

Brief Contents

The Poriferans and Placozoans

Phylum Porifera 79

Introduction 79

General Characteristics 81

Poriferan Diversity 86

Other Features of Poriferan Biology,
Reproduction, and Development 89

Phylum Placozoa 91

Introduction 91

1 Introduction and Environmental
Considerations 1

2 Invertebrate Classification
and Relationships 7

3 The Protists 37

4 The Poriferans and Placozoans 79

5 Introduction to the Hydrostatic
Skeleton 97

6 The Cnidarians 101

7 The Ctenophores 137

8 The Platyhelminths 149

9 The Mesozoans:
Possible Flatworm Relatives 179

10 The Gnathifera: Rotifers, Acanthocephalans,
and Two Smaller Groups 183

11 The Nemertines 203

12 The Molluscs 215

13 The Annelids 295

14 The Arthropods 341

15 Two Phyla of Likely Arthropod Relatives:
Tardigrades and Onychophorans 421

16 The Nematodes 431

17 Four Phyla of Likely Nematode Relatives:
Nematomorpha, Priapulida, Kinorhyncha,
and Loricifera 451

18 Three Phyla of Uncertain Affiliation:
Gastrotricha, Chaetognatha, and
Cycliophora 459

19 The "Lophophorates" (Phoronids,
Brachiopods, Bryozoans) and
Entoprocts 473

20 The Echinoderms 497

21 The Hemichordates 529

22 The Xenoturbellids: Deuterostomes
at Last? 537

23 The Nonvertebrate Chordates 539

24 Invertebrate Reproduction
and Development—An Overview 555

List *Expanded Contents*

List of Research Focus Boxes	iv
Preface	xi
Guide to the Major Animal Groups	xvi
The Geologic Time Scale	xvii

1

Introduction and Environmental Considerations 1

Introduction: The Importance of Research on Invertebrates	1
Environmental Considerations	2
Air Is Dry, Water Is Wet	2
Water Is the "Universal Solvent"	3
Water Is Denser than Air	4
Water Has Thermal Stability	4
Problems with the Aquatic Life	4
Origins and Diversity of Life	6

2

Invertebrate Classification and Relationships 7

Introduction	7
Classification by Cell Number, Embryology, and Body Symmetry	9
Classification by Developmental Pattern	9
Classification by Evolutionary Relationship	16
Inferring Evolutionary Relationships	19
Why Determine Evolutionary Trees?	22
How Evolutionary Relationships Are Determined	25
Uncertainty about Evolutionary Relationships	30
Time Machines: Help from the Fossil Record	31
Classification by Habitat and Lifestyle	31

3

The Protists 37

Introduction	37
The Protozoa	38
General Characteristics	39
Protozoan Locomotory Systems	42
Structure and Function of Cilia	42
Structure and Function of Flagella	43
Structure and Function of Pseudopodia	43
Protozoan Reproduction	44
Protozoan Feeding	46
General Summary	46
The Alveolates	46
Phylum Ciliophora	46
Patterns of Ciliation	47
Other Morphological Features	47
Reproductive Characteristics	49
Ciliate Lifestyles	52
Phylum Dinoflagellata (= Dinoflagellata)	54
Phylum Apicomplexa	58
A Brief Aside on Microsporideans and Myxozoans	61
Amoeboid Protozoans	62
The Amoebozoans	62
The Arcellinids and Related Test-Bearing Amoebae	63
The Rhizaria	65
Flagellated Protozoans	68
The Phytoflagellated Protozoans	68
The Zooflagellated Protozoans—Free-Living Forms	68
The Zooflagellated Protozoans—Parasitic Forms	68
Two Interesting Transitional Forms	72

