



**IN THE NAME OF ALLAH,  
MOST GRACIOUS, MOST MERCIFUL**



# MICROPALEONTOLOGY

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## PREFACE

*Micropaleontology* is designed to be a primary textbook for college courses in the marine microfossils for students in the Arab countries. This book will deal with an introductory survey of the major groups of microfossils, including calcareous, siliceous, phosphatic and organic-walled types (Foraminifera, Ostracodes, Calcareous Nannofossils, Radiolaria, and Conodonts). The skeletal anatomy, biology, mode of life, and geologic history of these benthic and planktic, marine and nonmarine organisms will be reviewed. Applications of micropaleontology to interdisciplinary research in biostratigraphy, paleoecology, paleoceanography, paleoclimatology and environmental science will be featured.

The specific goals of the *Micropaleontology* are:

- To identify the geologic range of the different fossil groups.
- To understand the general features of different group.
- To analyze the components of tests.
- To explain the basis of classification of the different fossil group.
- To identify the stratigraphic importance of the different fossil group.
- To understand the ecology and mode of life of the different group.
- To provide adequate principles for a foundation for graduate training in micropaleontology.
- To provide a sufficient base for graduates entering industry to apply micropaleontology to the solution of geologic problems.

In this book, we will deal with five major groups of microfossils that are important not only for biostratigraphy and paleoenvironments constructions, but also are applied in the hydrocarbon exploration in six chapters, each chapter followed by a series of questions that are added for the different chapters and in different styles to train the students for the micropaleontology exams. These groups of microfossils are:

- Foraminifera (small foraminifera and larger foraminifera).
- Ostracodes.
- Calcareous nannofossils.
- Radiolaria.
- Conodonts.

Chapter I gives an introduction to micropaleontology. Micropaleontology is the study of large numbers of taxonomically unrelated groups united solely by the fact that they must be examined with a microscope. Most marine microfossils are protists (unicellular plants and animals), but others are multicellular or microscopic parts of macroscopic forms. Thus, their grouping into one discipline remains essentially practical and utilitarian.

Chapter II deals with the most important group of microfossils, foraminifera which are a diverse group of protists. 220 foraminiferal families and 25,000 species have been recognized. They range in size from microforaminiferans as small as 0.02 mm to giant forms which can be 110 mm or more.

Chapter III is organized to explain larger foraminifera. Larger foraminifera are species from foraminifera that attain a large size more than 3 mm. They have complex internal morphologies. The numbers of large foraminifera include 40 families (Loeblich & Tappan, 1982). They are found both as fossils and in modern seas. The most abundant genus of larger foraminifera is Nummulites which is abundant in the limestone used by Egyptians to build the pyramids.

Chapter IV is devoted to ostracods which are the most complex organisms studied within the field of micropalaeontology. They are Metazoa and belong to the Phylum Arthropoda, Class Crustacea. They are found today in almost all aquatic environments including hot springs, caves, within the water table, semi-terrestrial environments, in both fresh and marine waters, within the water column as well as on (and in) the substrate.

Chapter V deals with calcareous nannofossils, which include the coccoliths and coccospheres of haptophyte algae and the associated nannoliths which are of unknown provenance. The organism which creates the coccosphere is called a coccolithophore, and they are phytoplankton (autotrophs that contain chloroplasts and photosynthesise).

In Chapter VI, we try to give brief information about Radiolarian and Conodonts. Radiolaria are holoplanktonic protozoa and form part of the zooplankton. Conodont elements are phosphatic tooth-like structures whose affinity and function is now believed to be part of the feeding apparatus of an extinct early vertebrate.

Chapter VII deals with the application of micropaleontology. One of the aims of micropaleontological studies is to resolve the geological history of the surface of the earth in a state that can be achieved, in relatively quick time and at the same time be economically being reasonable.

The appendixes to the book include a glossary of the scientific terms used in the book chapters. The authors would like to thank many colleagues who have contributed to the emergence of this book, even by moral support. A special word of thanks goes to Dr. Hisham Ahmed Hussein, South Valley University, Egypt. We would like also to thank Mr. Khaled Mohamed, E-learning Center, South Valley University, Egypt for his help in the modification of some figures.

#### Further Readings

**Bown, P.R. 1998.** Calcareous Nannofossil Biostratigraphy. Kluwer Academic Publishers, 314 pp.

**Haq, B., and Boersma, A. (Eds.) 1977.** Introduction to Marine Micropaleontology, Elsevier, Amsterdam, 376 pp.

**Lee, J.J & Anderson, O.R., (eds), 1991.** Biology of foraminifera. Academic Press, London.

**Lipps, J.H. (ed.) 1993.** Fossil Prokaryotes and Protists. Blackwell Scientific Publication, 342 pp.

**Loeblich, A. R. & Tappan, H., 1964.** *Part C. Protista 2. Chiefly "Thecamoebians and Foraminiferida.* In: Moore, R.C. (ED.), *Treatise on Invertebrate Paleontology.* The Geological Society of America and the University of Kansas. Lawrence Kansas, 900 pp.

