

## Contents

### Preface *XI*

<b>1</b>	<b>General Aspects of Parasite Biology</b>	<b>1</b>
	<i>Richard Lucius and Robert Poulin</i>	
1.1	Introduction to Parasitology and Its Terminology	2
1.1.1	Parasites	2
1.1.2	Types of Interactions Between Different Species	5
1.1.2.1	Mutualistic Relationships	5
1.1.2.2	Antagonistic Relationships	6
1.1.3	Different Forms of Parasitism	10
1.1.4	Parasites and Hosts	11
1.1.5	Modes of Transmission	16
	Further Reading	17
1.2	What Is Unique About Parasites?	18
1.2.1	A Very Peculiar Habitat: The Host	18
1.2.2	Specific Morphological and Physiological Adaptations	22
1.2.3	Flexible Strategies of Reproduction	27
	Further Reading	29
1.3	The Impact of Parasites on Host Individuals and Host Populations	30
	Further Reading	37
1.4	Parasite–Host Coevolution	38
1.4.1	Main Features of Coevolution	38
1.4.2	Role of Alleles in Coevolution	42
1.4.3	Rareness Is an Advantage	45
1.4.4	Malaria as an Example of Coevolution	46
	Further Reading	50
1.5	Influence of Parasites on Mate Choice	51
	Further Reading	57
1.6	Immunobiology of Parasites	58
1.6.1	Defense Mechanisms of Hosts	60
1.6.1.1	Innate Immune Responses (Innate Immunity)	60
1.6.1.2	Acquired Immune Responses (Adaptive Immunity)	62

1.6.1.3	Scenarios of Defense Reactions Against Parasites	63
1.6.1.4	Immunopathology	67
1.6.2	Immune Evasion	68
1.6.3	Parasites as Opportunistic Pathogens	72
1.6.4	Hygiene Hypothesis: Do Parasites Have a Good Side?	74
	Further Reading	76
1.7	How Parasites Alter Their Hosts	77
1.7.1	Alterations of Host Cells	78
1.7.2	Intrusion into the Hormonal System of the Host	79
1.7.3	Changing the Behavior of Hosts	82
1.7.3.1	Increase in the Transmission of Parasites by Bloodsucking Vectors	83
1.7.3.2	Increase in Transmission Through the Food Chain	83
1.7.3.3	Introduction into the Food Chain	88
1.7.3.4	Changes in Habitat Preference	92
	Further Reading	93
<b>2</b>	<b>Biology of Parasitic Protozoa</b>	<b>95</b>
	<i>Richard Lucius and Craig W. Roberts</i>	
2.1	Introduction	97
	Further Reading	98
2.2	Metamonada	99
2.2.1	<i>Giardia lamblia</i>	99
	Further Reading	102
2.3	Parabasala	102
2.3.1	<i>Trichomonas vaginalis</i>	103
2.3.2	<i>Tritrichomonas foetus</i>	106
	Further Reading	106
2.4	Amoebozoa	107
2.4.1	<i>Entamoeba histolytica</i>	108
2.4.2	<i>Entamoeba dispar</i>	114
2.4.3	Other <i>Entamoeba</i> Species	114
2.4.4	Further Intestinal Amoebae	115
2.4.5	<i>Acanthamoeba</i>	115
	Further Reading	116
2.5	Euglenozoa	117
2.5.1	Cell Biology and Genome	118
2.5.2	Phylogeny	121
2.5.3	<i>Trypanosoma brucei</i>	121
2.5.4	<i>Trypanosoma congolense</i>	131
2.5.5	<i>Trypanosoma vivax</i>	132
2.5.6	<i>Trypanosoma evansi</i>	133
2.5.7	<i>Trypanosoma equiperdum</i>	133
2.5.8	<i>Trypanosoma cruzi</i>	134
2.5.9	<i>Leishmania</i>	141

