center for microbial oceanography: research and education
C·MORE SCIENCE KITS

PLANKTON

Grade Level: This kit is appropriate for students in grades 3–12.

Standards: This kit is aligned with state science and art content standards for Hawai'i, California, Massachusetts, and Oregon, as well as national Ocean Literacy Principles.

Overview: This kit explores plankton and their global importance through four lessons and an optional extension activity. Plankton are tiny plants (phytoplankton) and animals (zooplankton) that are incapable of swimming against major currents in the ocean. In Lesson 1 (40 minutes), students learn about plankton through a narrated PowerPoint presentation and investigate and identify various phytoplankton. In Lesson 2 (45 minutes), students design their own phytoplankton. In Lesson 3 (50 minutes), students investigate zooplankton with a microscope. In Lesson 4 (60 minutes), students use an educational CD and virtual microscope to explore phytoplankton, learn about environmental factors that affect phytoplankton growth and distribution, and run a computer simulation to generate phytoplankton blooms. Lessons 1, 2, and 3 are suitable for Grades 3–12, whereas Lesson 4 is geared toward Grades 6–12. Computers (not provided) are required for Lesson 4, and the students (or the teacher) must provide the supplies for the optional extension activity. Pre- and post- surveys are included.

Suggestions for Curriculum Placement: This science kit can be successfully integrated into a biology, environmental science, or marine science unit. Three key concepts are addressed: 1) the global significance of plankton in the marine food web; 2) the environmental factors that affect the growth and distribution of plankton; and 3) the identification of these mysterious critters under a microscope.

Materials: (Paper materials contained in binder are shown in **BOLD CAPS**)

Front Binder Materials

1. CD with narrated PowerPoint presentation (also contains electronic versions of binder materials)
2. C-MORE *Key Concepts in Microbial Oceanography* brochure
3. C-MORE *Microbial Oceanography: Resources For Teachers* brochure

Lesson 1: Introduction to Plankton

Materials are provided for 5 groups. We suggest 4–6 students per group.

4. **TEACHER GUIDE – Lesson 1: Introduction to Plankton**
5. **PLANKTON SURVEY – Lessons 1, 2, and 3: Version 1** (geared towards elementary school standards)
6. **TEACHER ANSWER KEY to PLANKTON SURVEY – Lessons 1, 2, and 3: Version 1**
7. **PLANKTON SURVEY – Lessons 1, 2, and 3: Version 2** (geared towards middle school standards)
8. **TEACHER ANSWER KEY to PLANKTON SURVEY – Lessons 1, 2, and 3: Version 2**
9. **POWERPOINT SCRIPT**
10. **STUDENT WORKSHEET – POWERPOINT – Lesson 1: Introduction to Plankton**
11. **TEACHER ANSWER KEY to STUDENT WORKSHEET – POWERPOINT – Lesson 1: Introduction to Plankton**
12. **STUDENT WORKSHEET – Lesson 1: Phytoplankton Microscopy Lab**
13. **SLIDES – Lesson 1: Phytoplankton Microscopy Lab** (5 in Inner Box)
14. **ANSWER KEY – Lesson 1: Phytoplankton Microscopy Lab**
15. **PHYTOPLANKTON ID GUIDE – Lesson 1: Phytoplankton Microscopy Lab** (10 in Inner Box)
16. *The Invisible ABCs* reference book (elementary school level)
17. Sea Soup reference books (middle to high school level)
    - *Sea Soup Phytoplankton, Sea Soup Zooplankton,* and *Sea Soup Teacher's Guide*
18. Giant Microbes (5)
    - Krill, Red Tide, Sea Sparkle, Algae, T4 Virus

Lesson 2: Design Your Own Phytoplankton

Materials are provided for 5 groups. We suggest 4–6 students per group.

19. **TEACHER GUIDE – Lesson 2: Design Your Own Phytoplankton**
20. **GRADING SHEETS – Lesson 2: Design Your Own Phytoplankton**
21. Black construction paper
22. Oil pastels (5 packs)

Lesson 3: Zooplankton Microscopy Lab

Materials are provided for 5 groups. We suggest 4–6 students per group.

