

Contents

Contributors	xiii	III. Lotic Habitats	30
Preface	xv	A. Brief Overview of the Geomorphology of Rivers	30
		B. Headwaters and Stony Streams	30
		C. Major Rivers of North America	33
		D. The River Continuum and Other Models	35
		E. Benthic Habitats and Assemblages in Rivers	37
		F. Planktonic Habitats and Assemblages in Rivers	40
		IV. Wetland Habitats	42
		A. Functional Importance of Algae in Wetlands	42
		B. Algal Diversity and Production in Freshwater Wetlands	43
		V. Spring Habitats	45
		A. Thermal Springs	45
		B. Acid Springs	46
		C. Karst Springs	47
		VI. Subaerial Habitats	48
		A. Soils	48
		B. Epilithic and Endolithic Habitats	49
		C. Plants and Animals	50
		D. Snow and Ice	52
		Acknowledgments	53
		Literature Cited	53
		3. Coccoid Cyanobacteria	75
		<i>Jiří Komárek and Jeffrey R. Johansen</i>	
		I. Introduction	75
		II. Morphology and Diversity	76
		A. Cellular and Colonial Morphology	76
		B. Cytology	78
		C. Cell Division and Reproduction	79
		D. Diversity and Classification	79
		III. Ecology and Distribution	80
		A. Soils and Arid Environments	80
		B. Subaerial Environments	81
		C. Aquatic Environments	81
		D. Extreme Environments	83
		E. Geographic Distribution	84
			vii
1. Introduction to the Freshwater Algae	1		
<i>Robert G. Sheath and John D. Wehr</i>			
I. Introduction	1		
II. Classification	5		
A. Key to the Taxonomic Chapters in This Book	5		
III. Groups of Freshwater Algae	7		
A. Cyanobacteria	7		
B. Red Algae	7		
C. Green Algae	8		
D. Euglenoids	8		
E. Eustigmatophyte, Raphidiophyte, and Xanthophyte Algae	8		
F. Chrysophycean Algae	8		
G. Haptophyte Algae	9		
H. Synurophyte Algae	9		
I. Diatoms	9		
J. Dinoflagellates	9		
K. Cryptomonads	10		
L. Brown Algae	10		
Literature Cited	10		
2. Habitats of Freshwater Algae	13		
<i>John D. Wehr and Robert G. Sheath</i>			
I. What are Freshwater Habitats?	13		
II. Lentic Habitats	14		
A. Major Lakes of North America	14		
B. Lakes and Ponds	17		
C. Small-Scale Lentic Habitats and Microhabitats	20		
D. Mutualistic, Commensal, and Symbiotic Habitats in Lakes	21		
E. Planktonic Habitats and Assemblages in Lakes	23		
F. Benthic Habitats and Assemblages in Lakes	25		
G. Wastewater Systems	29		

IV. Collection, Preparation, and Culture	85	IV. Collection and Preparation for Identification	268
V. Key and Description of Genera	86	V. Key to GENERA	268
A. Key	86	VI. Description of North American Genera	271
B. Descriptions of Genera	89	VII. A Guide to the Literature for Species Identification	306
VI. Guide to the Literature for Species Identification	124	Literature Cited	308
Literature Cited	124		
4. Filamentous Cyanobacteria	135	7. Nonmotile Coccoid and Colonial Green Algae	315
<i>Jiří Komárek and Jeffrey R. Johansen</i>		<i>Elliot Shubert and Georg Gärtner</i>	
I. Introduction	135	I. Introduction	315
II. Diversity and Morphology	137	II. Diversity and Morphology	316
A. Cytology and Morphology	137	III. Ecology and Distribution	319
B. Specialized Cells	138	IV. Collection and Preparation for Investigation and Identification	320
C. Reproduction	139	V. Key and Descriptions of Genera	321
III. Ecology and Distribution	139	A. Key	321
IV. Collection and Preparation for Identification	140	B. Descriptions of Genera	328
V. Key to North American Genera	140	C. Addendum	368
A. Key	140	VI. A Guide to the Literature for Species Identification	370
B. Descriptions of Genera	146	Acknowledgments	370
VI. Guide to Literature for Species Identification	226	Literature Cited	370
Literature Cited	226		
5. Red Algae	237	8. Filamentous (Nonconjugating) and Plantlike Green Algae	375
<i>Robert G. Sheath and Morgan L. Vis</i>		<i>David M. John and Fabio Rindi</i>	
I. Introduction	237	I. Introduction	375
II. Diversity and Morphology	237	II. Diversity and Morphology	376
A. Diversity	237	A. Morphology and Cell Structure	376
B. Vegetative Morphology	240	B. Reproduction	376
C. Reproduction	241	C. Classification of Green Algae	377
III. Ecology and Distribution	243	III. Ecology and Distribution	378
A. Streams and Rivers	243	A. Aquatic Habitats	378
B. Other Inland Habitats	246	B. Soil and Subaerial Habitats	379
IV. Collection and Preparation for Identification	246	IV. Collection and Preparation of Samples	380
V. Key and Descriptions of Genera	247	V. Key and Descriptions of North American Genera	381
A. Key	247	A. Key to Groups	381
B. Descriptions of Genera	248	B. Key to Genera by Group	382
VI. Guide to the Literature for Species Identification	259	C. Descriptions of Genera	386
Acknowledgments	260	VI. Guide to Literature for Species Identification	419
Literature Cited	260	Acknowledgments	421
		Literature Cited	422
6. Flagellate Green Algae	265	9. Conjugating Green Algae Including Desmids	429
<i>Takashi Nakada and Hisayoshi Nozaki</i>		<i>John D. Hall and Richard M. McCourt</i>	
I. Introduction	265		
II. Diversity and Morphology	266		
III. Ecology and Distribution	267		

