



Edited by

ECATERINA ANDRONESCU

ALEXANDRU MIHAI GRUMEZESCU



NANOSTRUCTURES FOR ORAL MEDICINE

NANOSTRUCTURES IN
THERAPEUTIC MEDICINE SERIES

Nanostructures in Therapeutic Medicine Series

Nanostructures for Oral Medicine

Edited by

Ecaterina Andronescu

University Politehnica of Bucharest, Bucharest, Romania

Alexandru Mihai Grumezescu

University Politehnica of Bucharest, Bucharest, Romania



Elsevier

Radarweg 29, PO Box 211, 1000 AE Amsterdam, Netherlands

The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, United Kingdom

50 Hampshire Street, 5th Floor, Cambridge, MA 02139, United States

Copyright © 2017 Elsevier Inc. All rights reserved.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. Details on how to seek permission, further information about the Publisher's permissions policies and our arrangements with organizations such as the Copyright Clearance Center and the Copyright Licensing Agency, can be found at our website: www.elsevier.com/permissions.

This book and the individual contributions contained in it are protected under copyright by the Publisher (other than as may be noted herein).

Notices

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

Library of Congress Cataloging-in-Publication Data

A catalog record for this book is available from the Library of Congress

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library

ISBN: 978-0-323-47720-8

For information on all Elsevier publications visit our website at
<https://www.elsevier.com/books-and-journals>



Working together
to grow libraries in
developing countries

www.elsevier.com • www.bookaid.org

Publisher: Matthew Deans

Acquisition Editor: Simon Holt

Editorial Project Manager: Sabrina Webber

Production Project Manager: Julie-Ann Stansfield

Designer: Greg Harris

Typeset by Thomson Digital

Nanostructures for Oral Medicine

List of Contributors

Satish Agrawal

CSIR-Central Drug Research Institute, Lucknow, India

Hafsa Ahmad

CSIR-Central Drug Research Institute, Lucknow, India

Fabiana Alovero

National University of Cordoba (UNC), Córdoba, Argentina

Nicolas Anton

University of Strasbourg, Strasbourg, France

Abhishek Arya

CSIR-Central Drug Research Institute, Lucknow, India

Mohamadreza Baghaban-Eslaminejad

Royan Institute for Stem Cell Biology and Technology, ACECR, Tehran, Iran

Anil Kumar Bajpai

Government Autonomous Science College, Jabalpur, India

R. Baskaran

National Health Research Institutes, Zhunan, Taiwan

Marcelo P. Bernuci

University Center of Maringa, Maringá, Brazil

Karolina Bien

Military Institute of Hygiene and Epidemiology, Warsaw, Poland

Prakash S. Bisen

Jaipur National University, Jaipur; Jiwaji University; Tropilite Foods Pvt Ltd., Gwalior, India

Mariza Bortolanza

University of Sao Paulo, São Paulo, Brazil

Virginie Busignies

University of Bordeaux; CNRS, Bordeaux INP, ENSAM, I2M, Talence, France

Grzegorz Celichowski

University of Lodz, Lodz, Poland

Christine Charrueau

UTCBS, CNRS; INSERM; University of Paris Descartes, Sorbonne Paris City; Chimie ParisTech, PSL Research University, Paris, France

Nagendra S. Chauhan

Government Ayurvedic College Campus, Raipur, India

Raje Chouhan

Government Autonomous Science College, Jabalpur, India

Máximo P. Díaz

Instituto Tecnológico de Querétaro, Santiago de Querétaro, Mexico

Daniele Ribeiro de Araújo

Federal University of ABC, Santo André, Brazil

Nathalie Ferreira Silva de Melo

São Leopoldo Mandic Institute and Research Center, Campinas, Brazil

Lígia Nunes de Moraes Ribeiro

University of Campinas—UNICAMP, Campinas, Brazil

Eneida de Paula

University of Campinas—UNICAMP, Campinas, Brazil

Elaine Del-Bel

University of Sao Paulo, São Paulo, Brazil

Meenal Dixit

Jaipur National University, Jaipur, India

Yuan-Cai Dong

Institute of Chemical and Engineering Sciences, A*STAR, Jurong Island, Singapore

Anil K. Dwivedi

CSIR-Central Drug Research Institute, Lucknow, India

Aylin T. Ermertcan

Manisa Celal Bayar University, Manisa, Turkey

Virginie Escriou

UTCBS, CNRS; INSERM, University of Paris Descartes, Sorbonne Paris City; Chimie ParisTech, PSL Research University, Paris, France