23. **TEACHER GUIDE – Lesson 3: Zooplankton Microscopy Lab**
24. **MATERIALS PHOTO GUIDE – Lesson 3: Zooplankton Microscopy Lab**
25. **STUDENT WORKSHEET – Lesson 3: Zooplankton Microscopy Lab**
26. **ZOOPLANKTON ID GUIDE (Drifting Along) – Lesson 3: Zooplankton Microscopy Lab** (5 in Inner Box)
27. Plankton net with attached line
28. Plastic bottle to transport plankton to the classroom (1)
29. Squeeze bottle to rinse sample from net (1)
30. Plankton sieve (1)
31. Plastic beakers (5)
32. Plastic droppers (5)
33. Petri dishes (5)
34. Dissecting needles: straight (2) and curved (1)
35. Motic digital dissecting microscope (1) and cords (2) for microscope set-up
36. ThinkPad computer and power cord
37. Motic Images Plus CD
38. Motic Live Imaging Module: Quick Start Guide
39. Motic Instruction Manual SMZ-143
40. Extra microscope parts
    - Black and white stage plate
    - Calibration slide
    - Spare microscope bulb

Lesson 4: Phytopia

41. **TEACHER GUIDE – Lesson 4: Phytopia**
42. **PLANKTON SURVEY – Lesson 4**
43. **TEACHER ANSWER KEY to PLANKTON SURVEY – Lesson 4**
44. **STUDENT WORKSHEET – Lesson 4a: Introduction to Phyto Files**
45. **TEACHER ANSWER KEY to STUDENT WORKSHEET – Lesson 4a: Introduction to Phyto Files**
46. **STUDENT WORKSHEET – Lesson 4b: Phytoplankton in the Water Column**
47. **TEACHER ANSWER KEY to STUDENT WORKSHEET– Lesson 4b: Phytoplankton in the Water Column**
48. **STUDENT WORKSHEET – Lesson 4c: Can You Make a Bloom?**
49. **TEACHER ANSWER KEY to STUDENT WORKSHEET– Lesson 4c: Can You Make a Bloom?**
50. *Phytopia: Discovery of the Marine Ecosystem* CD-ROM (20)
51. Headphones (30)
52. Headphone adapters (15)

Extension: Build your own plankton net

Materials are not provided for the extension activity, but they are common household items.

53. **TEACHER GUIDE – Extension: Let's Build a Plankton Net**
54. **STUDENT INSTRUCTIONS – Extension: Let's Build a Plankton Net**
55. Example of a handmade plankton net

Other Materials:

56. **GLOSSARY**
57. **TEACHER EVALUATION**
58. **SUPPLY CHECKLIST**
59. Speakers

Materials Not Included in this Kit:

60. Projector
61. Student computers with CD-ROM drive
62. Materials for the extension activity (see Extension Tab)

State Standards for Hawai'i, California, Massachusetts and Oregon. The following science and art standards and benchmarks can be addressed through this C-MORE science kit:

Hawai'i Content & Performance Standards (HCPS III):

Science Standard 3: Life and Environmental Sciences: ORGANISMS AND THE ENVIRONMENT: Understand the unity, diversity, and interrelationships of organisms, including their relationship to cycles of matter and energy in the environment.

Grades 3–8 Benchmarks for Science:

SC.4.3.1 Explain how simple food chains and food webs can be traced back to plants.
SC.4.3.2 Describe how an organism's behavior is determined by its environment.
SC.5.3.1 Describe the cycle of energy among producers, consumers, and decomposers.
SC.5.3.2 Describe the interdependent relationships among producers, consumers, and decomposers in an ecosystem in terms of the cycles of matter.
SC.6.3.1 Describe how matter and energy are transferred within and among living systems and their physical environment.
SC.7.3.1 Explain how energy moves through food webs, including the roles of photosynthesis and cellular respiration.
SC.7.3.2 Explain the interaction and dependence of organisms on one another.
SC.7.3.3 Explain how biotic and abiotic factors affect the carrying capacity and sustainability of an ecosystem.
SC.7.5.4 Analyze how organisms' body structures contribute to their ability to survive and reproduce.

Grades 9–12 Benchmarks for Science:

SC.BS.3.1 Describe biogeochemical cycles within ecosystems.
SC.BS.3.2 Explain the chemical reactions that occur in photosynthesis and cellular respiration that result in cycling of energy.
SC.BS.3.3 Explain how matter and energy flow through living systems and the physical environment.

Fine Arts Standard 1: VISUAL ARTS: Understand and apply art materials, techniques, and processes in the creation of works of art and understand how the visual arts communicate a variety of ideas, feelings, and experiences.

Grades 3–8 Benchmarks for Visual Arts:

FA.3.1.3 Use observational skills in creating an original work of art.
FA.4.1.4 Use properties, personal response, and research to make informed judgments about artwork.
FA.5.1.1 Use the principles of art and design, including unity and harmony, in works of art.
FA.5.1.4 Explain how an original artwork demonstrates a concept or idea from another discipline.
FA.6–8.1.2 Apply selected elements and principles of art and design to communicate a particular message or opinion in an original work of art.