I. Introduction	429	Acknowledgments	530
II. Biodiversity and Morphology	430	Literature Cited	530
A. Biodiversity	430		
B. Morphology	430		
III. Ecology and Distribution	437		
IV. Collection and Preparation for Identification	437		
V. Key to North American Genera	438		
VI. Descriptions of Genera	440		
A. Zygnematales	440		
B. Desmidiaceae	445		
VII. Guide to the Literature for Species Identification	454		
Literature Cited	454		
10. Photosynthetic Euglenoids	459		
<i>Richard E. Triemer and Bożena Zakrys</i>			
I. Introduction	459		
II. Diversity and Morphology	461		
III. Ecology and Distribution	468		
IV. Collection and Preparation for Identification	469		
V. Key to North American Genera	470		
VI. A Guide to the Literature for Species Identification	479		
Literature Cited	480		
11. Xanthophyte, Eustigmatophyte, and Raphidophyte Algae	485		
<i>Donald W. Ott, Carla K. Oldham-Ott, Nataliya Rybalka, and Thomas Friedl</i>			
I. General Introduction	485		
II. Xanthophytes	486		
A. Introduction	486		
B. Diversity and Morphology	487		
C. Ecology and Distribution	490		
III. Eustigmatophyceae	492		
A. Introduction	492		
B. Diversity and Morphology	492		
C. Ecology and Distribution	494		
IV. Keys and Descriptions of Genera of Xanthophytes and Eustigmatophytes	494		
V. Raphidophytes	526		
A. Introduction	526		
B. Diversity and Morphology	527		
C. Ecology and Distribution	527		
D. Key and Descriptions of Genera	527		
VI. Collection and Preparation for Identification	529		
VII. Guide to the Literature for Species Identification	529		
		12. Chrysophyceae and Phaeothamniophyceae	537
		<i>Kenneth H. Nicholls and Daniel E. Wujek</i>	
		I. Introduction	537
		A. History	537
		B. Characteristics	538
		C. Molecular Systematics	539
		II. Diversity and Morphology	541
		A. Diversity	541
		B. Vegetative Morphology	541
		C. Reproduction	546
		III. Ecology	554
		A. Distribution	554
		B. Habitat Characteristics	556
		IV. Collection and Preparation for Identification	561
		A. Collection	561
		B. Preparation	561
		V. Key and Descriptions of Genera	562
		A. Key to Genera	562
		B. Descriptions of Genera	566
		VI. Guide to Literature for Species Identification	577
		A. Proceedings of International Chrysophyte Symposia	577
		B. Web Sources	577
		Acknowledgments	578
		Literature Cited	578
		13. Haptophyte Algae	587
		<i>Kenneth H. Nicholls</i>	
		I. Introduction	587
		II. Diversity and Morphology	589
		III. Ecology and Distribution	591
		A. <i>Chrysochromulina</i>	591
		B. <i>Prymnesium</i>	592
		IV. Collection and Preparation for Identification	594
		V. Key and Descriptions of Genera	596
		A. Taxonomic Considerations	596
		B. Notes on the Validity of <i>Chrysochromulina asquamosa</i> Aguiar et Kugrars	597
		C. Key to Freshwater Haptophytes	598
		D. Descriptions of Genera	599
		VI. Guide to the Literature for Species Identification	601
		Acknowledgments	601
		Literature Cited	601