4

The Poriferans
and Placozoans 79

Phylum Porifera 79

Introduction 79

General Characteristics 81

Poriferan Diversity 86

Other Features of Poriferan Biology: Reproduction
and Development 89

Phylum Placozoa 91

Introduction 91

General Characteristics 91

5

Introduction to the
Hydrostatic Skeleton 97

6

The Cnidarians 101

Introduction and General Characteristics 101

Subphylum Medusozoa 104

Class Scyphozoa 104

Class Cubozoa 108

Class Hydrozoa 110

Order Hydroida 110

Order Siphonophora 113

The Hydrocorals 114

One Group of Non-Medusozoans 115

Class Myxozoa (= Myxospora) 115

Class Anthozoa 118

Subclass Hexacorallia (= Zoantharia) 120

Subclass Octocorallia (= Alcyonaria) 124

7

The Ctenophores 137

Introduction and General Characteristics 137

Ctenophore Diversity 143

Class Tentaculata 144

Class Nuda 146

8

The Platyhelminths 149

Introduction and General Characteristics 149

Class Turbellaria 151

Class Cestoda 157

Class Monogenea 160

Class Trematoda 161

The Digeneans 161

The Aspidogastrea (= Aspidobothreans) 170

9

The Mesozoans: Possible
Flatworm Relatives 179

The Mesozoans 179

Class Orthonectida 180

Class Rhombozoa 181

10

The Gnathifera: Rotifers,
Acanthocephalans, and
Two Smaller Groups 183

Introduction 183

Phylum Rotifera 184

Introduction and General Characteristics 184

Class Seisonidea 188

Class Bdelloidea 188

Class Monogononta 190

Other Features of Rotifer Biology 195

Digestive System 195

Nervous and Sensory Systems 195

Excretion and Water Balance 196

Phylum Acanthocephala 196

Phylum Gnathostomulida 198

Phylum Micrognathozoa 199

11

The Nemertines 203

Introduction and General Characteristics 203

Other Features of Nemertine Biology 210

Classification 210

- Protection from Predators 210
- Reproduction and Development 210

12

The Molluscs 215

- Introduction and General Characteristics 215
- Class Polyplacophora 218
- Class Aplacophora 222
- Class Monoplacophora 222
- Class Gastropoda 224
 - The Prosobranchs 229
 - The Opisthobranchia 235
 - The Pulmonata 237
- Class Bivalvia (= Pelecypoda) 238
 - Subclass Protobranchia 239
 - The Lamellibranchs 241
 - Subclass Anomalodesmata 254
- Class Scaphopoda 255
- Class Cephalopoda 256
- Other Features of Molluscan Biology 265
 - Reproduction and Development 265
 - Circulation, Blood Pigments, and Gas Exchange 266
 - Nervous System 266
 - Digestive System 269
 - Excretory System 271

13

The Annelids 295

- Introduction 295
- Phylum Annelida 295
 - General Annelid Characteristics 295
- Class Polychaeta 297
 - Polychaete Reproduction 300
- Family Siboglinidae (formerly the Pogonophora) 304
 - General Characteristics 304
 - Siboglinid Reproduction and Development 311
- The Echiurans 312
- The Sipunculans 314
- Class Clitellata 318

- Subclass Oligochaeta 318
 - Oligochaete Reproduction 322
- Subclass Hirudinea 322
 - Leech Reproduction 325
- Other Features of Annelid Biology 325
- Digestive System 325
 - Nervous System and Sense Organs 327
 - Circulatory System 328

14

The Arthropods 341

- Introduction and General Characteristics 341
 - The Exoskeleton 342
 - The Hemocoel 342
 - Molting 343
 - Nerves and Muscles 344
 - The Circulatory System 344
 - Arthropod Visual Systems 345
 - Arthropod Reproduction 349
 - Classification and Evolutionary Relationships 349
- Subphylum Trilobitomorpha 350
 - Class Trilobita 351
- Subphylum Chelicerata 352
 - Class Merostomata 352
 - Class Arachnida 352
 - Class Pycnogonida (= Pantopoda) 357
- Subphylum Mandibulata 358
 - Class Myriapoda 358
- Superclass Hexapoda 360
 - Class Insecta 360
 - Class Crustacea 373
 - Subclass Malacostraca 374
 - Subclass Branchiopoda 379
 - Subclass Ostracoda 381
 - Subclass Copepoda 381
 - Subclass Pentastomida 382
 - Subclass Cirripedia 389
 - Crustacean Development 389
- Other Features of Arthropod Biology 392
 - Digestion 392
 - Excretion 395
 - Blood Pigments 396