Content Standards for California Public Schools:

Physical Sciences

Grade 3 – Standard 1a. Students know energy comes from the Sun to Earth in the form of light.
Grade 3 – Standard 1d. Students know energy can be carried from one place to another by waves, such as water waves and sound waves, by electric current, and by moving objects.

Life Sciences

Grade 3 – Standard 3a. Students know plants and animals have structures that serve different functions in growth, survival, and reproduction.
Grade 3 – Standard 3d. Students know when the environment changes, some plants and animals survive and reproduce; others die or move to new locations.
Grade 4 – Standard 2a. Students know plants are the primary source of matter and energy entering most food chains.
Grade 4 – Standard 2b. Students know producers and consumers (herbivores, carnivores, omnivores, and decomposers) are related in food chains and food webs and may compete with each other for resources in an ecosystem.
Grade 4 – Standard 3b. Students know that in any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all.
Grade 5 – Standard 2f. Students know plants use carbon dioxide (CO_2) and energy from sunlight to build molecules of sugar and release oxygen.

Investigation and Experimentation

Grade 3 – Standard 4e. Collect data in an investigation and analyze those data to develop a logical conclusion.
Grade 4 – Standard 6c. Formulate and justify predictions based on cause-and-effect relationships.
Grade 4 – Standard 6d. Conduct multiple trials to test a prediction and draw conclusions about the relationships between predictions and results.
Grade 5 – Standard 6a. Classify objects (e.g., rocks, plants, leaves) in accordance with appropriate criteria.
Grade 5 – Standard 6e. Identify a single independent variable in a scientific investigation and explain how this variable can be used to collect information to answer a question about the results of the experiment.
Grade 6 – Standard 7b. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.
Grade 7 – Standard 7a. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

Earth Sciences

Grade 6 – Standard 3a. Students know energy can be carried from one place to another by heat flow or by waves, including water, light and sound waves, or by moving objects.
Grade 6 – Standard 5a. Students know energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis and then from organism to organism through food webs.
Grade 6 – Standard 5b. Students know matter is transferred over time from one organism to others in the food web and between organisms and the physical environment.
Grade 6 – Standard 5c. Students know populations of organisms can be categorized by the functions they serve in an ecosystem.
Grade 6 – Standard 5e. Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.
Grades 9–12 – Standard 5d. Students know properties of ocean water, such as temperature and salinity, can be used to explain the layered structure of the oceans, the generation of horizontal and vertical ocean currents, and the geographic distribution of marine organisms.

Physics

Grades 9–12 – Standard 4a. Students know waves carry energy from one place to another.

Biology/Life Sciences

Grades 9–12 – Standard 6b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of non-native species, or changes in population size.
Grades 9–12 – Standard 6e. Students know a vital part of an ecosystem is the stability of its producers and decomposers.

Visual Arts

Standard 1. Students perceive and respond to works of art, objects in nature, events, and the environment. They also use the vocabulary of the visual arts to express their observations.
Grade 5 – Standard 1.3. Use their knowledge of all the elements of art to describe similarities and differences in works of art and in the environment.

Standard 2. Students apply artistic processes and skills, using a variety of media to communicate meaning and intent in original works of art.
Grade 3 – Standard 2.1. Explore ideas for art in a personal sketchbook.
Grade 4 – Standard 2.1. Use shading (value) to transform a two-dimensional shape into what appears to be a three-dimensional form (e.g., circle to sphere).
Grade 4 – Standard 2.5. Use accurate proportions to create an expressive portrait or a figure drawing or painting.
Grade 4 – Standard 2.7. Use contrast (light and dark) expressively in an original work of art.
Grade 4 – Standard 2.8. Use complementary colors in an original composition to show contrast and emphasis.
Grade 5 – Standard 2.4. Create an expressive abstract composition based on real objects.
Grade 5 – Standard 2.7. Communicate values, opinions, or personal insights through an original work of art.

State of Massachusetts Curriculum Frameworks:

Life Sciences (Biology)

Adaptations of Living Things
Grades 3–5 – Standard 8. Describe how organisms meet some of their needs in an environment by using behaviors (patterns of activities) in response to information (stimuli) received from the environment. Recognize that some animal behaviors are instinctive (e.g., turtles burying their eggs), and other are learned (e.g., humans building fires for warmth, chimpanzees learning how to use tools).
Grades 3–5 – Standard 11. Describe how energy derived from the sun is used by plants to produce sugars (photosynthesis) and is transferred within a food chain from plants (producers) to consumers to decomposers.

