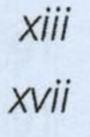
# Contents

List of contributors Preface



1

v

Particles and microbiota: interaction to death or resilience? 1.

Djouhar Souak, Ségolène Depayras, Mohamed Zommiti, Nathalie Connil, Sandra Leblanc, Nicole Orange, Marc Feuilloley and Cécile Duclairoir Poc

- Introduction 1.1
- 1.2 Human microbiota: various specific microbiota

1.2	Huma	n microbiota: various specific microbiota		2
	1.2.1	Difference between microbiota and microbiome		4
	1.2.2	Characteristics of microbiota related to its habitat		5
1.3	Experi	mental strategies to evaluate the responses of microbiota	a to	
	enviro	nmental factors		5
	1.3.1	From the human scale to the microorganism		6
	1.3.2	Experimental models		7
1.4	Huma	n exposure to nanoparticles		10
	1.4.1	Various nanoparticles		10
		Usual exposure of human to nanoparticles (except for		
	X	therapeutics purpose)		11
	1.4.3	General traits of microbial response to nanoparticles		1.1
		exposition		11
	1.4.4	Experimental bias through microbial exposure to		15
1.5	C	nanoparticles		15
1.5		icrobiota and nanoparticles		
		The intestinal microbiota		15
		Nanoparticles used in foods and human exposure		17
		Impacts of silver nanoparticles on gut microbiota		17
		Impacts of TiO <sub>2</sub> nanoparticles on gut microbiota		18
		Impacts of SiO <sub>2</sub> nanoparticles on gut microbiota		18
		Impacts of ZnO nanoparticles on gut microbiota		18
		nicrobiota and nanoparticles		20
		nicrobiota and nanoparticles		24
		y microbiota and nanoparticles		28
1.9	Vagina	al microbiota and nanoparticles		30
1.10	Conclu	usion and perspectives		33
Refere	ences			34



2.	Current and future prospects of nanoparticles to
	combat bacterial infections
	Dinesh Prasad Gond, Atul Srivastava, Subhashini, Anjney Sharma and

Kumari Mrinalini

2.1	Introd	luction	49		
	2.1.1	Bacterial infection	49		
	2.1.2	Nanoparticles as antibacterial agents	50		
2.2	Pharm	nacodynamic properties of nanoparticles exhibiting antibacterial			
	activit	FATTALE STOPP, DOUB SERVICE STOP STOP SOUTH STOP STOP STOP STOP STOP STOP STOP STOP	51		
2.3	Nanor	materials mechanisms to mitigate bacterial infection	52		
2.4	Applic	cation of nanoparticles	54		
	2.4.1	Antibacterial coating on implantable devices	54		
	2.4.2	Wound dressing	54		
	2.4.3	Bone cement	54		
	2.4.4	Dental materials	55		
	2.4.5	Antibiotic delivery system	55		
2.5		ent classes of nanoparticles currently used for antibacterial			
	applic		55		
		Metallic nanoparticles	56		
		Carbon nanoparticles	58		
	2.5.3	Polymeric nanoparticles	59		
		Nanocomposites	61		
		Nanoemuslions	61		
		Smart materials	62		
		Nanomaterials conjugated with Antimicrobial Peptides	62		
2.6		ation of nanoparticles application against bacterial infection and			
		future prospects	62		
	Concl		63		
Con	Conflict of Interest 63				

#### References

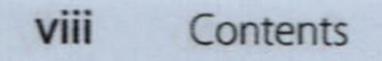
3

		s of biosynthesized nanoparticles in treating eutical wastewater in relation to human health	75
Kari	shma [	Das Purkayastha and Nayanmoni Gogoi	
3.1	Introd	uction	75
3.2	Biolog	ical synthesis of single metallic and bimetallic nanoparticles	77
	3.2.1	Single metallic or monometallic nanoparticles	78
	3.2.2	Bimetallic nanoparticles	79
	3.2.3	Plant extracts as reducing and capping agents	83
	3.2.4	Stabilizers	86