Görkem Eskiizmir

Manisa Celal Bayar University, Manisa, Turkey

Ana Figueiras

REQUIMTE/LAQV, Group of Pharmaceutical Technology, Faculty of Pharmacy, University of Coimbra, Coimbra; Health Sciences Centre, Faculty of Health Sciences, University of Beira Interior, Covilhã, Portugal

Michelle Franz-Montan

University of Campinas—UNICAMP, Piracicaba, Brazil

Kunihiko Fukuchi

Showa University, Tokyo, Japan

Toshiyuki Fukuda

Satoen Co., Ltd., Shizuoka, Japan

Shilpi Goswami

Government Autonomous Science College, Jabalpur, India

Avinash Gothwal

Central University of Rajasthan, Ajmer, India

Jaroslav Grobelny

University of Lodz, Lodz, Poland

Lokesh Gupta

Central University of Rajasthan, Ajmer, India

Madhu Gupta

Shri Rawatpura Sarkar Institute of Pharmacy, Datia, India

Umesh Gupta

Central University of Rajasthan, Ajmer, India

Rosa Martha Perez Gutierrez

National Polytechnic Institute, Mexico City, Mexico

Gabriel H. Hawthorne

University Center of Maringa, Maringá, Brazil

Kang Moo Huh

Chungnam National University, Daejeon, Republic of Korea

Ana C. Issy

University of Sao Paulo, São Paulo, Brazil

Indrani Jadhav

Jaipur National University, Jaipur, India

Sougata Jana

Gupta College of Technological Sciences, Asansol, India

Alvaro F. Jimenez-Kairuz

National University of Cordoba (UNC), Córdoba, Argentina

Namrata A. Kadowkar

Institute of Chemical Technology, Mumbai, India

Amir Kamali

Shiraz University, Shiraz, Iran

Taisei Kanamoto

St. Marianna University School of Medicine, Kanagawa, Japan

Sayali Karandikar

Bharati Vidyapeeth's College of Pharmacy, Navi-Mumbai, India

Iliyas Khan

Central University of Rajasthan, Ajmer, India

Prachi B. Kharkar

Institute of Chemical Technology, Mumbai, India

Zohaib Khurshid

King Faisal University, Al-Hofuf, Saudi Arabia

Ozcan Konur

Yildirim Beyazit University, Ankara, Turkey

Kayoko Kotohda

Cascade Resources Laboratory Co., Ltd., Nagano, Japan

Malgorzata Krzyzowska

Military Institute of Hygiene and Epidemiology, Warsaw, Poland

Niha M. Kulshreshtha

Jaipur National University, Jaipur, India

Sevinc Kurbanoglu

Ankara University, Ankara, Turkey

Yong-Kyu Lee

Korea National University of Transportation, Chungju, Republic of Korea

Kumaran Letchmanan

Institute of Chemical and Engineering Sciences, A*STAR, Jurong Island, Singapore

Sabyasachi Maiti

Gupta College of Technological Sciences, Asansol, India

Ruben H. Manzo

National University of Cordoba (UNC), Córdoba, Argentina

Alejandro R. Martínez

Instituto Tecnológico de Querétaro, Santiago de Querétaro, Mexico

Juan Vicente Mendez Mendez

National Polytechnic Institute, Mexico City, Mexico

Jorge E. Miranda Calderon

Laboratory of Molecular Pharmacy and Controlled Release, México D.F., Mexico

Amit Mirani

Institute of Chemical Technology, Mumbai, India

Ali Moshiri

Iran University of Medical Sciences, Tehran, Iran

Yuvashree Muralidaran

VIT University, Vellore, India

Shariq Najeeb

Al-Farabi Colleges, Riyadh, Saudi Arabia

Hideki Nakashima

St. Marianna University School of Medicine, Kanagawa, Japan

Wai Kiong Ng

Institute of Chemical and Engineering Sciences, A*STAR, Jurong Island, Singapore

Thi Trinh Lan Nguyen