Living Things and Their Environment
Grades 6–8 – Standard 13. Give examples of ways in which organisms interact and have different functions within an ecosystem that enable the ecosystem to survive.

Energy and Living Things
Grades 6–8 – Standard 16. Recognize that producers (plants that contain chlorophyll) use the energy from the sunlight to make sugars from carbon dioxide and water through a process called photosynthesis. This food can be used immediately, stored for later use, or used by other organisms.

Visual Arts

Grades 3–4 – Standard 1.1. Use a variety of materials and media, for example, crayons, chalk, paint, clay, various kinds of papers, textiles, and yarns, and understand how to use them to produce different visual effects.
Grades 3–4 – Standard 1.3. Learn and use the appropriate vocabulary related to methods, materials, and techniques.
Grades 3–4 – Standard 1.4. Learn to take care of materials and tools and to use them safely.
Grades 3–4 – Standard 1.9. Demonstrate the ability to create 2D and 3D works that show knowledge of unique characteristics of particular media, materials, and tools.
Grades 3–4 – Standard 2.4. For shape and form, explore the use of shapes and forms in 2D and 3D works.
Grades 3–4 – Standard 3.1. Create 2D and 3D artwork from direct observation.
Grades 3–4 – Standard 3.3. Create 2D and 3D artwork from memory or imagination to tell a story or embody an idea or fantasy.
Grades 3–4 – Standard 4.1. Select a work or works created during the year and discuss them with a parent, classmate, or teacher, explaining how the work was made, and why it was chosen for discussion.
Grades 3–4 – Standard 5.3. Describe similarities and differences in works, and present personal responses to the subject matter, materials, techniques, and use of design elements in artworks.
Grades 3–4 – Standard 5.4. Explain strengths and weaknesses in their own work, and share comments constructively and supportively within the group.

State of Oregon Standards by Design:

Engineering Design

3.4D.3 Give examples of inventions that enable scientists to observe things that are too small or too far away.

4.4D.2 Design, construct, and test a prototype of a possible solution to a problem using appropriate tools, materials, and resources.

Interaction and Change

4.2L.1 Describe the interactions of organisms and the environment where they live.

5.2L.1 Explain the interdependence of plants, animals, and environment, and how adaptation influences survival.

6.2L.2 Explain how individual organisms and populations in an ecosystem interact and how changes in populations are related to resources.

7.2L.2 Explain the processes by which plants and animals obtain energy and materials for growth and metabolism.

H.2L.2 Explain how ecosystems change in response to disturbances and interactions. Analyze the relationships among biotic and abiotic factors in ecosystems.

Scientific Inquiry

H.3S.3 Analyze data and identify uncertainties. Draw a valid conclusion, explain how it is supported by the evidence, and communicate the findings of a scientific investigation.

Arts

Create, present, and perform works of art.

AR.03.CP.01 Use experiences, imaginations, essential elements and organizational principles to achieve a desired effect when creating, presenting, and/or performing works of art.

AR.05.CP.01 Use experiences, imaginations, observations, essential elements and organizational principles to achieve a desired effect when creating, presenting, and/or performing works of art.

AR.08.CP.01 Select and combine essential elements and organizational principles to achieve a desired effect when creating, presenting, and/or performing works of art.

AR.CM.01 Select and combine essential elements and organizational principles to achieve a desired effect when creating, presenting, and/or performing works of art for a variety of purposes.

Apply the use of ideas, techniques, and problem solving to the creative process and analyze the influence that choices have on the result.

AR.03.CP.02 Explore aspects of the creative process and the effect of different choices on one's work.

AR.05.CP.02 Identify the creative process used, and the choices made, when combining ideas, techniques and problem solving to produce one's work.

AR.08.CP.02 Describe the creative process used, and the effects of the choices made, when combining ideas, techniques, and problem solving to produce one's work.

AR.CM.CP.02 Explain the choices made in the creative process when combining ideas, techniques, and problem solving to produce one's work, and identify the impact that different choices might have made.

Express ideas, moods, and feelings through the arts and evaluate how well a work of art expresses one's intent.

AR.03.CP.03 Create, present, and/or perform a work of art that demonstrates an idea, mood, or feeling.

AR.05.CP.03 Create, present, and/or perform a work of art and explain how the use of essential elements and organizational principles shapes an idea, mood, or feeling found in the work.

AR.08.CP.03 Create, present, and/or perform a work of art by controlling essential elements and organizational principles to express an intended idea, mood, or feeling.