14. Synurophyte Algae 607*Peter A. Siver*

I. Introduction	607
II. Diversity and Morphology	608
A. General Characteristics	608
B. Scale and Bristle Anatomy	614
C. Arrangement of Scales on the Cell Surface	616
D. Cysts, Life Cycle, and Cell Division	616
E. Taxonomic and Phylogenetic Considerations	618
III. Ecology and Distribution	619
A. General Comments	619
B. Primary Habitat Requirements	623
C. Distribution Along a pH Gradient	624
D. Distribution Along a Dissolved Salt Gradient	625
E. Distribution Along a Trophic Gradient	626
F. Distribution Along a Temperature Gradient	626
G. Biogeographic Patterns	627
IV. Collection and Preparation for Identification	629
A. Collection of Samples	629
B. Preparing Samples for Observation with LM	629
C. Preparing Samples for Observation with Electron Microscopy	630
D. Storage of Samples and Preparations of Scales and Bristles	631
V. Keys to Genera and Common Species Found in North America	631
A. Introduction to Keys	631
B. Key to Genera of Synurophyceae	631
C. Key to Common Species of <i>Mallomonas</i>	631
D. Key to Common Species of <i>Synura</i> and <i>Tesselaria</i>	637
E. Diagnostic Features for Selected <i>Mallomonas</i> Species	638
F. Diagnostic Features for Selected <i>Synura</i> and <i>Tesselaria</i> Species	643
VI. A Guide to the Literature for Species Identification & Museum Collections	644
Acknowledgments	644
Literature Cited	644

15. Centric and Araphid Diatoms 653*J. Patrick Kociolek, Edward C. Theriot, David M. Williams, Matthew Julius, Eugene F. Stoermer, and John C. Kingston*

I. General Introduction to the Diatoms	653
A. Introduction	653
B. North American flora	655

II. Diversity and Morphology	656
A. Non-pennate (Centric) Diatoms	656
B. Non-raphid Pennate (Araphid) Diatoms	657
III. Ecology and Distribution	659
IV. Collection and Preparation for Identification	662
V. Key and Descriptions of Genera	662
A. Key	662
VI. Descriptions of Genera	664
A. Freshwater Centric Diatoms	664
VII. Genera	666
VIII. Freshwater Araphid Diatoms	680
A. Classification	680
B. Fragillariales	682
C. Tabellariales	689
IX. Guide to Literature for Species Identification	693
Acknowledgments	694
Literature Cited	694

16. Bacillariophyceae: The Raphid Diatoms 709*J. Patrick Kociolek, S.A. Spaulding, and R.L. Lowe*

I. Introduction	709
II. Diversity and Morphology	712
A. Eunotiales	712
B. Achnanthes	714
C. Bacillariales	715
D. Naviculales	715
III. Ecology and Distribution	719
A. General Introduction	719
B. Eunotiales	722
C. Achnanthes	723
D. Naviculales	724
E. Bacillariales, Rhopalodiales, and Surirellales	725
IV. Collection and Preparation for Identification	725
V. Keys and Description of Genera	726
A. Key to the Orders of Freshwater Raphid Diatoms	726
B. Key to the North American Genera of Eunotiales	727
C. Key to the North American Genera of Achnanthes	727
D. Key to North American Genera of Bacillariales	727
E. Key to the Genera of North American Naviculales	728
F. Key to the North American Genera of Rhopalodiales	731
G. Key to North American Genera of Surirellales	731