University of Strasbourg, Strasbourg, France

Norma A. Noguez Méndez

Laboratory of Molecular Pharmacy and Controlled Release,
México D.F., Mexico

Md Nurunnabi

Chungnam National University, Daejeon; Korea National University of Transportation, Chungju, Republic of Korea

Hirokazu Ohno

Maruzen Pharmaceuticals Co. Ltd., Tokyo, Japan

Takaaki Oizumi

Daiwa Biological Research Institute Co., Ltd., Kanagawa, Japan

María E. Olivera

National University of Cordoba (UNC), Córdoba, Argentina

Piotr Orlowski

Military Institute of Hygiene and Epidemiology, Warsaw, Poland

Ahmad Oryan

Shiraz University, Shiraz, Iran

Sibel A. Ozkan

Ankara University, Ankara, Turkey

V. Vijaya Padma

Bharathiar University, Coimbatore, India; China Medical University; Asia University, Taichung, Taiwan

Xochitl C. Palomec

Laboratory of Molecular Pharmacy and Controlled Release, México D.F., Mexico

Sandeep Patankar

Bharati Vidyapeeth's College of Pharmacy, Navi-Mumbai, India

Vandana B. Patravale

Institute of Chemical Technology, Mumbai, India

L. Bharathi Priya

Bharathiar University, Coimbatore, India

Carlos T. Quirino Barreda

Laboratory of Molecular Pharmacy and Controlled Release, México D.F., Mexico

Gokulakannan Ragavan

VIT University, Vellore, India

María V. Ramírez-Rigo

National University of the South, Bahía Blanca, Argentina

Katarzyna Ranoszek-Soliwoda

University of Lodz, Lodz, Poland

Ihtesham Ur Rehman

The University of Sheffield, Sheffield, United Kingdom

Vishnu Revuri

Korea National University of Transportation, Chungju, Republic of Korea

Andreza Maria Ribeiro

Faculty of Pharmacy, University of Coimbra, Coimbra, Portugal; Department of Engineering and Material Sciences, University of Federal of Paraná (UFPR), Curitiba, Brazil

Hiroshi Sakagami

Meikai University School of Dentistry, Saitama, Japan

Mohsin Shah

Khyber Medical University, Peshawar, Pakistan

Ashok K. Sharma

Central University of Rajasthan, Ajmer, India

Vikas Sharma

Shri Rawatpura Sarkar Institute of Pharmacy, Datia, India

Shou-Cang Shen

Institute of Chemical and Engineering Sciences, A*STAR, Jurong Island, Singapore

Hong Sheng

Meikai University School of Dentistry, Saitama, Japan

Divya Shrivastava

Jaipur National University, Jaipur, India

Anurag K. Singh

Central University of Rajasthan, Ajmer, India

Nehi Sinha

Jaipur National University, Jaipur, India

Swapnil S. Talkar

Institute of Chemical Technology, Mumbai, India

Pierre Tchoreloff

University of Bordeaux; CNRS, Bordeaux INP, ENSAM, I2M, Talence, France

Shigemi Terakubo

St. Marianna University School of Medicine, Kanagawa, Japan

Emilia Tomaszewska

University of Lodz, Lodz, Poland

César G. Urioste

Laboratory of Molecular Pharmacy and Controlled Release, México D.F., Mexico

Bengi Uslu

Ankara University, Ankara, Turkey

Thierry F. Vandamme

University of Strasbourg, Strasbourg, France

Israel Arzate Vazquez

National Polytechnic Institute, Mexico City, Mexico

Abraham F. Vega

Laboratory of Molecular Pharmacy and Controlled Release, México D.F., Mexico

Francisco Veiga

REQUIMTE/LAQV, Group of Pharmaceutical Technology, Faculty of Pharmacy, University of Coimbra, Coimbra, Portugal

