

Contents

Preface

Macrofossils on CD-ROM

Part One General Palaeontological Concepts

1 Principles of palaeontology

1.1 Introduction	3
1.2 Occurrence of invertebrate fossils in Phanerozoic rocks	3
Hard-part preservation	3
Soft-part preservation	6
1.3 Divisions of invertebrate palaeontology	6
Taxonomy	8
The species concept	8
Nomenclature and identification of fossil species	9
Taxonomic hierarchy	10
Use of statistical methods	12
Palaeobiology	13
Palaeoecology	13
Functional morphology, growth and form	19
Stratigraphy	20
Lithostratigraphy	20
Biostratigraphy	20
Chronostratigraphy	22
Bibliography	23
Books, treatises and symposia	23
Individual papers and other references	25

2 Evolution and the fossil record

2.1 Introduction	26
2.2 Darwin, the species and natural selection	26
Inheritance and the source of variation	28
Where does variation come from?	30
Significance of alleles	32
Mutation	33
Spread of mutations through populations	34
Isolation and species formation	35
Genetic drift: gene pools	35
Molecular genetics and evolution	37
Gene regulation during development	38
2.3 Fossil record and modes of evolution	38

Microevolution	39
Allopatric speciation	40
Heterochrony	41
Testing microevolutionary patterns	41
Analysis of case histories	42
Co-evolution	43
Macroevolution	44
Species selection	44
Origins of higher taxa	45
Rates of evolution, adaptive radiations and extinction	47
2.4 Competition and its effects	49
2.5 Summary of palaeontological evolution theory	50
Bibliography	51
Books, treatises and symposia	51
Individual papers and other references	53
3 Major events in the history of life	55
3.1 Introduction	55
3.2 Prokaryotes and eukaryotes	55
3.3 Earliest metazoans	57
Ediacara fauna: two viewpoints	58
The traditional view	58
Medusoids	59
Pennatulaceans	59
Annelids	60
Fossils of unknown affinities	60
Vendozoan hypothesis	60
Small shelly fossils	61
Precambrian trace fossils	63
Causes of the Cambrian ‘explosion of life’	64
Physicochemical factors	64
Biological factors	64
Biological evidence on metazoan relationships	65
3.4 Major features of the Phanerozoic record	68
Diversification of invertebrate life	68
Changes in species diversity and habitat	69
Problematic early Palaeozoic fossils	69
Marine evolutionary faunas	71
Climatic and sea-level changes	72
Extinctions	73
Possible causes of mass extinctions	73
Earthbound mechanisms	74
Extraterrestrial mechanisms	74
Late Ordovician (Ashgillian) extinction event	75
Late Devonian (Frasnian–Famennian) extinction event	75
Late Permian extinction event	76
Late Triassic (Carnian–Norian) extinction event	76
Cretaceous–Tertiary boundary extinction	77
Bibliography	78
Books, treatises and symposia	78
Individual papers and other references	79

Part Two Invertebrate Phyla	83
4 Sponges	85
4.1 Phylum Porifera: sponges	85
4.2 Classification	87
4.3 Class Demospongea	88
Spicular demosponges	88
Sclerosponges	89
Chaetetids	90
Stromatoporoids	90
Sphinctozoans	92
4.4 Class Calcarea	93
4.5 Class Hexactinellida	94
4.6 Incertae sedis: Archaeocyatha	95
Soft parts, organization and ecology	96
Distribution and stratigraphic use	97
4.7 Geological importance of sponges	98
4.8 Sponge reefs	98
Spicular sponge reefs	98
Calcareous sponge reefs	99
Bibliography	100
Books, treatises and symposia	100
Individual papers and other references	100
5 Cnidarians	102
5.1 Introduction	102
5.2 Major characteristics and classes of Phylum Cnidaria	104
5.3 Class Hydrozoa	104
Order Hydroida	104
Order Hydrocorallina	105
5.4 Class Scyphozoa	107
5.5 Class Anthozoa	107
Subclass Ceriantipatharia	107
Subclass Octocorallia	108
Subclass Zoantharia: corals	108
Order Rugosa	109
Order Tabulata	124
Order Scleractinia	128
Coral reefs	132
Geological uses of corals	135
Corals as colonies: the limits of zoantharian evolution	137
Minor orders	138
Bibliography	139
Books, treatises and symposia	139
Individual papers and other references	140
6 Bryozoans	143
6.1 Introduction	143
6.2 Two examples of living bryozoans	143
<i>Bowerbankia</i>	143
<i>Smittina</i>	145

6.3 Classification	147
6.4 Morphology and evolution	150
6.5 Ecology and distribution	154
Shallow-water bryozoans	154
Reef-dwelling bryozoans	155
Deep-water bryozoans	156
6.6 Stratigraphical use	156
Bibliography	156
Books, treatises and symposia	156
Individual papers and other references	157
7 Brachiopods	158
7.1 Introduction	158
7.2 Morphology	158
Subphylum Rhynchonelliformea	159
Morphology of three genera	159
Preservation, study and classification of articulated brachiopods	164
Major features of brachiopod morphology	167
Endopunctuation and pseudopunctuation in shells	171
Subphylum Linguliformea	175
<i>Lingula</i>	176
Other Linguliformea	177
Subphylum Craniiformea	178
7.3 Ontogeny	179
7.4 Classification	179
7.5 Evolutionary history	183
7.6 Ecology and distribution	184
Ecology of individual species	184
Epifaunal brachiopods	185
Endofaunal brachiopods	185
Brachiopod assemblages and 'community' ecology	188
Ordovician palaeocommunities	188
Silurian palaeocommunities	188
Devonian brachiopod assemblages	191
Permian reef associations	191
Mesozoic brachiopod associations	192
7.7 Faunal provinces	192
7.8 Stratigraphical use	193
Bibliography	194
Books, treatises and symposia	194
Individual papers and other references	194
8 Molluscs	197
8.1 Fundamental organization	197
8.2 Classification	199
8.3 Some aspects of shell morphology and growth	201
Coiled shell morphology	201
Septation of the shell	203
8.4 Principal fossil groups	203
Class Bivalvia	203