2.5.9.1	Development	142
2.5.9.2	Morphology	143
2.5.9.3	Leishmaniosis	143
2.5.9.4	Cell and Immune Biology	143
2.5.10	<i>Leishmania tropica</i>	148
2.5.11	<i>Leishmania donovani</i>	150
2.5.12	<i>Leishmania braziliensis</i> and <i>Leishmania mexicana</i>	151
	Further Reading	151
2.6	Alveolata	153
2.6.1	Apicomplexa	155
2.6.1.1	Development	155
2.6.1.2	Morphology	157
2.6.1.3	Cell Biology	160
2.6.2	Coccidea	165
2.6.2.1	<i>Cryptosporidium parvum</i>	166
2.6.2.2	<i>Eimeria</i>	169
2.6.2.3	<i>Eimeria tenella</i>	174
2.6.2.4	<i>Eimeria bovis</i>	175
2.6.2.5	<i>Isospora</i> and <i>Cyclospora</i>	175
2.6.2.6	<i>Toxoplasma gondii</i>	176
2.6.2.7	<i>Neospora caninum</i>	186
2.6.2.8	<i>Sarcocystis</i>	187
2.6.3	Haematozoa	190
2.6.3.1	<i>Plasmodium</i>	190
2.6.3.2	<i>Plasmodium vivax</i> , a Causative Agent of Tertian Malaria	199
2.6.3.3	<i>Plasmodium ovale</i> , a Causative Agent of Tertian Malaria	200
2.6.3.4	<i>Plasmodium malariae</i> , the Causative Agent of Quartan Malaria	200
2.6.3.5	<i>Plasmodium falciparum</i> , the Causative Agent of Malignant Tertian Malaria or Malaria tropica	201
2.6.3.6	<i>Plasmodium</i> species of Monkeys, Rodents, and Birds	210
2.6.4	Piroplasms	211
2.6.4.1	<i>Babesia</i>	211
2.6.4.2	<i>Theileria</i>	214
2.6.5	Ciliophora	218
2.6.5.1	<i>Balantidium coli</i>	219
2.6.5.2	<i>Ichthyophthirius multifiliis</i>	219
2.6.5.3	<i>Trichodina</i>	221
	Further Reading	222
<b>3</b>	<b>Parasitic Worms</b>	<b>225</b>
	<i>Brigitte Loos-Frank and Richard K. Grencis</i>	
3.1	Platyhelminths	228
3.1.1	Digenea	230
3.1.1.1	Development	230

- 3.1.1.2 Morphology 232
- 3.1.1.3 Adults 234
- 3.1.1.4 Systematics and Evolutionary History 237
- 3.1.1.5 *Schistosoma* 238
- 3.1.1.6 *Leucochloridium paradoxum* 248
- 3.1.1.7 *Diplostomum spathaceum* 248
- 3.1.1.8 *Fasciola hepatica* 251
- 3.1.1.9 *Opisthorchis felineus* 254
- 3.1.1.10 *Paragonimus westermani* 257
- 3.1.1.11 *Dicrocoelium dendriticum* 259
- Further Reading 262
- 3.1.2 Cestoda 263
  - 3.1.2.1 Development 265
  - 3.1.2.2 Evolution and Origin of Life Cycles 266
  - 3.1.2.3 Morphology 266
  - 3.1.2.4 Genome 269
  - 3.1.2.5 Diphylobothriidea 269
  - 3.1.2.6 *Mesocestoides* 272
  - 3.1.2.7 Cyclophyllidea 272
  - 3.1.2.8 *Moniezia expansa* 273
  - 3.1.2.9 *Hymenolepis diminuta* 274
  - 3.1.2.10 *Rodentolepis nana* (*Hymenolepis nana*) 275
  - 3.1.2.11 Taeniidae 277
  - 3.1.2.12 *Taenia saginata* 281
  - 3.1.2.13 *Taenia solium* 282
  - 3.1.2.14 *Taenia asiatica* 282
  - 3.1.2.15 *Hydatigera taeniaeformis* 283
  - 3.1.2.16 *Echinococcus* 283
  - 3.1.2.17 *Echinococcus granulosus* 283
  - 3.1.2.18 *Echinococcus multilocularis* 285
  - 3.1.2.19 *Echinococcus vogeli* and *Echinococcus oligarthrus* 286
  - Further Reading 287
- 3.2 Acanthocephala 288
  - Further Reading 293
- 3.3 Nematoda 294
  - 3.3.1 Development 295
  - 3.3.2 Morphology 297
  - 3.3.3 Dorylaimea 300
    - 3.3.3.1 *Trichinella spiralis* 300
    - 3.3.3.2 *Trichuris trichiura* 305
  - 3.3.4 Chromadorea 306
    - 3.3.4.1 *Strongyloides stercoralis* 306
    - 3.3.4.2 *Ancylostoma duodenale* and *Necator americanus* 308
    - 3.3.4.3 *Angiostrongylus cantonensis* 311
    - 3.3.4.4 *Haemonchus contortus* 312