VI. Description of Genera	732	B. Biological Considerations	820
A. Achnanthales	733	C. Cryptomonad Endosymbionts and Pathogens	821
VII. Guide to Literature for Species Identification	736	D. Types of Nutrition—Carbon Sources	821
A. Monoraphid Diatoms	736	V. Collection, Isolation, and Culturing	822
VIII. Guide to the Literature of Species of Bacillariales, Rhopalodiales, and Surirellales	760	VI. Classification and Key	822
Literature Cited	760	A. Introduction	822
17. Dinoflagellates	773	B. General Features Useful in Determining Genera and Species	823
<i>Susan Carty and Matthew W. Parrow</i>		C. Classification of the Phylum Cryptophyta	831
I. Introduction	773	D. Key	835
II. Diversity and Morphology	776	VII. Descriptions of Genera	836
A. Anatomy	776	A. Freshwater Cryptomonad Genera and Species	836
B. Life Cycle	779	B. Guide to Literature for Species Identification	841
C. Classification	781	VIII. Availability of Cryptomonads	842
III. Ecology and Distribution	783	IX. Phylum Kathablepharida	842
A. Dinoflagellate Blooms	783	A. Ecology	843
B. Trophic States	786	B. Cell Structure	844
C. Specificity of Habitat	787	C. Classification of Kathablepharida	845
D. Geographic Distribution	787	D. Isolation and Culturing Techniques for Kathablepharids	845
IV. Collection and Preparation for Identification	790	Literature Cited	845
A. Collection	790	19. Brown Algae	851
B. Fixation	790	<i>John D. Wehr</i>	
C. Preparation for Identification	790	I. Introduction	851
V. Key to North American Genera	791	II. Diversity and Morphology	852
A. Key to the Assimilative Cell in the Life Cycle of Freshwater Dinoflagellates	791	A. Diversity and Classification	852
B. Descriptions of Genera	793	B. Morphology and Reproduction	852
VI. A Guide to the Literature for Species Identification	801	III. Ecology and Distribution	856
Literature Cited	802	A. Ecological Factors	856
18. Cryptomonads	809	B. Geographical Distribution	860
<i>Brec L. Clay</i>		IV. Methods for Collection and Identification	861
I. Introduction	809	V. Key and Description of Genera	862
II. Ultrastructure and Morphology	810	A. Key	862
A. External Cell Architecture	810	B. Description of Genera	862
B. Periplast Structure	810	VI. Guide to Literature for Species Identification	868
C. Flagella and Flagellar Apparatus	813	Acknowledgments	868
D. Ejectisomes	814	Literature Cited	868
E. Ejectosome Digestion Vesicles	814	20. Harmful Algal Blooms	873
F. Mitochondrion and Chloroplasts	814	<i>Sue B. Watson, Brian A. Whitton, Scott N. Higgins, Hans W. Paerl, Bryan W. Brooks, and John D. Wehr</i>	
G. Nucleomorphs	815	I. Introduction and Overview	873
H. Reproduction and Life Cycles	815	II. Planktonic Blooms	878
I. Nucleus and Mitosis	816	A. Prokaryotes	878
J. Contractile Vacuoles	816	B. Eukaryotes: Nonflagellates	882
K. Starch	816	C. Eukaryotes: Flagellates	883
III. Origin of Cryptomonads	818		
IV. Ecology and Distribution	819		
A. Abiotic Considerations	819		

III. Benthic HABs	887	IV. Characterizing Attributes of Algal Assemblages	929
A. Prokaryotes	888	A. Biomass	930
B. Eukaryotes	889	B. Chemical Composition	931
IV. Chemical Ecology of HABs (Semiocchemicals)	895	C. Functional Attributes	933
A. Volatile Organic Compounds (VOCs): Taste and Odour	895	D. Taxonomic Composition	933
B. Toxins	901	E. Inferring Stressor Conditions	939
V. Quantifying, Monitoring, Modeling, and Managing HABs	904	F. Measuring Biological Condition and Ecosystem Services	942
Acknowledgments	905	G. Multimetric Indices	944
Literature Cited	905	H. Testing Metrics	945
21. Use of Algae in Ecological Assessments	921	I. Bioassay	946
<i>R. Jan Stevenson and John P. Smol</i>		V. Characterizing Condition	946
I. Introduction	921	VI. Diagnosing Stressors	948
II. A Framework for Ecological Assessment	922	VII. Management Decisions	950
III. Sampling Algae in Freshwater Habitats	926	VIII. Conclusions	950
A. Sampling Design	926	Acknowledgments	952
B. Sampling Techniques	927	Literature Cited	952
		Glossary	963
		Author Index	979
		Subject Index	1015
		Taxonomic Index	1025