**Loeblich, A. R. & Tappan, H., 1987.** *Foraminiferal genera and their Classification.* Van Nostrand Reinhold. 970 pp + 847 Pl.

**Loeblich, A. R. & Tappan, H., 1992.** Present Status of Foraminiferal classification. In: Takayanagi, Y., & Saito, T. (eds) *Studies in Benthic Foraminifera, Proceedings of the Fourth International Symposium on benthic Foraminifera, Sendai, 1990.* Tokai Univ. Press, 93-101.

**Murray, J. W., 1991.** Ecology and Paleoecology of benthic foraminifera. Longman Scientific. 397 pp.

### **Micropaleontological Journals**

1. Contributions from the Cushman Laboratory for Foraminiferal Research (1925-1950).
2. Contributions from the Cushman Laboratory for Foraminiferal Research (1951-1973).
3. Journal of Foraminiferal Research, Cushman Foundation (1973- present).
4. Journal of Micropaleontology, the Micropaleontology Society (1982- present).
5. Marine Micropaleontology, Elsevier, Netherlands (1976-present).
6. Micropaleontology, Micropaleontology Press, N.Y. (1955- present).
7. Revista Espanola de Micropaleontologia, Spain.
8. Revue de Micropaleontologie, Elsevier, Netherlands.
9. Revue de paleobiologie, Switzerland.
10. British Micropaleontology Society Special Publications (Chapman & Hall, Kluwer Acad Press).
11. Cushman Foundation Special Publications (Washington, D.C.).
12. Grzybowski Foundation Special Publications (Krakow, Poland).

### **Internet Sites Related to Micropaleontology**

- <http://www.ucl.ac.uk/GeolSci/micropal/welcome.html>
- <http://ead.univ-angers.fr/~geologie/atlas/Taxo.htm>
- <http://www.ucmp.berkeley.edu/allife/eukaryotasy.html>
- [http://www.nhm.ac.uk/hosted\\_sites/ina/](http://www.nhm.ac.uk/hosted_sites/ina/)
- <http://services.chronos.org/foramatlas/pages/home.htm>
- <http://www.ucmp.berkeley.edu/foram/foramintro.html>
- <http://www.foraminifera.eu/>
- <http://foraminifera.net/>
- <http://www.ucmp.berkeley.edu/arthropoda/crustacea/maxillopoda/ostracoda.html>
- [http://www.gaultammonite.co.uk/pages/Ostracoda/Albian\\_Ostracoda.htm](http://www.gaultammonite.co.uk/pages/Ostracoda/Albian_Ostracoda.htm)
- <http://www.ucl.ac.uk/GeolSci/micropal/ostracod.html>
- <http://www.ucl.ac.uk/GeolSci/micropal/foram.html>
- <http://www.ucl.ac.uk/GeolSci/micropal/calcnanno.html>
- <http://userpage.fu-berlin.de/~palaeont/irgo/irgohome.html>





## CONTENTS

	Page
<b>Preface</b> .....	v
<b>Chapter I: Introduction</b> .....	1
<b>Chapter II: Small Foraminifera</b> .....	7
Introduction .....	9
History of the Study.....	9
Application .....	9
Preparation Techniques.....	10
Observation Techniques .....	11
Range.....	12
Living Foraminifera.....	12
Biology .....	13
Life Cycle.....	13
Classification .....	14
Test Morphology .....	15
Taxonomy.....	21
Ecology.....	24
Distribution of Recent Foraminifera.....	27
Questions .....	30
<b>Chapter III: Larger Foraminifera</b> .....	35
Introduction .....	37
Classification .....	38
Questions .....	50
<b>Chapter IV: Ostracoda</b> .....	51
Introduction .....	53
Classification .....	55
Description of Ostracoda .....	57
Ecology.....	73
Distribution of Marine Ostracodes.....	73
Paleoecology.....	74
Questions .....	76
<b>Chapter V: Calcareous NannoFossils</b> .....	79
Introduction .....	81