AR.CM.CP.03 Create, present, and/or perform a work of art by controlling essential elements and organizational principles and describe how well the work expresses an intended idea, mood, or feeling.

Ocean Literacy Principles. The following ocean literacy principles can be addressed through these lessons:

Ocean Literacy Principle 1: The Earth has one big ocean with many features.

c. Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of the Earth's rotation (Coriolis effect), the Sun, and water density differences. The shape of ocean basins and adjacent land masses influence the path of circulation.

Ocean Literacy Principle 3: The ocean is a major influence on weather and climate.

e. The ocean dominates the Earth's carbon cycle. Half the primary productivity on Earth takes place in the sunlit layers of the ocean and the ocean absorbs roughly half of all carbon dioxide added to the atmosphere.

Ocean Literacy Principle 5: The ocean supports a great diversity of life and ecosystems.

a. Ocean life ranges in size from the smallest virus to the largest animal that has lived on Earth, the blue whale.
b. Most life in the ocean exists as microbes. Microbes are the most important primary producers in the ocean. Not only are they the most abundant life form in the ocean, they have extremely fast growth rates and life cycles.
d. Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.
f. Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy". Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.

References:

Phytopia: Discovery of the Marine Ecosystem (2003) Bigelow Laboratory for Ocean Sciences, University of New England and NASA's Jet Propulsion Laboratory

Phytopia: Classroom Ideas http://www.bigelow.org/phytopia/ideas.html

- Introduction to Phyto Files by Susan Richman, Phytoplankton in the Water Column, and Can You Make a Bloom

Sheean T. Haley and Sonya T. Dyhrman (2009) The Artistic Oceanographer Program—Enhancing ocean science literacy through multidisciplinary learning. *Science and Children*, **46**: 31–35

Phytoplankton Monitoring Network (PMN) http://www.chbr.noaa.gov/pmn/

Credits:

Lesson 2 is based on the Artistic Oceanographer Program created by Sheean Haley and Sonya Dyhrman of Woods Hole Oceanographic Institution http://www.whoi.edu/sbl/liteSite.do?litesiteid=6692&articleId=10031

Lesson 4a was developed by Susan Richman, South Portland High School, Maine. Lessons 4b and 4c were created by Phytopia. These lessons are available at http://www.bigelow.org/phytopia/ideas.html, and have been reformatted and slightly modified by C-MORE for this science kit.

We are grateful to the feedback received from teachers nationwide, which resulted in significant improvements to this Science Kit. In particular, Scott LaChance of Kapolei Middle School, Hawai'i helped revise the plankton survey for lessons 1-3 and developed the PowerPoint worksheet.

TEACHER GUIDE

Lesson 1: Introduction to Plankton

Time Required: 40 minutes. Advance preparation requires an additional 15 minutes.

Structure: In this lesson, students first develop the requisite background knowledge on plankton through a short PowerPoint presentation (10 minutes). Students then investigate and identify various phytoplankton using images that were previously taken with a compound microscope (25 minutes). We recommend students work in small groups. Materials are provided for five groups. A combined pre- and post- survey for Lessons 1, 2, and 3 is included. The pre-survey is given at the beginning of Lesson 1 (5 minutes) and the post-survey is given at the end of Lesson 3.

Materials: (Paper materials contained in binder are shown in **BOLD CAPS**)
Materials are provided for 5 groups. We suggest 4–6 students per group.

1. CD with narrated PowerPoint Presentation
2. Speakers
3. **PLANKTON SURVEY – Lessons 1, 2, and 3: Version 1** (geared towards elementary school standards)
4. **TEACHER ANSWER KEY to PLANKTON SURVEY – Lessons 1, 2, and 3: Version 1**
5. **PLANKTON SURVEY – Lessons 1, 2, and 3: Version 2** (geared towards middle school standards)
6. **TEACHER ANSWER KEY to PLANKTON SURVEY – Lessons 1, 2, and 3: Version 2**
7. **POWERPOINT SCRIPT**
8. **STUDENT WORKSHEET – POWERPOINT – Lesson 1: Introduction to Plankton**
9. **TEACHER ANSWER KEY to STUDENT WORKSHEET – POWERPOINT – Lesson 1: Introduction to Plankton**
10. **STUDENT WORKSHEET – Lesson 1: Phytoplankton Microscopy Lab**
11. **SLIDES – Lesson 1: Phytoplankton Microscopy Lab** (5 in Inner Box)
12. **ANSWER KEY – Lesson 1: Phytoplankton Microscopy Lab**
13. **PHYTOPLANKTON ID GUIDE – Lesson 1: Phytoplankton Microscopy Lab** (10 in Inner Box)
14. **GLOSSARY**
15. *The Invisible ABCs* reference book (elementary school level)
16. Sea Soup reference books (middle to high school level)
    - *Sea Soup Phytoplankton, Sea Soup Zooplankton,* and *Sea Soup Teacher's Guide*
17. Giant Microbes (5)
    - Krill, Red Tide, Sea Sparkle, Algae, and T4 Virus