Pragasam Viswanathan

VIT University, Vellore, India

Vishal Waybhase

Bharati Vidyapeeth's College of Pharmacy, Navi-Mumbai, India

Jingqi Xie

Huaqiao University, Quanzhou; Engineering Research Center of Molecular Medicine, Ministry of Education; Key Laboratory of Molecular Medicine in Fujian Province, Xiamen, China

Ruian Xu

Huaqiao University, Quanzhou; Engineering Research Center of Molecular Medicine, Ministry of Education; Key Laboratory of Molecular Medicine in Fujian Province, Xiamen, China

Masaji Yamamoto

Maruzen Pharmaceuticals Co. Ltd., Tokyo, Japan

Kerim Yapici

Cumhuriyet University, Sivas, Turkey

Toshikazu Yasui

Meikai University School of Dentistry, Saitama, Japan

Sung C. Yoon

Gyeongsang National University, Jinju; ReSEAT Program, KISTI, Daejeon, Republic of Korea

Hideobu Yoshida

Cascade Resources Laboratory Co., Ltd., Nagano, Japan

Muhammad S. Zafar

Taibah University, Al Madinah, Saudi Arabia; Riphah International University, Islamabad, Pakistan

Sana Zohaib

King Faisal University, Al-Hofuf, Saudi Arabia

Foreword of the Series

Material science and engineering at the nanoscale have brought revolutionary advances to the biomedical sciences, overturning many of the known traditional approaches. Nanotechnology has driven many of the most successful innovative technologies, and their impressive record of accomplishment has made nanostructures promising candidates for future therapy. The advantages that nanomaterials have already provided to therapeutics, such as targeted and controlled delivery, wide accessibility, high specificity, low side effects, improved efficiency, and impressive versatility are currently considered key elements in designing personalized medicine approaches for prophylaxis, diagnosis, and therapy.

Therapeutic nanostructures can be highly diverse, and their unique properties have led to the development of highly specialized biosensors, more efficient drug delivery vehicles, and controlled release targeting systems to fight severe or incurable diseases, such as cancer, infections, and cardiovascular disease.

In view of the astounding progress made in the field of therapeutic nanotechnology, and its rapidly progressing expansion, this book aims to collect together in one place all the most recent and innovative aspects regarding the impact of nanomaterials in both current and future therapy. The book is organized in five volumes, covering the main areas that are relevant for the design and implementation of nanostructures in medical therapies.

The first volume, *Nanostructures for Novel Therapy: Synthesis, Characterization, and Applications* describes methods to obtain and characterize nanosystems, emphasizing their biomedical applications. Special attention in this volume was paid to modern synthesis methods to reduce side effects and limit the toxicity of nanomaterials in biomedical applications. Numerous examples of nanostructures designed for therapy, as well as the most efficient synthesis and characterization routes for these materials are clearly described and critically analyzed.

The second volume, entitled *Nanostructures for Drug Delivery* covers one of the most widely utilized and investigated applications of nanomaterials in the biomedical field, namely drug delivery. The design of nanoscale agents in order to specifically and safely carry therapeutic agents to their final destination is an intriguing approach to future targeted therapeutics. This approach could provide a treatment for previously incurable diseases, as well as reducing the side effects of current drugs. Many highly active drugs are severely limited by side effects related to their unspecific sites of action. This book introduces the readers to the amazing field of nanomedicine by discussing the versatility and variety of nanovehicles for drug delivery and targeting. Moreover, readers will find numerous examples, and will learn about the currently used or investigational drug delivery agents for therapy, prophylaxis, and diagnosis.