3.3.4.5	<i>Dictyocaulus viviparus</i>	315
3.3.4.6	<i>Ascaris lumbricoides</i>	315
3.3.4.7	<i>Ascaris suum</i>	318
3.3.4.8	<i>Toxocara canis</i>	318
3.3.4.9	<i>Anisakis simplex</i> and <i>Anisakis</i> spp.	320
3.3.4.10	<i>Dracunculus medinensis</i>	321
3.3.4.11	<i>Enterobius vermicularis</i>	323
3.3.4.12	Filariæ	325
3.3.4.13	<i>Wuchereria bancrofti</i> and <i>Brugia malayi</i>	326
3.3.4.14	<i>Onchocerca volvulus</i>	330
3.3.4.15	<i>Loa loa</i> and <i>Dirofilaria immitis</i>	334
3.3.4.16	Rodent Models of Filariosis	334
	Further Reading	335
<b>4</b>	<b>Arthropods</b>	<b>337</b>
	<i>Brigitte Loos-Frank and Richard P. Lane</i>	
4.1	Introduction	338
4.1.1	Vector Concepts	340
4.1.2	Impact of Bloodfeeding	343
	Further Reading	343
4.2	Acari – Mites and Ticks	344
4.2.1	Morphology	346
4.2.2	Development	347
4.2.3	Anactinotrichida (= Parasitiformes)	347
4.2.3.1	Mesostigmata	347
4.2.3.2	<i>Dermanyssus gallinae</i>	348
4.2.3.3	<i>Varroa destructor</i>	348
4.2.3.4	Metastigmata (= Ixodida or Ixodoidea, Ticks)	350
4.2.3.5	Development	353
4.2.3.6	Tick Bites and Saliva	353
4.2.3.7	Ixodidae – Hard Ticks	354
4.2.3.8	Argasidae (Soft Ticks)	358
4.2.3.9	Tick-Borne Diseases	359
4.2.4	Actinotrichida (= Acariformes)	361
4.2.4.1	Prostigmata = Actinedida = Trombidiformes	362
4.2.4.2	Trombiculidae – Harvest Mites, Chiggers	363
4.2.4.3	Astigmata = Acaridida = Sarcoptiformes	364
	Further Reading	365
4.3	Crustacea	366
4.3.1	<i>Argulus foliaceus</i>	367
4.3.2	<i>Sacculina carcini</i>	368
	Further Reading	370
4.4	Insecta	370
4.4.1	Phthiraptera – Lice	374
4.4.2	“Mallophaga” – Chewing Lice	375

4.4.3	Anoplura – Sucking Lice	375
4.4.3.1	<i>Pediculus humanus capitis</i>	377
4.4.3.2	<i>Pediculus humanus humanus</i>	378
4.4.3.3	<i>Pthirus pubis</i>	378
4.4.3.4	Disease Transmission by Lice	379
4.4.4	Heteroptera – True Bugs	380
4.4.5	Triatominae – Kissing Bugs	380
4.4.6	Cimicidae – Bedbugs	382
4.4.6.1	<i>Cimex lectularius</i>	383
4.4.7	Siphonaptera – Fleas	384
4.4.7.1	Biology and Development	384
4.4.7.2	Morphology	385
4.4.7.3	<i>Pulex irritans</i>	387
4.4.7.4	<i>Ctenocephalides</i> : Cat and Dog Fleas	387
4.4.7.5	<i>Tunga penetrans</i> – Jiggers	388
4.4.7.6	Disease Transmission by Fleas	388
4.4.8	Diptera – Flies	390
4.4.8.1	Lower Diptera	390
4.4.8.2	Ceratopogonidae – Biting Midges, No-see-ums, Punkies	391
4.4.8.3	Disease Transmission	393
4.4.8.4	Culicidae – Mosquitoes	394
4.4.8.5	Disease Transmission	398
4.4.8.6	Simuliidae – Blackflies	401
4.4.8.7	Phlebotominae – Sandflies	404
4.4.8.8	Brachycera	408
4.4.8.9	Tabanidae – Horse Flies	408
4.4.8.10	Muscidae – House and Stable Flies	410
4.4.8.11	Calliphoridae – Blowflies, Screwworms	413
4.4.8.12	Oestridae – Bot or Warble Flies	413
4.4.8.13	Glossinidae – Tsetse Flies	415
4.4.8.14	Hippoboscidae, Nycteribiidae, Streblidae – Louse Flies, Keds and Bat Flies	418
	Further Reading	419

**Answers to Test Questions** 423

Chapter 1	423
Chapter 2	426
Chapter 3	429
Chapter 4	431

**Index** 435