<i>Cerastoderma</i>	203
Range of form and structure in bivalves	206
Classification	209
Evolutionary history	210
Functional morphology and ecology	213
Ecology and palaeoecology	219
Stratigraphical use	220
Class Rostroconchia	221
Class Gastropoda	222
Introduction and anatomy	222
Classification	224
Shell structure and morphology	224
Shell composition	226
Evolution	226
Class Cephalopoda	229
Subclass Nautiloidea	230
Subclass Ammonoidea	238
Subclass Coleoidea: dibranchiate cephalopods	251
8.5 Predation and the evolution of molluscs	255
Bibliography	256
Books, treatises and symposia	256
Individual papers and other references	257
9 Echinoderms	262
9.1 Introduction	262
9.2 Classification	262
9.3 Subphylum Echinozoa	263
Class Echinoidea	263
Morphology and life habits of three genera	263
Classification	269
Subclass Perischoechinoidea	270
Subclass Cidaroidea	273
Subclass Euechinoidea and the morphological characters of euechinoids	276
Evolution in echinoids	282
Class Holothuroidea	285
Class Edrioasteroidea	286
9.4 Subphylum Asterozoa	288
Subclass Asteroidea	288
Subclass Somasteroidea	289
Subclass Ophiuroidea	290
Starfish beds	290
9.5 Subphylum Crinozoa	291
Class Crinoidea	291
Main groups of crinoids	293
Palaeozoic crinoids	293
Mesozoic to recent crinoids: articulates	297
Ecology of crinoids	298
Formation of crinoidal limestones	300
9.6 Subphylum Blastozoa	301
Classes Diploporeta and Rhombifera: cystoids	301

Structural characteristics	301
Pore structures	301
Classification	303
Ecology	304
Class Blastoidea	304
Diversity and function of hydrospires	305
Classification and evolution of blastoids	306
Ecology and distribution of blastoids	307
9.7 Subphylum Homalozoa, otherwise calcichordates	307
9.8 Evolution	311
Earliest echinoderms and their radiations	311
Evolution of the tube feet	313
Why pentamery?	313
Convergent evolution and intermediate forms	314
Bibliography	314
Books, treatises and symposia	314
Individual papers and other references	315
10 Graptolites	318
10.1 Structure	318
Order Graptoloidea	318
<i>Saetograptus chimaera</i>	318
<i>Diplograptus leptotheca</i>	320
Order Dendroidea	320
<i>Dendrograptus</i>	320
Preservation and study of graptolites	322
Ultrastructure and chemistry of graptolite periderm	324
10.2 Classification	326
10.3 Biological affinities	329
10.4 Evolution	329
Shape of graptolite rhabdosomes	329
Proximal end in graptoloids	333
Thecal structure	335
Cladia	337
Structure of retiolitids	338
10.5 How did graptolites live?	338
Passive drifting	339
Automobility	340
Use of models in interpreting the mode of life of graptoloids	340
10.6 Faunal provinces	343
10.7 Stratigraphical use	344
Bibliography	345
Books, treatises and symposia	345
Individual papers and other references	346
11 Arthropods	348
11.1 Introduction	348
11.2 Classification and general morphology	348
Diversity of arthropod types	348
Features of arthropod organization	349

11.3 Trilobita	351
General morphology	351
<i>Acaste downingiae</i>	352
Detailed morphology of trilobites	354
Cuticle	355
Cephalon	357
Glabella	357
Cephalic sutures	357
Hypostome	359
Eyes	360
Cephalic fringes	363
Enrollment and coaptative structures	365
Thorax	366
Pygidium	367
Appendages	367
Trilobite tracks and trails	370
Walking movements in arthropods	372
Different kinds of trilobite trails	372
Life attitudes, habits and ecology	374
Ecdysis and ontogeny	377
Classification	380
Evolution	382
General pattern of evolution	382
Microevolution	383
Faunal provinces	386
Stratigraphical use	387
11.4 Phylum Chelicerata	388
Class Merostomata	388
Subclass Xiphosura	388
Subclass Eurypterida	392
11.5 Phylum Crustacea	397
Bibliography	400
Books, treatises and symposia	400
Individual papers and other references	400
12 Exceptional faunas; ichnology	406
12.1 Introduction	406
12.2 Burgess Shale fauna	409
Arthropods	410
Lobopods	412
Other invertebrates	413
Significance of the Burgess Shale faunas	415
Ecology	415
Geographical distribution	416
Diversity	416
Persistence	416
12.3 Upper Cambrian of southern Sweden	418
12.4 Hunsrückshiefer fauna	420
12.5 Mazon Creek fauna	422
12.6 Solnhofen lithographic limestone, Bavaria	424

12.7 Ichnology	426
Classification of trace fossils	426
Morphological and preservational classification	426
Behavioural classification	426
Phylogenetic classification	429
Uses of ichnology	429
Sedimentary environment	429
Stratigraphy	430
Fossil behaviour	430
Bibliography	431
Books, treatises and symposia (exceptional faunas)	431
Individual papers and other references (exceptional faunas)	431
Books, treatises and symposia (ichnology)	434
Individual papers (ichnology)	434

Systematic index	435
-------------------------	------------

General index	443
----------------------	------------