The third volume, *Nanostructures for Antimicrobial Therapy* highlights the impressive progress made by nanotechnology in the design of novel antimicrobial approaches. Since microbial resistance to antibiotics is a very real and worrying issue growing throughout the world, the development of more efficient antimicrobial agents has a high priority to allow control of infections in the future. Antimicrobial nanosystems have proved to be highly efficient against drug-resistant microorganisms, are able to fight biofilm-associated infections and control the social behavior of microbial communities. Nanostructures can also reduce microbial virulence factors and reduce pathogenesis mechanisms thus offering a promising alternative for future therapy.

The fourth volume, entitled *Nanostructures for Cancer Therapy* covers the applications of nanomedicine in cancer diagnosis and treatment. The use of nanoparticles for cancer therapy is not in itself a new approach, but numerous advances have been recently made in this area, and the aim of this book is to cover the most interesting new approaches in the management of this deadly disease. Nanosized drugs are currently believed to represent the most efficient approach in cancer chemotherapy, and this volume provides coverage of the latest novel findings, while also discussing possible improvements in more established types of nanosystems to increase the efficiency of cancer therapy.

Last but not least, the fifth volume of this series entitled *Nanostructures for Oral Medicine* covers the progress made in applications of nanotechnology in treating various diseases of the oral cavity and in dentistry. Readers will have the chance to learn about the most efficient modern materials used to treat or to prevent widely encountered oral diseases, such as gingivitis, periodontitis, caries, and dental plaque. Moreover restorative dentistry also now makes wide use of nanomaterials.

Overall, this book series will provide a state-of-the-art compendium of knowledge, and a crystal ball to see into the future of biomedical nanotechnology and nanomedicine. It will appeal to researchers, clinicians, engineers, pharmacologists, pharmacists, oncologists, infectious disease experts, and dentists. More many interested general readers may discover the impact, current progress and future applications of nanotechnology in therapeutics and diagnosis. Taken together, nanoscale approaches will improve the efficiency of personalized medicine for better management of diseases in the 21st century.

Michael R. Hamblin

Wellman Center for Photomedicine, Massachusetts General Hospital, Boston, MA, United States;

Harvard Medical School, Boston, MA, United States;

Harvard-MIT Division of Health Sciences and Technology, Cambridge, United States

Preface

ABOUT THE SERIES (VOLUMES I–V)

In our permanently changing world, novel therapeutics are constantly required to manage health and well-being of population. Although numerous diseases are currently considered incurable, massive progress made in biomedicine but also associated fields, such as chemistry, physics, engineering, pharmacology, and materials science, offers a new light to the therapeutics domain. In this context, most physicists and researchers believe that a personalized and adequate treatment may significantly improve the outcome of severe diseases and ensure a faster healing. Nanotechnology offers great perspectives for personalized medicine, since nanostructured therapeutics proved their efficiency and amazing impact in improving therapy, prophylaxis, and diagnosis. The emerging field of nanosized materials have numerous applications in the biomedical field, especially in therapy. This series of five volumes came out by the need of learning about recent progress of the science of nanostructured materials in order to improve current therapy and lead to the next level. The books offer an interesting and updated perspective regarding applications of nanomaterials in therapy of most investigated and difficult to treat diseases, such as cancer and severe infections. The presentation approach of each chapter contained in those five volumes is clear and easy to understand by most readers and for biomedical specialists, researchers, and engineers. The series is organized in an attractive manner for students and academics on the field, starting with a volume dealing with synthesis, characterization, and main applications of nanostructures, emphasizing on their impact in therapy. Next volume reveals the most recent progress made on a very investigated field, considered a key element in personalized medicine and future therapy, namely nanostructured drug delivery systems. Their impact in antimicrobial therapy is also widely discussed and suggestive examples are given and explained. Moreover, a whole volume is dedicated to the management of the disease of the century—cancer—revealing the huge value added by the utilization of nanosystems in the therapy of this deadly disease. Important aspects related to improved diagnosis and prophylaxis are highlighted. In the last volume, the progress and novel applications of nanotechnology in oral medicine are dissected. The field of oral diseases represents a wide-interest and priority field since both physicists and researchers believe that they can be prevented and treated more easily with targeting systems and nanofunctional prosthetics. All chapters are clearly illustrated to highlight most important or difficult to understand aspects and suggestive examples are often enumerated in organized tables, which are explained and discussed. Overall, the series contain very recent but accessible information regarding the progress of nanostructures in therapeutics and give a novel perspective about future therapy of severe diseases.