49

### Contents vii

		3.2.5	Kinetics of synthesis		87
		3.2.6	Characterization		89
		3.2.7	Storage and sustainable use		89
	3.3	Pharm	naceutical waste		90
		3.3.1	Antibiotics and their classes		91
		3.3.2	Fate of antibiotics in the ecosystem		91
		3.3.3	Antibiotic-resistant bacteria and human health		97
		3.3.4	Antibiotic-resistant genes		99
		3.3.5	Multidrug resistance		100
	3.4	Variou	is strategies to treat pharmaceutical wastes		104
		3.4.1	Conventional methods		104
		3.4.2	Modern methods	S.2.3 Epid	107
		3.4.3	Combined methods		108
	3.5	Concl	usion and future prospects		112
	Refe	rences	iests of nanonhaterials		112
1	Role	e of n	lant and microbe-derived nanoparticles in		
30			waste management		121
			nan, Kingshuk Panda, Atreyee Sur Roy Chowdhury	1	
			a and Punuri Jayasekhar Babu	CONCINEMON	
	Rah	ul Deka	a and Punuri Jayasekhar Babu	Concession ire prospects	121
	Rahu 4.1	ul Deka Introd	a and Punuri Jayasekhar Babu luction	rences	121 122
	Rahu 4.1	ul Deka Introd Plant-	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles		
	Rahu 4.1	Introd Plant- 4.2.1	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae)		122
	Rahu 4.1	ul Deka Introd Plant- 4.2.1 4.2.2	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes		122 123
	Rahu 4.1	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.3	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes		122 123 124
	Rahu 4.1	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.3 4.2.3	a and Punuri Jayasekhar Babu Juction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes Pteridophytes Gymnosperms		122 123 124 125
	Rah	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.3 4.2.3 4.2.4 4.2.5	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes Pteridophytes		122 123 124 125 125
	Rah	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.3 4.2.4 4.2.5 Micro	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes Pteridophytes Gymnosperms Angiosperms (flowering plants)		122 123 124 125 125 126
	Rah	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.3 4.2.4 4.2.5 Micro 4.3.1	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes Pteridophytes Gymnosperms Angiosperms (flowering plants) bes-mediated synthesis of nanoparticles		122 123 124 125 125 126 128
	Rah	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.3 4.2.4 4.2.5 Micro 4.3.1 4.3.1	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes Pteridophytes Gymnosperms Angiosperms (flowering plants) bes-mediated synthesis of nanoparticles Bacterial mode of nanoparticle synthesis		122 123 124 125 125 126 128 132
	Rah	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.3 4.2.3 4.2.5 Micro 4.3.1 4.3.2 4.3.2	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes Pteridophytes Gymnosperms Angiosperms (flowering plants) bes-mediated synthesis of nanoparticles Bacterial mode of nanoparticle synthesis Fungal mode of nanoparticle synthesis		122 123 124 125 125 126 128 132 133
	Rah 4.1 4.2	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.3 4.2.4 4.2.5 Micro 4.3.1 4.3.2 4.3.2 4.3.2	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes Pteridophytes Gymnosperms Angiosperms (flowering plants) bes-mediated synthesis of nanoparticles Bacterial mode of nanoparticle synthesis Fungal mode of nanoparticle synthesis Yeast mode of nanoparticle synthesis		122 123 124 125 125 126 128 132 132 133
	Rah 4.1 4.2	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.3 4.2.4 4.2.5 Micro 4.3.1 4.3.2 4.3.2 4.3.2	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes Pteridophytes Gymnosperms Angiosperms (flowering plants) bes-mediated synthesis of nanoparticles Bacterial mode of nanoparticle synthesis Fungal mode of nanoparticle synthesis Yeast mode of nanoparticle synthesis Viral mode of nanoparticle synthesis	ine picospects rences in synthes in ayasekh Nanotechno Nanotechno 6.3.1 Conc 6.3.2 Sont 6.3.3 Appl conclusion n	122 123 124 125 125 126 128 132 132 133 134 135