## Contents

History of the Nannoplankton Research .....	82
Biology of the Organisms .....	82
Coccolith Shape Classification .....	84
Life Cycle (Reproduction, Nutrition and Growth).....	86
Mineralogy of Coccolith.....	87
Morphology of Coccolith.....	87
Function of Coccolith .....	89
Major Morphologic Groups .....	91
Ecology.....	100
Biogeography.....	100
Questions .....	101
<b>Chapter VI: Radiolaria and Conodonts.....</b>	<b>103</b>
Radiolaria.....	105
Conodont .....	109
Questions .....	113
<b>Chapter VII: Application of Micropaleontology.....</b>	<b>115</b>
Introduction .....	117
Different Microfossils Groups .....	117
Biostratigraphy .....	120
Kinds of Biostratigraphic Units .....	120
<b>References.....</b>	<b>125</b>
<b>Glossary .....</b>	<b>127</b>
<b>Subject Index.....</b>	<b>133</b>

## LIST OF FIGURES

	Page
Fig. 1. Stratigraphic distribution of the major marine microfossil groups .....	3
Fig. 2. Division of the marine environment .....	4
Fig. 3. Material necessary for dealing with Foraminifera .....	11
Fig. 4. Binocular zoom stereomicroscope .....	11
Fig. 5. Geologic time scale based on Harland <i>et al.</i> (1989) .....	12
Fig. 6. A living planktonic foraminifera .....	13
Fig. 7. Life cycle of foraminifera (simplified) .....	14
Fig. 8. Foraminiferal suborders and their envisaged phylogeny .....	14
Fig. 9. Agglutinated wall structure .....	15
Fig. 10. Examples of agglutinated wall structure .....	16
Fig. 11. Calcareous hyaline wall structure .....	16
Fig. 12. Examples of calcareous hyaline wall structure .....	16
Fig. 13. The optical axis orientation in porcelaneous test .....	17
Fig. 14. Examples of calcareous porcelaneous wall structure .....	17
Fig. 15. Chamber shape and arrangement in foraminifera .....	18
Fig. 16. Principle type of chamber arrangement .....	18
Fig. 17. Some chamber arrangements in foraminifera .....	19
Fig. 18. Principle types of aperture .....	20
Fig. 19. Some types of sculpture in foraminifera .....	20
Fig. 20. Habitats of foraminifera .....	24
Fig. 21. Depth distribution of recent benthic foraminifera .....	25
Fig. 22. Distribution of larger benthic foraminifera .....	25
Fig. 23. Zoogeographical planktonic foraminiferal provinces .....	26
Fig. 24. Trends in bathymetry and fossil content of sediments from the shelf to the abyssal environments .....	28
Fig. 25. Distribution of foraminifera from the shelf to the abyssal environments .....	29
Fig. 26. Fusulinellid wall .....	38
Fig. 27. Schwagriniid wall .....	38
Fig. 28. Types of septa .....	39
Fig. 29. Types of sections in <i>Fusulina</i> and <i>Schwagerina</i> .....	40
Fig. 30. Genus <i>Fusulina</i> .....	41
Fig. 31. Genus <i>Schwagerina</i> .....	41
Fig. 32. Family Neoschwageriniidae .....	42
Fig. 33. Wall structure in Alveolonidae .....	42
Fig. 34. Praealveolina .....	43
Fig. 35. Septa, septum in the Nummulitidae .....	43
Fig. 36. Septal filaments in Nummulitidae .....	44
Fig. 37. Granules in Nummulitidae .....	44

List of Figures

Fig. 38. Equatorial section in Nummulitidae .....	45
Fig. 39. Tight and lax spire coiling in Nummulitidae .....	45
Fig. 40. Axial section in Nummulitidae .....	45
Fig. 41. Two types of sections in Nummulitidae .....	46
Fig. 42. Shapes of the equatorial chamber in Orbitoididae .....	46
Fig. 43. Axial section of Orbitoididae .....	46
Fig. 44. Orbitoides .....	47
Fig. 45. Axial section in Orbitoides .....	47
Fig. 46. Genus: <i>Lepidocyclina</i> .....	47
Fig. 47. Axial section in <i>Lepidocyclina</i> .....	48
Fig. 48. Axial section of <i>Discocyclina</i> .....	48
Fig. 49. Type of hinges in Ostracoda .....	54
Fig. 50. Types of muscles in Ostracoda .....	55
Fig. 51. Orientation of the carapace .....	58
Fig. 52. Maximum length, height and width of ostracoda .....	59
Fig. 53. Outline of the carapace in the lateral view .....	60
Fig. 54. Outline of the carapace in the lateral view (continued) .....	60
Fig. 55. Outline of the carapace in the lateral view (continued) .....	61
Fig. 56. Outline of the carapace in the lateral view (continued) .....	61
Fig. 57. Maximum height of the carapace .....	62
Fig. 58. Maximum length of the carapace .....	62
Fig. 59. Dorsal margin .....	62
Fig. 60. Ventral margin .....	63
Fig. 61. Overhanging valves .....	63
Fig. 62. Anterior margin end of the carapace .....	63
Fig. 63. Posterior margin end .....	64
Fig. 64. Outline of the carapace in “dorsal view” .....	65
Fig. 65. Outline of the carapace in “dorsal view” (continued) .....	66
Fig. 66. Outline of the carapace in “dorsal view” (continued) .....	67
Fig. 67. Thickness of the carapace in dorsal view .....	67
Fig. 68. Outline of the carapace in “dorsal view” (continued) .....	68
Fig. 69. Types of ribs according to their development .....	69
Fig. 70. Types of ridges .....	70
Fig. 71. Types of inflation according to its position .....	71
Fig. 72. Types of inflation according to its position .....	71
Fig. 73. Shape of opening .....	72
Fig. 74. Size of opening .....	72
Fig. 75. Arrangement of opening .....	73
Fig. 76. Diagram illustrating the ecological distribution of recent ostracoda .....	75
Fig. 77. Cocosphere .....	81
Fig. 78. Living cell .....	83
Fig. 79. Component of the living cell .....	83
Fig. 80. Early stage of coccolith formation in <i>E. huxleyi</i> .....	84
Fig. 81. Shape of coccolith .....	85
Fig. 82. Shape of coccolith (continued) .....	86
Fig. 83. Coccolithophorid life cycle .....	86
Fig. 84. Mineralogy of coccolith .....	87