Alexandru Mihai Grumezescu

University Politehnica of Bucharest, Bucharest, Romania

ABOUT VOLUME V

The fifth volume of the series *Therapeutic Nanostructures* is entitled *Nanostructures for Oral Medicine*. This volume reveals numerous applications of nanostructures in oral medicine. Various key approaches, such as drug design and delivery, oral vaccines, and therapeutic systems for oral applications, are

discussed and exemplified in this volume. Oral medicine represents a widely investigated field, where nanotechnology has found numerous applications. From improved implantable materials to specialized drug-delivery systems, nanomaterials have offered solutions to serious clinical conditions from diagnosis to therapy. The book describes not only the preparation of oral nanomedicines but also their main properties, applications and principal advantages and drawbacks. Applications and impact on human life quality of recently developed nanomaterials aimed at oral therapy are also presented here. Similar to general medicine, the trend in oral medicine seems to follow technological progress, the specificity and sensibility of nanostructured drugs playing an important role in the design of tailored approaches for oral therapy. Aspects related to oral cancers, oral drug delivery, personalized therapy, regenerative local medicine, and disease-preventing oral nanoagents are widely dissected in this book.

Volume V contains 29 chapters, prepared by outstanding international researchers from Turkey, India, Pakistan, South Korea, Brazil, Portugal, Iran, China, Poland, France, Argentina, Japan, Taiwan, Mexico, Singapore, Iran, Saudi Arabia, and the United Kingdom.

In Chapter 1, entitled *Bacterial Polyester Nanoparticles for Drug Delivery*, Mohsin Shah and Sung Chul Yoon describe the methods of preparation and characterization of drug-encapsulated polymeric nanoparticles formulated with various copolymers, drug release kinetics, and evaluation of their localization in cancer cells in vitro and in vivo.

Rosa Martha Perez Gutierrez et al., in Chapter 2, entitled *A Novel Approach to the Oral Delivery: Nanostructures and Biomaterials for Systemic Disease*, shed light on oral delivery nanostructures researched in medicine, including synthesis techniques and materials that can be effectively used for controlled oral drug delivery application used in disease treatments.

Chapter 3, prepared by Andreza Maria Ribeiro et al., entitled *Biodegradable Polymeric Nanostructures: Design and Advances in Oral Drug Delivery for Neurodegenerative Disorders*, highlights the main advances in polymeric nanocarriers as vehicles for oral delivery systems used in the therapy of neurodegenerative disorders. First, a brief introduction into the field of biodegradable polymeric materials used in nanostructures formulation is presented. Considering their structure and characteristics, the next section offers a detailed description of the technologies and recent modifications to improve their specificity. Finally, new approaches are presented with clinical applications in neurodegenerative disorders.

Chapter 4, entitled *Nanostructured Systems for Transbuccal Drug Delivery*, prepared by Michelle Franz-Montan et al., outlines the use of nanostructures as tools for the development of new formulations for topical use at the oral mucosa in dental clinical practice. Topics covered in this chapter include the structure, organization, and permeability of oral mucosa; permeation pathways at oral mucosa; chemical permeation enhancers for oral mucosa topical formulations; mechanisms of permeation enhancers; and the use of the following nanostructures to improve transbuccal drug delivery for the treatment of oral mucosa infections, inflammation, and pain conditions: liposomes, polymeric nanoparticles/micelles, nanostructured lipid carriers, and cyclodextrins.