	Rah 4.1 4.2	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.3 4.2.3 4.2.5 Micro 4.3.1 4.3.2 4.3.2 4.3.2 4.3.2	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes Pteridophytes Gymnosperms Angiosperms (flowering plants) bes-mediated synthesis of nanoparticles Bacterial mode of nanoparticle synthesis Fungal mode of nanoparticle synthesis Yeast mode of nanoparticle synthesis Viral mode of nanoparticle synthesis cation of nanoparticles in medical waste remediation	ine picospects rences in synthes in ayasekh Nanotechno Nanotechno 6.3.1 Conc 6.3.2 Sont 6.3.3 Appl conclusion n	122 123 124 125 125 126 128 132 132 133 134 135
	Rah 4.1 4.2	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.3 4.2.4 4.2.5 Micro 4.3.1 4.3.2 4.3.2 4.3.3 4.3.4 Applic 4.4.1	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes Pteridophytes Gymnosperms Angiosperms (flowering plants) bes-mediated synthesis of nanoparticles Bacterial mode of nanoparticle synthesis Fungal mode of nanoparticle synthesis Yeast mode of nanoparticle synthesis Viral mode of nanoparticle synthesis cation of nanoparticles in medical waste remediation Nanoparticle-based treatment of virus and microb	ine picospects rences in synthes in ayasekh Nanotechno Nanotechno 6.3.1 Conc 6.3.2 Sont 6.3.3 Appl conclusion n	122 123 124 125 125 126 128 132 132 133 134 135 136
	Rah 4.1 4.2 4.3	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.2 4.2.3 4.2.4 4.2.5 Micro 4.3.1 4.3.2 4.3.3 4.3.4 Applio 4.4.1	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes Pteridophytes Gymnosperms Angiosperms (flowering plants) bes-mediated synthesis of nanoparticles Bacterial mode of nanoparticle synthesis Fungal mode of nanoparticle synthesis Yeast mode of nanoparticle synthesis Viral mode of nanoparticle synthesis viral mode of nanoparticle synthesis cation of nanoparticles in medical waste remediation Nanoparticle-based treatment of virus and microb contamination Bioremediation of solid medical waste Nanomaterial-based strategies for cleaning radioad	rences Nanctechno Nanctechno Nanctechno Sal Cold no Sal Cold n	122 123 124 125 125 126 128 132 132 133 134 135 136
	Rah 4.1 4.2 4.3	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.3 4.2.4 4.2.5 Micro 4.3.1 4.3.2 4.3.1 4.3.2 4.3.3 4.3.4 Applie 4.4.1	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes Pteridophytes Gymnosperms Angiosperms (flowering plants) bes-mediated synthesis of nanoparticles Bacterial mode of nanoparticle synthesis Fungal mode of nanoparticle synthesis Yeast mode of nanoparticle synthesis Viral mode of nanoparticle synthesis cation of nanoparticles in medical waste remediation Nanoparticle-based treatment of virus and microb contamination Bioremediation of solid medical waste Nanomaterial-based strategies for cleaning radioad onmental issues and challenges associated with	rences Nanctechno Nanctechno Nanctechno Sal Cold no Sal Cold n	122 123 124 125 125 126 128 132 132 133 134 135 136 136 141 145
	Rah 4.1 4.2 4.3	ul Deka Introd Plant- 4.2.1 4.2.2 4.2.3 4.2.4 4.2.5 Micro 4.3.1 4.3.2 4.3.1 4.3.2 4.3.3 4.3.4 Applio 4.4.1	a and Punuri Jayasekhar Babu uction mediated synthesis of nanoparticles Thallophytes (algae) Bryophytes Pteridophytes Gymnosperms Angiosperms (flowering plants) bes-mediated synthesis of nanoparticles Bacterial mode of nanoparticle synthesis Fungal mode of nanoparticle synthesis Yeast mode of nanoparticle synthesis Viral mode of nanoparticle synthesis viral mode of nanoparticle synthesis cation of nanoparticles in medical waste remediation Nanoparticle-based treatment of virus and microb contamination Bioremediation of solid medical waste Nanomaterial-based strategies for cleaning radioad	rences Nanctechno Nanctechno Nanctechno Sal Cold no Sal Cold n	122 123 124 125 125 126 128 132 132 133 134 135 136 136



