

# *Exploring Creation with Marine Biology*

## Table of Contents

<b>MODULE #1: The Oceans of Our Planet.....</b>	<b>1</b>
Introduction .....	1
The Geography of the Oceans .....	1
The Earth's Structure .....	2
Continental Drift and Plate Tectonics .....	3
Plate Interactions .....	7
Features of the Ocean Bottom .....	8
Properties of Water .....	10
Experiment 1.1: The Expansion of Solid Water .....	11
Seawater .....	13
Experiment 1.2: Removing the Salt From Salt Water .....	14
Salinity, Temperature, and Density .....	17
Experiment 1.3: The Effects of Salinity and Temperature on the Density of Water .....	17
Light in the Sea .....	19
Pressure .....	20
The Motion of the Ocean .....	21
Experiment 1.4: The Coriolis Effect .....	22
Waves .....	24
Experiment 1.5: The Motion of Waves .....	25
Tides .....	26
Vertical Motion .....	27
Summing Up .....	28
<b>MODULE #2: Life in the Sea .....</b>	<b>33</b>
Introduction .....	33
The Process of Life .....	33
Photosynthesis .....	34
Experiment 2.1: Photosynthesis .....	34
Respiration .....	36
Experiment 2.2: Respiration .....	37
Cells .....	38
Levels of Organization .....	40
The Challenge of Life in the Sea .....	41
Diffusion and Osmosis .....	42
Experiment 2.3: Osmosis .....	42
Temperature .....	45
Reproduction in the Sea .....	47
Asexual and Sexual Reproduction .....	47
Reproductive Strategies .....	48
Classifying Life in the Sea .....	49
Summing Up .....	51

**MODULE #3: The First Four Kingdoms ..... 55**

Introduction .....	55
Kingdom Monera .....	55
Kingdom Protista: The Unicellular Algae.....	58
Diatoms .....	58
Dinoflagellates .....	60
Experiment 3.1: Unicellular Algae.....	62
Kingdom Protista: The Marine Protozoans .....	62
Foraminiferans.....	63
Radiolarians.....	64
Ciliates.....	64
Experiment 3.2: Marine Protozoans.....	64
Kingdom Protista: The Multicellular Algae.....	65
Green Algae.....	66
Brown Algae.....	67
Red Algae.....	67
Reproduction of Multicellular Algae .....	68
Kingdom Fungi.....	71
Kingdom Plantae .....	71
The Seagrasses .....	71
Salt Water Marsh Plants.....	72
The Mangroves.....	72
Summing Up.....	73

**MODULE #4: Marine Invertebrates I..... 77**

Introduction .....	77
Phylum Porifera.....	77
Experiment 4.1: Observation of a Sponge .....	79
Phylum Cnidaria.....	82
Class Hydrozoa .....	85
Class Scyphozoa.....	86
Class Anthozoa.....	86
Phylum Ctenophora.....	87
The Bilateral Worms .....	87
Phylum Platyhelminthes.....	88
Phylum Nemertea.....	90
Phylum Nematoda.....	90
Phylum Annelida.....	90
Experiment 4.2: Locomotion in the Annelids .....	91
Class Polychaeta.....	91
Lophophorates .....	93
Summing Up.....	93

<b>MODULE #5: Marine Invertebrates II</b> .....	<b>97</b>
Introduction .....	97
Phylum Mollusca.....	97
Class Gastropoda.....	97
Class Bivalvia.....	99
Class Cephalopoda .....	100
Other Mollusk Classes .....	102
Mollusk Biology.....	103
Dissection Experiment 5.1: The Clam .....	104
Phylum Arthropoda .....	106
Class Crustacea .....	107
Crustacean Biology .....	109
Experiment 5.2: Crustacean Larvae .....	110
Other Arthropod Classes .....	111
Phylum Echinodermata .....	112
Class Asteroidea .....	114
Dissection Experiment 5.3: The Sea Star.....	114
Class Ophiuroidea .....	116
Class Echinoidea .....	117
Class Holothuroidea .....	117
Class Crinoidea .....	117
Echinoderm Biology.....	118
Phylum Chordata.....	120
Subphylum Urochordata.....	121
Subphylum Cephalochordata .....	122
Summing Up.....	124
 <b>MODULE #6: Marine Vertebrates I</b> .....	 <b>129</b>
Introduction .....	129
Class Agnatha.....	129
Class Chondrichthyes.....	131
Rays and Skates.....	134
The Bony Fishes.....	136
Experiment 6.1: Types of Fish Scales .....	136
The Biology of Fishes .....	138
Coloration in Fishes .....	140
Locomotion .....	142
Feeding and Digestion.....	142
The Circulatory System.....	144
The Gills and Respiratory System.....	144
The Nervous System in the Fishes .....	146
Dissection Experiment 6.2: The Shark.....	148
Social Behavior .....	150
Migrations .....	151
Reproduction in the Fishes.....	152
Summing Up.....	155

**MODULE #7: Marine Vertebrates II..... 159**

Introduction .....	159
Class Reptilia.....	159
Class Aves .....	163
Gulls and Similar Birds .....	164
Penguins .....	165
Shearwaters and Similar Birds .....	166
Pelicans and Similar Birds .....	167
Birds at the Shore .....	168
Class Mammalia .....	169
Order Cetacea .....	169
Order Sirenia .....	173
Order Pinnipedia .....	173
Order Carnivora.....	174
Echolocation.....	175
Movement in the Water.....	177
Experiment 7.1: What Causes the Bends? .....	178
Behavior .....	179
Mating and Reproduction.....	181
Summing Up.....	182