Chapter 5, entitled *Trends in Orally Viral Vector Gene Delivery and Therapy*, prepared by Jingqi Xie and Ruian Xu, highlights the merits and disadvantages of novel applications and their relationship between sizes and structures of nanoparticles and the efficacy of oral gene delivery and therapy. In addition, this chapter reveals orally viral vector gene delivery timing, and systematically discusses the effect of age, delivery route, cell preference, organ distribution, and so on on orally viral vector delivery and trends in oral viral vector gene delivery and therapy.

Virginie Busignies et al., in Chapter 6, entitled *Nanostructures for Oral Delivery of Therapeutic Nucleic Acids*, discuss the barriers to oral delivery of nucleic acids and review the various technologies already tested in preclinical study and the experimental models available to assay oral delivery systems.

Pragasam Viswanathan et al., in Chapter 7, entitled *Challenges in Oral Drug Delivery: A Nano-Based Strategy to Overcome*, offer an overview about the strategy to override such drawbacks by ushering in various nanotechnology platforms, such as polymer-based nanocarriers, lipid-based nanocarriers, and metal- and inorganic-based nanoparticles.

Thi Trinh Lan Nguyen et al., in Chapter 8, *Oral Pellets Loaded With Nanoemulsions*, present an up-to-date review about nanoemulsion and its subsequent transformation into pellet systems that offer several advantages for improving solubility and dissolution rates of poorly water-soluble drugs for oral delivery in order to overcome the poor absorption of some active pharmaceutical ingredients.

Anurag Kumar Singh et al., in Chapter 9, entitled *Oral Drug Delivery Potential of Dendrimers*, focus on the oral potential applicability of dendrimers for delivering various categories of drugs, such as antimicrobial agents, antifungal drugs, and certain catheter-related substances.

Chapter 10, prepared by Sayali Karandikar et al., entitled *Nanovaccines for Oral Delivery-Formulation Strategies and Challenges*, summarizes nanoformulation strategies for oral delivery of vaccines, which can potentially help to overcome existing problems. Also, this chapter briefly presents their challenges and regulatory aspects.

Chapter 11, prepared by Prachi B. Kharkar et al., entitled *Nanosystems for Oral Delivery of Immunomodulators*, gives an insight into nanostructured immunomodulators, their routes of administration, and newer sophisticated methods of their formulation for better therapeutic effect.

Chapter 12, entitled *Tannic Acid Modification of Metal Nanoparticles: Possibility for New Antiviral Applications*, prepared by Malgorzata Krzyzowska et al., presents an up-to-date overview about tannic-acid-modified silver nanoparticles consisting of a novel potential microbicide for herpes virus infection in the mucosal tissues.

Chapter 13, *Polyelectrolyte-Drug Ionic Complexes as Nanostructured Drug Carriers to Design Solid and Liquid Oral Delivery Systems*, prepared by Maria E. Olivera et al., deals with the description of main pharmaceutical applications of drug-delivery systems based on the unique properties of complexes of polyelectrolytes with ionizable drugs.

Chapter 14, prepared by Md Nurunnabi et al., entitled *Polysaccharide Based Nano/Micro Formulation: An Effective and Versatile Oral Drug Delivery System*, focuses on potential applications of polysaccharides for oral drug delivery, their biocompatibility, as well as their advantages and disadvantages over conventional strategies. The authors also highlight recent advances in oral drug delivery based on specific polysaccharides, including chitosan, heparin, hyaluronic acid, beta glucan, and chondroitin sulfate.

Raje Chouhan et al., in Chapter 15, entitled *Recent Advancements in Oral Delivery of Insulin: From Challenges to Solutions*, present an overview of diabetes highlighting various aspects of insulin therapy, including insulin analogs, oral delivery of insulin, mechanistic action of insulin, challenges of oral administration of insulin, and breakthroughs in insulin delivery at the global level. The chapter also discusses economical aspects related to the commercialization level of insulin.