Materials <u>Not</u> Included in this Kit but Needed for Lesson 1:

18. Projector

Advance Preparation:

1. A short (10 minute), narrated PowerPoint entitled *Introduction to Plankton* can be found on the CD located in the binder. This PowerPoint presentation is preloaded on the computer in the microscope box. If you prefer to use your own computer, load the PowerPoint presentation by dragging the file from the CD onto the computer desktop. Eject the CD and return it to the binder.

2. Speakers are included in the kit for playing the narrated presentation. Refer to the laminated manual attached to the speaker storage case for set-up instructions.

3. If you prefer to present the information yourself, load the non-narrated version of the PowerPoint presentation. A **POWERPOINT SCRIPT** is included as a guide.

4. Photocopy or print the **PLANKTON SURVEY – Lessons 1, 2, and 3** version that is appropriate for your students (one per student). This is given as a pre-survey at the beginning of this lesson. It will also be given as a post-survey at the end of Lesson 3.

5. A **GLOSSARY** is provided for Lesson 3, but may also be helpful for Lesson 1. Photocopy or print the **GLOSSARY** (one per student) if desired.

Instructional Procedures:

1. Pass out the **PLANKTON SURVEY – Lessons 1, 2, and 3** (one per student). Have students check the pre-survey box and answer the questions (allow 5 minutes). After Lesson 3 is completed, the students will answer these same questions as a post-survey. A **TEACHER ANSWER KEY** is provided for your convenience.

2. Distribute a **STUDENT WORKSHEET – PowerPoint – Lesson 1: Introduction to Plankton** to each student. Play the narrated PowerPoint presentation to familiarize your students with marine plankton.

3. Review the main topics of the PowerPoint presentation with your students: phytoplankton are plant-like and have certain adaptations for survival; zooplankton are animal-like and can exist as meroplankton or holoplankton; and plankton form the basis of the marine food web. Go over the answers to the student worksheet.

4. Distribute a **STUDENT WORKSHEET – Lesson 1: Phytoplankton Microscopy Lab** to each student.

5. Divide the students into five groups. Distribute one copy of **SLIDES – Lesson 1: Phytoplankton Microscopy Lab** and two copies of **PHYTOPLANKTON ID GUIDE – Lesson 1: Phytoplankton Microscopy Lab** to each group.

6. Tell your students that they will be completing a phytoplankton microscopy lab. Explain that the **SLIDES – Lesson 1: Phytoplankton Microscopy Lab** are phytoplankton images that were taken with a compound microscope. Compound microscopes have very high magnification, which is essential to view these tiny phytoplankton. In Lesson 2, dissecting microscopes (which have lower magnification) suffice to study the larger zooplankton. After a quick introduction to the phytoplankton lab, students should be able to work independently in their groups.

7. Have students use the **PHYTOPLANKTON ID GUIDE – Lesson 1: Phytoplankton Microscopy Lab** to identify the marine phytoplankton that are found on the various photomicrographs (microscope images) provided in the **SLIDES – Lesson 1: Phytoplankton Microscopy Lab**.

8. Have the students draw the phytoplankton on their **STUDENT WORKSHEET – Lesson 1: Phytoplankton Microscopy Lab**.

9. When students are finished, have them check their answers using the **ANSWER KEY – Lesson 1: Phytoplankton Microscopy Lab**. (*Note: For each slide, only one of each type of phytoplankton is identified on the answer key.)*

10. Encourage the students to check out the Giant Microbe plush toys and the reference books when they are finished with the lab. Mention that the size of the plush toys is much larger than actual size. The tag on each plush toy gives its magnification.

Assessment and Clean-up:

1. Have students return the **SLIDES – Lesson 1: Phytoplankton Microscopy Lab** and the **PHYTOPLANKTON ID GUIDE – Lesson 1: Phytoplankton Microscopy Lab**.

2. Disconnect the speakers and place them back into the science kit container.

3. Eject the CD with the PowerPoint presentation (if you have not already), and put it back into the binder.

4. If you plan to complete additional lessons from this kit, please do not have students complete the post-survey (this will be done after Lesson 3) and do not complete the **TEACHER EVALUATION** at this time.