15

Two Phyla of Likely Arthropod Relatives: Tardigrades and Onychophorans 421

Introduction and General Characteristics 421

Phylum Tardigrada 422

Phylum Onychophora 424

16

The Nematodes 431

Introduction and General Characteristics 431

Body Coverings and Body Cavities 432

Musculature, Internal Pressure, and Locomotion 434

Organ Systems and Behavior 436

Reproduction and Development 438

Parasitic Nematodes 438

Beneficial Nematodes 444

17

Four Phyla of Likely Nematode Relatives: Nematomorpha, Priapulida, Kinorhyncha, and Loricifera 451

Introduction 451

Phylum Nematomorpha 452

Phylum Priapulida 454

Phylum Kinorhyncha (= Echinoderida) 454

Phylum Loricifera 456

18

Three Phyla of Uncertain Affiliation: Gastrotricha, Chaetognatha, and Cyclophora 459

Introduction 459

Phylum Gastrotricha 459

Phylum Chaetognatha 461

General Characteristics and Feeding 461

Chaetognath Reproduction 463

Chaetognath Lifestyles and Behavior 463

Chaetognath Relationships 465

Phylum Cyclophora 467

19

The "Lophophorates" (Phoronids, Brachiopods, Bryozoans) and Entoprocts 473

Introduction and General Characteristics 473

Phylum Phoronida 475

Phylum Brachiopoda 476

Phylum Bryozoa (= Ectoprocta; = Polyzoa) 480

Class Phylactolaemata 482

Class Gymnolaemata 484

Class Stenolaemata 487

Other Features of "Lophophorate"

Biology 488

Reproduction 488

Digestion 490

Nervous System 490

Phylum Entoprocta (= Kamptozoa) 490

20

The Echinoderms 497

Introduction and General Characteristics 497

Class Crinoidea 500

Class Stelleroidea 503

Subclass Ophiuroidea 503

Subclass Asteroidea 505

Class Echinoidea 509

Class Holothuroidea 513

Other Features of Echinoderm

Biology 518

Reproduction and Development 518

Nervous System 520

21

The Hemichordates 529

Introduction and General Characteristics 529

Class Enteropneusta 530

Class Pterobranchia 534

22

The Xenoturbellids: Deuterostomes at Last? 537

Phylum Xenoturbellida 537

23

The Nonvertebrate Chordates 539

Introduction and General Characteristics 539

Subphylum Tunicata (= Urochordata) 540

Class Ascidiacea 540

Class Larvacea (= Appendicularia) 543

Class Thaliacea 544

Other Features of Urochordate Biology 547

Reproduction 547

Excretory and Nervous Systems 547

Subphylum Cephalochordata (= Acrania) 548

24

Invertebrate Reproduction and Development— An Overview 555

Introduction 555

Asexual Reproduction 556

Sexual Reproduction 558

Patterns of Sexuality 558

Gamete Diversity 561

Getting the Gametes Together 561

Larval Forms 567

Dispersal as a Component of the Life-History

Pattern 577

Glossary of Frequently Used Terms 587

Index 590

25

The Annelids

Introduction 295

Class Annelida 295

Class Polychaeta 297

Class Oligochaeta 297

Class Echiurida 298

Family Siboglinidae 312

General Characteristics 312

Other Features of Annelid Biology 318

Reproduction and Development 318

Nervous System 320

The Spermatozoa 314

Class Sipuncularia 314