Madhu Gupta et al., in Chapter 16, *Nanotechnology for Oral Delivery of Anticancer Drugs: An Insight Potential*, review the challenges encountered in oral delivery with various nanoconstructs employed for oral anticancer drug delivery comprehensively as well as their applications.

Chapter 17, entitled *Nanomaterials: Promising Structures for the Management of Oral Cancer*, prepared by Görkem Eskiizmir et al., presents the role and potential effectiveness of using nanomaterials in different aspects of oral cancer. Recently, nanotechnology has offered new strategies in cancer management: (1) early detection of cancers via specialized probes and biosensors, (2) better diagnosis and staging via improving the imaging systems, (3) nanoscale drug-delivery systems that may provide a significant decrease in adverse effects and toxicities of chemotherapeutics, and (4) nanotheranostics that integrate both diagnosis and therapy simultaneously.

Hiroshi Sakagami et al., in Chapter 18, entitled *Therapeutic Potential of Solubilized Nanolignin Against Oral Diseases*, offer relevant information about the lignin-carbohydrate complex and its excellent anti-HIV activity and anti-UV activity, in contrast to its weak tumor-selective cytotoxicity.

Chapter 19, prepared by Hafsa Ahmad et al., *Novel Lipid Nanostructures for Delivery of Natural Agents With Antioxidant, Antiinflammatory, and Antistroke Potential: Perspectives and Outcomes*, presents many bioactive nanocombinations with antioxidant, anti-inflammatory, and neuroprotective effects that might promote alleviation of neuronal and tissue damage following stroke and reverse pathophysiological changes in ischemia-reperfusion injury that fail clinically due to degradation, poor aqueous solubility, and subsequent bioavailability.

Sougata Jana and Sabyashachi Maiti, in Chapter 20, entitled *Chitosan-Based Nanoparticulate Systems for Oral Drug Delivery*, discuss various methods of preparation of chitosan-based nanoparticles, structural modifications of chitosan, and the latest developments in the field of oral drug delivery.

Chapter 21, prepared by Lohanathan Bharathi Priya and Viswanadha Vijaya Padma, entitled *Phytonanoconjugates in Oral Medicine*, focuses on the role of nanostructures conjugated to phytochemicals (phytonanoconjugates) in oral medicine by extensively reviewing of the latest research findings.

Chapter 22, entitled *Design and Development of Pharmaceutical Microprocesses in the Production of Nanomedicine*, prepared by Norma Angélica Noguez Méndez et al., presents an up-to-date overview about the microfluidics and examples of nano- and microparticles involved in this field: liquid crystals (LCs) and solid lipid nanoparticles (SLNs). Also, the authors present details about synthetic polymerosomes that imitate biological membrane functions.

Chapter 23, prepared by Shou-Cang Shen et al., entitled *Mesoporous Materials and Technologies for Development of Oral Medicine*, presents recent progress in the development of mesoporous materials as drug carriers for applications in oral medicine formulation according to the types of mesoporous excipients, drug loading techniques, characterization and stability studies, and applications in oral medicine.

Nehi Sinha et al., in Chapter 24, entitled *Nanodentistry: Novel Approaches*, focus on the role of nanostructures to keep teeth and oral tissues healthy and functioning. The challenges faced by this technology for the betterment of human health are also discussed.

Chapter 25, entitled *The Role of Nanomedicine, Nanotechnology, and Nanostructures on Oral Bone Healing, Modeling, and Remodeling*, prepared by Mohamadreza Baghaban-Eslaminejad et al., covers the most important information regarding manufacturing methods, available and future options, and the role of nanostructures on bone health, healing, and repair based on their basic to clinical evidence.

Muhammad Sohail Zafar et al., in Chapter 26, entitled *Therapeutic Applications of Nanotechnology in Dentistry*, highlight recent developments regarding therapeutic applications of nanomaterials in dentistry. In addition, chemistry, synthesis, properties, and benefits of therapeutic nanomaterials over conventional materials in relation to dentistry are discussed.