5. If you are not completing additional lessons:
    - Please have students complete the post-survey (you will need to make one additional photocopy per student). As the students are completing the post-survey, we would be grateful if you would complete the **TEACHER EVALUATION** of this kit. All comments, corrections, and suggestions are very welcome. If you prefer, you can complete the evaluation online (see **TEACHER EVALUATION** for website address).
    - Re-pack the kit. Double check that all the items are included and in their proper place by completing the **SUPPLY CHECKLIST**. Please make a note of missing, broken, or damaged items so that they can be replaced. Please pack the kit so that the materials are stored as they were when you received them.

Mahalo!

PLANKTON SURVEY – LESSONS 1, 2, and 3
VERSION 1

Name:_____

Check one:

_____ Pre-survey

_____ Post-survey

Period: _____

Directions:

This survey is both a pre- and post- survey. Put a check mark at the top of this paper next to the survey you are doing (pre- or post- survey). Please answer each question to the best of your ability. Circle the most correct answer.

1. All _____ are animals.
   a. phytoplankton
   b. algae
   c. diatoms
   d. zooplankton

2. These organisms make food from sunlight and are the base of the ocean food web.
   a. crustaceans
   b. copepods
   c. phytoplankton
   d. zooplankton

3. Which of the following spend only part of their life cycles as plankton?
   a. holoplankton
   b. meroplankton
   c. phytoplankton
   d. zooplankton

4. Phytoplankton produce about _____ of the oxygen that you breathe every day.
   a. 5%
   b. 10%
   c. 20%
   d. 50%

5. Plankton can swim against major currents.
   a. True
   b. False

6. Animals in the ocean could survive without plankton.
   a. True
   b. False

7. Scientists collect plankton using _____.
   a. spear guns
   b. nets
   c. hooks
   d. harpoons

8. Which adaptation do phytoplankton have to survive in the ocean?
    a. spines
    b. teeth
    c. fins
    d. claws

9. Which of the following shows a simple ocean food chain?
    a. sun → diatoms → copepods → fish → whales
    b. sun → copepods → fish →diatoms → whales
    c. sun → fish → diatoms → copepods → whales
    d. diatoms → sun → fish → whales → copepods

10. Which of the following reduces greenhouse gas in the atmosphere?
    a. dolphins
    b. copepods
    c. zooplankton
    d. phytoplankton

TEACHER ANSWER KEY
PLANKTON SURVEY – LESSONS 1, 2, and 3
VERSION 1

Elementary

Check one:
_____ Pre-survey
_____ Post-survey

Email kits@soest.hawaii.edu to request a completed teacher answer key. Please include name, school and grade(s) taught in your request. Mahalo!

Name:_____

Period: _____

Directions:
This survey is both a pre- and post- survey. Put a check mark at the top of this paper next to the survey you are doing (pre- or post- survey). Please answer each question to the best of your ability. Circle the most correct answer.

1. All _____ are animals. (4.3.2)
   a. phytoplankton
   b. algae
   c. diatoms
   d. zooplankton

2. These organisms make food from sunlight and are the base of the ocean food web. (4.3.1, 5.3.1, 7.3.1, SC.BS. 3.1, 3.2)
   a. crustaceans
   b. copepods
   c. phytoplankton
   d. zooplankton

3. Which of the following spend only part of their life cycles as plankton? (4.3.2)
   a. holoplankton
   b. meroplankton
   c. phytoplankton
   d. zooplankton

4. Phytoplankton produce about _____ of the oxygen that you breathe every day. (4.3.2, 4.2.1)
   a. 5%
   b. 10%
   c. 20%
   d. 50%

5. Plankton can swim against major currents. (4.3.2)
   a. True
   b. False

6. Animals in the ocean could survive without plankton. (4.3.1)
   a. True
   b. False

7. Scientists collect plankton using _____. (4.2.1)
   a. spear guns
   b. nets
   c. hooks
   d. harpoons

8. Which adaptation do phytoplankton have to survive in the ocean? (4.2.1)
    a. spines
    b. teeth
    c. fins
    d. claws

9. Which of the following shows a simple ocean food chain? (SC. 4.3.1, 7.3.2, SC.BS. 3.3)
    a. sun → diatoms → copepods → fish → whales
    b. sun → copepods → fish →diatoms → whales
    c. sun → fish → diatoms → copepods → whales
    d. diatoms → sun → fish → whales → copepods

10. Which of the following reduces greenhouse gas in the atmosphere? (SC.BS. 3.1, 4.3.2)
    a. dolphins
    b. copepods
    c. zooplankton
    d. phytoplankton

Key to notation:
Hawai'i Content and Performance Standards
The relevant benchmarks for each question are shown in red in parentheses, and refer to *Hawai'i Content and Performance Standards* Version III.