List of Figures

Fig. 85. Heterococcolith.....	88
Fig. 86. Holococcolith.....	88
Fig. 87. Protection-related functions of coccolith.....	89
Fig. 88. Biochemical functions of coccolith.....	90
Fig. 89. Flotation-related functions of coccolith.....	90
Fig. 90. Light regulation functions of coccolith.....	91
Fig. 91. Morphology of coccolith.....	92
Fig. 92. Morphology of Discoaster.....	92
Fig. 93. <i>Arkangelskiella</i> .....	93
Fig. 94. Genus: <i>Broinsonia</i> .....	93
Fig. 95. Genus: <i>Watznauria</i> .....	94
Fig. 96. Coccolithaceae ( <i>Cruciplacolithus</i> , <i>Chiasmolithus</i> , and <i>Coccolithus</i> ).....	94
Fig. 97. Genus: <i>Prinsius</i> .....	95
Fig. 98. Genus: <i>Toweius</i> .....	95
Fig. 99. Genus: <i>Gephyrocapsa</i> .....	95
Fig. 100. Genus: <i>Emiliana</i> .....	95
Fig. 101. <i>Pontosphaera</i> , <i>Transversopoints</i> , <i>Lophodolitus</i> , and <i>scyphosphaera</i> .....	96
Fig. 102. Genus: <i>Braarudosphaera</i> .....	96
Fig. 103. Genus: <i>Ceratolithus</i> .....	96
Fig. 104. <i>Discoaster multiradiatus</i> .....	97
Fig. 105. <i>Discoaster mirus</i> .....	97
Fig. 106. <i>Discoaster lodoensis</i> .....	97
Fig. 107. <i>Tribrachitus orthostylus</i> .....	98
Fig. 108. Genus: <i>Fasciculthus</i> .....	98
Fig. 109. <i>Heliolithus</i> .....	98
Fig. 110. <i>Sphenolithus</i> .....	98
Fig. 111. <i>Thoracosphaera</i> .....	99
Fig. 112. Genus: <i>Microrhabdulus</i> .....	99
Fig. 113. Genus: <i>Micula</i> .....	99
Fig. 114. Genus: <i>Nannoconus</i> .....	100
Fig. 115. Radiolaria (cross-sections).....	107
Fig. 116. Basic morphological features of radiolarian (nassellarian).....	107
Fig. 117. Some images of Radiolaria.....	108
Fig. 118. The morphological terminology of conodont.....	110
Fig. 119. Some images of Conodont.....	112
Fig. 120. Biosteering in a horizontal well.....	118
Fig. 121. Benthic foraminiferal species.....	118
Fig. 122. Planktonic foraminiferal species.....	119
Fig. 123. Calcareous nannofossils species.....	119
Fig. 124. Palynomorphs: <i>Oligosphaeridium</i> (left) and <i>Chlamydochorella nyei</i> (right).....	120
Fig. 125. Taxon-range zone.....	121
Fig. 126. Concurrent-range zone.....	121
Fig. 127. Interval zone.....	122
Fig. 128. Interval (highest-occurrence zone) zone.....	122
Fig. 129. Examples of lineage zones.....	123
Fig. 130. Assemblage zone.....	124
Fig. 131. Abundance zone.....	124