approaches in tumor therapeutics. The authors have provided a brief preamble to different nanocarriers for cancer diagnosis; thereafter, the mechanism of tumor targeting have been discussed in detail. In addition, novel nanotechnology-based drug carriers have been described with respect to tumor therapy.

[Chapter 10](#), *Nanobiomaterials for Cancer Therapy*, written by Kevin J. Quigley and Paul Dalhaimer, gives a focused view of nanocarriers explored for drug delivery in cancer and that have demonstrated improved drug delivery to tumor sites. The authors have availed the current status of nanotechnology-based drug formulations. Subsequently the hurdles posed by biological milieu have been discussed. Attempts to overcome barriers have also been described.

[Chapter 11](#), *Nanotechnology in Hyperthermia-Based Therapy and Controlled Drug Delivery*, written by Anamaria Orza and Christopher Clark, describes the drug delivery approaches based on phenomenon of hyperthermia. The in-depth details regarding the mechanism of such systems have been provided in this chapter. Moreover, characterization of nanotechnology products has been described with incorporating recent studies. An outlook of obstacles and future course of hyperthermia-based formulations is also given.

[Chapter 12](#), *Nano Carrier Systems of Ubidecarenone (Coenzyme Q10) for Cosmetic Applications*, written by N. K. Yadav and colleagues, has addressed the eternal desire of men and women to look beautiful. However, females appear more concerned toward beauty versus their counterparts. The cosmetic applications of antioxidant enzymes have been elaborated on with suitable instances wherever applicable. The variety of nano preparations incorporating Coenzyme Q10 has been discussed. A summary of cosmetic products is provided in tabulated form.

Chapter 13, *Nanobased CNS Delivery Systems*, written by Rahimeh Rasouli and Mahmood Alaei-Beirami, deals in drug delivery to the brain by different nanotechnology-based products. The authors have provided details with respect of the brain's physiology, inherent barriers in the way of drug delivery and emergence of nanotechnology. Further, the formulations are discussed with a focus on targeting aspect to organs of central nervous system (CNS).

The details of nanocarriers employed for delivery of genes have been provided in **Chapter 14**, *Nanobiomaterial for Non-Viral Gene Delivery*, written by Kirti Rani Sharma. As we are familiar with the fact that the delivery of genes is carried out predominantly by viral vectors, the author has compiled information regarding use of variety of nanosystems to deliver genes in treatment of diverse ailments.

ABOUT THE EDITORS

Anil K. Sharma, MPharm

*Delhi Institute of Pharmaceutical Sciences and Research,
University of Delhi, India*

Anil K. Sharma, MPharm, is a lecturer at the Delhi Institute of Pharmaceutical Sciences and Research, University of Delhi, India. He has published 25 peer-reviewed papers in the field of pharmaceutical sciences in national and international reputed journals as well as 10 book chapters. His research interests include nutraceutical and functional foods, novel drug delivery systems (NDDs), drug delivery, nanotechnology, health science/life science, and biology/cancer biology/neurobiology. He graduated with a degree in pharmacy from the University of Rajasthan, Jaipur, India, and received a Master of Pharmacy (MPharm) from the School of Pharmaceutical Sciences, Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal, India, with a specialization in pharmaceutics.

Raj K. Keservani, MPharm

*Faculty of Pharmaceutics, Sagar Institute of Research and Technology-
Pharmacy, Bhopal, India*

Raj K. Keservani, MPharm, has more than seven years of academic teaching experience at various institutes in India in pharmaceutical science. He has published 25 peer-reviewed papers in the field of pharmaceutical sciences in national and international reputed journals, 10 book chapters, and two co-authored books. He is also active as a reviewer for several international scientific journals. His research interests encompass nutraceutical and functional foods, novel drug delivery systems (NDDs), transdermal drug delivery, health science/life science, and biology/cancer biology/neurobiology. Mr. Keservani earned his BPharm at the Department of Pharmacy at Kumaun University, Nainital, India, and received his MPharm from the School of Pharmaceutical Sciences at Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal, India, with a specialization in pharmaceutics.

Rajesh K. Kesharwani, PhD

Department of Biotechnology, NIET, Nims University, Jaipur-303121, India

Rajesh K. Kesharwani, PhD, has more than seven years of research and two years of teaching experience at various institutes in India in bioinformatics and biotechnology education. He has authored over 29 peer-reviewed articles and 15 book chapters and has co-edited one book. He has been a member of many scientific communities and is a reviewer for many international journals. His research fields of interest are medical informatics, protein structure and function prediction, computer-aided drug designing, structural biology, drug delivery, cancer biology, and next-generation sequence analysis. Dr. Kesharwani is a recipient of the Swarna Jayanti Puraskar Award from the National Academy of Sciences, India, for best paper presentation. Dr. Kesharwani earned a BSc in Biology from the Ewing Christian College, Allahabad, an autonomous college of the University of Allahabad, and received his MSc in Biochemistry from Singh University, Rewa, Madhya Pradesh, India. He earned a PhD from the Indian Institute of Information Technology, Allahabad and received a Ministry of Human Resource Development/India fellowship and a Senior Research Fellowship from the Indian Council of Medical Research, India.

PART I

**AN OVERVIEW OF
NANOBIOMATERIALS**



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>