4.7 Conclusion				152
References				152

5.			nology: a new strategy to combat bacterial in	fections	
	and	l antik	piotic resistant bacteria		167
	Rab	iya Tak	bassum Khan and Shafaq Rasool		
	5.1	Introd	luction	3.3.4	167
	5.2	Antibi	iotics, antibiotic resistance, and its epidemiology		168
		5.2.1	History of antibiotics		169
		5.2.2	Classes of antibiotics and their mode of action		169
		5.2.3	Epidemiology of antibiotic resistance		175
	5.3	Introd	luction to nanotechnology		176
		5.3.1	Types of nanoparticles		177
		5.3.2	Synthesis of nanomaterials		179
	5.4	Role o	of nanotechnology in combating antibiotic resistance		179
		5.4.1	Use of nanoparticles as antimicrobials		180
		5.4.2	Multidrug delivery using nanoparticles		184
		5.4.3	Prevention of biofilm formation		184
	5.5	Concl	usion		186
	Futu	ure pro	spects		186
	Refe	erences	the states of th	ubortal. 1.	187
			ediabed synthesis of nanoparticles	2 Plant-m	
6.			nthesis of gold nanoparticles and their biomed	dical	
	and	heal	thcare applications		191
	Pun	uri Jay	asekhar Babu and Akriti Tirkey		
	6.1	Nano	technology	4.2.9	191
		6.1.1	Concept of "nano" and comparison		192
	6.2	Nano	technology and its applications		193
	6.3		materials and its types		194
		6.3.1	Gold nanoparticles		194
		6.3.2	Synthesis of gold nanoparticles		196
		6.3.3	Applications of gold nanoparticles		211
	6.4	Conc	lusion and future prospective		219
	Refe	erences			220

- 7. Nanomedicines in cancer immunotherapy: challenges and opportunities Sarang Tartey
  - 7.1 Introduction

231

231

	7.2	Nanomedicine	232
	7.3	Nanoparticle therapeutics in cancer and its mode of action	234
		7.3.1 Antigen presentation to immune cells	234
		7.3.2 Promoting immunogenic cell death	238
		7.3.3 Intracellular delivery of danger signals and nucleic acids	239
		7.3.4 Targeting myeloid cells	239
	7.4	Challenges in clinical translation	241
		7.4.1 Precision-guided reproducible synthesis of nanoparticles	241
		7.4.2 Evaluation and screening of nanoparticles	242
	7.5	Conclusion	242
	Refe	rences	243
		9.6 Nanotechnology: future approaches to challenge COVID-185-	
8.	Rec	ent applications of nanomedicine in lung disease	247
		Srivastava, Mrinalini kumari, Dinesh Prasad Gond and Subhashini	
	Atu	Shvastava, Minhalim Kuman, Dinesh Plasad Gond and Subhashim	
	8.1	Introduction	247
	8.2	Nanotechnology: an emerging revolution	248
		8.2.1 Nanotechnology and its application	249
		Pros and constof nanotechnology	252
	8.4	Nanomedicine: an approach for healthcare	253
		8.4.1 Application of nanomedicine in the medical field	254
		8.4.2 Challenges and perspectives of nanomedicines	254
285		Lungs ås an organ for drug delivery	255
		Nanocarriers for lung treatment	256
	8.7	Common respiratory disease and nanomedicines as therapeutic	257
		8.7.1 Chronic obstructive pulmonary disease	258
		8.7.2 Bronchial asthma	259
		8.7.3 COVID-19	260
		8.7.4 Tuberculosis	261
		8.7.5 Pneumonia	262
	~ ~	8.7.6 Lung cancer	262
		Conclusion and future perspective of nanoparticles in lung disease	263
	Rele	rences	263
000	Del	a glimpse	
9.		e of nanotechnology in diagnosis and disease control	260
		h a focus on COVID-19 and future perspectives	269
	Md.	Harun Al Rashid, Dhananjoy Saha and Subhash C. Mandal	
	9.1	Introduction	269
	9.2	Nanoparticles	271
		9.2.1 COVID-19 infections	271

.