**MODULE #8: Marine Ecology..... 187**

Introduction .....	187
The Ecosystem .....	187
Population Growth .....	188
Predator and Prey Relationships .....	191
Symbiosis .....	192
Trophic Relationships .....	195
Primary Productivity .....	198
Experiment 8.1: Exploring Carbon Fixation .....	198
The Nitrogen and Carbon Cycles.....	202
Environmental Zones .....	204
Summing Up.....	206

<b>MODULE #9: The Intertidal Zone .....</b>	<b>211</b>
Introduction .....	211
Intertidal Communities.....	211
The Rocky Intertidal.....	212
Rocky Intertidal Abiotic Conditions .....	213
Intertidal Feeding and Reproduction.....	215
Wave Action.....	216
Surviving the Waves .....	217
Zonation of the Rocky Intertidal .....	219
The Upper Intertidal Zone.....	220
The Middle Intertidal Zone .....	221
The Lower Intertidal Zone .....	225
The Sandy and Muddy Intertidal.....	226
Experiment 9.1: Exploring Intertidal Sediments.....	228
Experiment 9.2: The Movement of Water through Sediment.....	229
Survival in the Mud.....	230
Summing Up.....	232
<b>MODULE #10: Estuary Communities.....</b>	<b>237</b>
Introduction .....	237
The Ice Age: The Most Likely Cause of Most Estuaries .....	238
Types of Estuaries .....	240
Abiotic Factors in Estuaries .....	243
Estuarine Communities .....	247
Estuarine Habitats .....	248
Wetlands.....	249
Experiment 10.1: Distribution of Mangroves in an Estuary .....	251
Mudflats .....	253
Channels.....	255
Estuary Production .....	256
Summing Up.....	256
<b>MODULE #11: Coral Reefs.....</b>	<b>261</b>
Introduction .....	261
Coral Reef Requirements and Locations.....	261
Reef Composition.....	262
Coral Reef Formation and Growth.....	264
Experiment 11.1: Examining Coral.....	267
Types of Reefs.....	269
Coral Reef Ecology .....	275
Reef Relationships.....	277
Symbiotic Relationships.....	278
Summing Up.....	280

**MODULE #12: Continental Shelf Communities ..... 285**

Introduction ..... 285  
Physical Features of the Continental Shelf ..... 285  
Soft-Bottom Shelf Communities ..... 286  
Unvegetated Soft Bottom Environments ..... 288  
Experiment 12.1: Meiofaunal Organisms ..... 289  
Vegetated Soft-Bottom Environments ..... 292  
Hard-Bottom Shelf Communities ..... 294  
Kelp Beds and Forests ..... 297  
Sea Urchins ..... 302  
Summing Up ..... 303

**MODULE #13: The Epipelagic Zone..... 307**

Introduction ..... 307  
The Epipelagic Zone ..... 307  
Life in the Epipelagic ..... 308  
Epipelagic Phytoplankton ..... 309  
Epipelagic Zooplankton ..... 311  
Experiment 13.1: Observing Live Microplankton ..... 312  
Epipelagic Nekton ..... 316  
Staying Afloat in the Epipelagic ..... 317  
Experiment 13.2: Water Drag ..... 317  
Life in the Epipelagic Zone ..... 320  
Vertical Migration ..... 322  
The Epipelagic Food Web ..... 322  
Primary Productivity ..... 325  
Nutrients and Productivity ..... 325  
El Niño ..... 328  
Summing Up ..... 329

**MODULE #14: The Deep Ocean..... 333**

Introduction ..... 333  
The Mesopelagic ..... 333  
Mesopelagic Food Webs ..... 336  
Mesopelagic Body Design ..... 338  
Experiment 14.1: Chemical “Bioluminescence” ..... 341  
Experiment 14.2: The Bioluminescence of Plankton ..... 342  
The Deep Sea ..... 343  
The Deep Sea Floor ..... 346  
Hydrothermal Vents ..... 348  
Other Vent Communities ..... 350  
Deep Sea Photosynthesis ..... 350  
Summing Up ..... 351

<b>MODULE #15: Ocean Resources</b> .....	<b>355</b>
Introduction .....	355
Food From the Sea .....	355
Food Species and Their Locations .....	356
“Experiment” 15.1: Mapping Ocean Resources .....	357
Managing Populations.....	362
Mariculture .....	365
Other Living Resources.....	368
Nonliving Ocean Resources .....	369
Summing Up.....	373
<b>MODULE #16: Effects of Humans on the Sea</b> .....	<b>377</b>
Introduction .....	377
Ocean Habitat Damage.....	377
Effects on Coral Reefs.....	378
Pollution .....	379
Sewage.....	380
Fertilizers.....	381
Oil.....	381
Synthetic Pollutants.....	383
DDT.....	383
Experiment 16.1: Biomagnification .....	385
Other Toxic Chemicals.....	387
Metals and Other Toxic Materials.....	388
Trash and Other Debris .....	389
Our Responsibility.....	389
In Summary .....	391
<b>Glossary</b> .....	<b>395</b>
<b>Appendix A</b> .....	<b>403</b>
<b>Appendix B</b> .....	<b>411</b>
<b>Appendix C</b> .....	<b>443</b>
<b>Index</b> .....	<b>449</b>