Contents ix

#### **x** Contents

	9.2.2	Gene		271
	9.2.3	Structure		272
	9.2.4	Transmission		272
	9.2.5	Entrance to body		273
	9.2.6	Target organ		273
9.3	Patho	genesis of COVID-19		274
	9.3.1	Potential management		274
	9.3.2	Diagnosis		275
	9.3.3	Vaccine for COVID-19		275
9.4	Nanor	medicine therapy for COVID-19 infections		276
9.5	Applic	cations of nanomedicine in diagnosing COVID-19		276
9.6	Nanot	technology: future approaches to challenge COVID-19		277
9.7	Concl	usion		278
Ack	nowled	Igments		279
Con	flict of	interest		279
Fun	ding	na katektinology in comballing antibictic resistancenolitati		279
	erences			279

285

in st

10.	Nanotechnology for	r the treatment	of cancer:	progress and
	challenges			A set

Mansavi Bhardwaj and Shafaq Rasool

	10.1	Background	285
	10.2	Nanoparticle therapeutics in cancer treatment	287
		10.2.1 Unique properties of nanoparticles	288
		10.2.2 Types of nanoparticles used for cancer diagnosis and treatment	290
		10.2.3 Challenges associated with cancer nanotechnology	298
	10.3	Conclusion	301
	10.4	Future perspectives	302
	Refere	ences	303
11.	a gli	role of chitosan-based nanoparticles to reduce obesity: mpse am Rakshit, Kalyanbrata Pal, Keshab Chandra Mondal and	309
11.	a glin Subha	role of chitosan-based nanoparticles to reduce obesity: mpse	309
11.	a glin Subha	role of chitosan-based nanoparticles to reduce obesity: mpse am Rakshit, Kalyanbrata Pal, Keshab Chandra Mondal and	<b>309</b> 309
11.	a glin Subha Suma 11.1	role of chitosan-based nanoparticles to reduce obesity: mpse am Rakshit, Kalyanbrata Pal, Keshab Chandra Mondal and in Kumar Halder	
11.	a glin Subha Suma 11.1 11.2	role of chitosan-based nanoparticles to reduce obesity: mpse am Rakshit, Kalyanbrata Pal, Keshab Chandra Mondal and in Kumar Halder Introduction	309

11.4.1 Experimental evidence of antiobese activity of chitosan	313
11.4.2 Experimental evidence of use of chitosan nanoparticles	
as a carrier of antiobese drugs	316
11.5 Conclusion and future perspectives	327
References vebs / smult de	327

12. Nanotechnology for the removal of pesticides hazardous to human health

333

Fatima Abla, Javad M.B. Parambath, Sofian M. Kanan and Ahmed A. Mohamed

12.1 Introduction

333

	12.2	Pesticides	334
	12.3	Removal routes of pesticides	336
		12.3.1 Zeolites	336
	12.4	Metal oxide nanoparticles	342
	12.5	Zero-valent iron nanoparticles	345
	12.6	Graphene-based substrates	349
		Conclusion	352
	Ackno	owledgments	353
	Refere	ences	353
13.	Imm	unomodulation through nanoparticles	363
	Ivan Aranha		
	13.1	Introduction	363
	13.2	The immune system	366
	13.3	Nanotechnology in immune system modulation	368
	13.4	Nanoparticles in innate immunity	370
		13.4.1 The innate immune cells	370
		13.4.2 Recognizing nanoparticles by innate immune cells	371
	13.5	Nanoparticles in adaptive immunity	372
		13.5.1 Nanoparticles targeting B cells	373
		13.5.2 Nanoparticles targeting T cells	374
	13.6	Immunomodulation properties of nanomaterials in vaccination	374
	13.7	Conclusions	376
	13.8	Future prospective	377
	Ackno	owledgment	378
	Refere	ences	378

## 14. Role of nanoparticles in the treatment of human disease: a comprehensive review

381

Ruth Zomuansangi, Bhim Pratap Singh, Garima Singh, Zothanpuia, Prashant Kumar Singh, Jae Jun Song, Arun S Kharat, Purbhajyoti Deka and Mukesh Kumar Yadav

14.1	Introduction	381
14.2	Classification of nanoparticles	383
14.3	Biological barriers that nanoparticles can overcome	388
14.4	Nanoparticles used in a drug delivery system	389
14.5	Nanoparticles and drug delivery	394
14.6	Nanoparticles in precision medicine	394
14.7	Future prospective of nanomedicine and drug delivery system	397
Acknowledgment		