PLANKTON SURVEY – LESSONS 1, 2, and 3
VERSION 2

Name:_____

Check one:

_____ Pre-survey

_____ Post-survey

Period: _____

Directions:

This survey is both a pre- and post- survey. Put a check mark at the top of this paper next to the survey you are doing (pre- or post- survey). Please answer each question to the best of your ability. Circle the most correct answer.

1. What is the general term for animals that drift in the ocean?
   a. copepods
   b. holoplankton
   c. meroplankton
   d. zooplankton

2. These organisms photosynthesize and form the base of the ocean food web.
   a. crustaceans
   b. copepods
   c. phytoplankton
   d. zooplankton

3. Which of the following adaptations would not help phytoplankton float in the photic (light) zone?
   a. chlorophyll
   b. spines
   c. forming chains of cells
   d. flagella (hair-like tails)

4. Animals in the ocean could survive without plankton.
   a. True
   b. False

5. Which of the following shows energy flow through a simple ocean food chain?
   a. sun → diatoms → copepods → fish → whales
   b. sun → copepods → fish →diatoms → whales
   c. sun → fish → diatoms → copepods → whales
   d. diatoms → sun → fish → whales → copepods

6. Which of the following reduces greenhouse gas in the atmosphere?
   a. meroplankton
   b. copepods
   c. zooplankton
   d. diatoms

7. Which best defines the difference between holoplankton and meroplankton?
   a. Meroplankton photosynthesize. Holoplankton don't.
   b. Meroplankton are smaller and more abundant than holoplankton.
   c. Meroplankton are only plankton when they are young. Holoplankton are always plankton.
   d. Meroplankton stay near the lit ocean surface. Holoplankton are found throughout the ocean.

8. Which best describes why plankton are important to people?
    a. Plankton create much of the oxygen that humans breathe.
    b. Plankton support all the marine organisms that humans eat.
    c. Plankton are a potential source of medicine.
    d. all of the above

9. Human activities can increase CO_2 in the ocean, and this increased CO_2 can be harmful to marine organisms. Which of the following may help decrease CO_2 in the ocean?
    a. phytoplankton blooms
    b. zooplankton migration
    c. meroplankton
    d. holoplankton

10. If you were a scientist who studied phytoplankton, which tool would <u>not</u> help you study these organisms?
    a. a satellite photo
    b. a stethoscope
    c. a plankton net
    d. a microscope

11. If copepods disappeared, which would most likely increase?
    a. fish
    b. diatoms
    c. humpback whales
    d. cnidarians

TEACHER ANSWER KEY
PLANKTON SURVEY – LESSONS 1, 2, and 3
VERSION 2

Middle School

Check one:
_____ Pre-survey
_____ Post-survey

Email kits@soest.hawaii.edu to request a completed teacher answer key. Please include name, school and grade(s) taught in your request. Mahalo!

Name:_____

Period: _____

Directions:
This survey is both a pre- and post- survey. Put a check mark at the top of this paper next to the survey you are doing (pre- or post- survey). Please answer each question to the best of your ability. Circle the most correct answer.

1. What is the general term for animals that drift in the ocean? (4.3.2, SC.7.3.1)
   a. copepods
   b. holoplankton
   c. meroplankton
   d. zooplankton

2. These organisms photosynthesize and form the base of the ocean food web. (4.3.1, 5.3.1, 7.3.1, SC.BS. 3.1, 3.2)
   a. crustaceans
   b. copepods
   c. phytoplankton
   d. zooplankton

3. Which of the following adaptations would not help phytoplankton float in the photic (light) zone? (4.3.2, SC.7.5.4)
   a. chlorophyll
   b. spines
   c. forming chains of cells
   d. flagella (hair-like tails)

4. Animals in the ocean could survive without plankton. (4.3.1)
   a. True
   b. False

5. Which of the following shows energy flow through a simple ocean food chain? (SC. 4.3.1, 7.3.2, SC.BS. 3.3)
   a. sun → diatoms → copepods → fish → whales
   b. sun → copepods → fish →diatoms → whales
   c. sun → fish → diatoms → copepods → whales
   d. diatoms → sun → fish → whales → copepods

6. Which of the following reduces greenhouse gas in the atmosphere? (SC.BS. 3.1, 4.3.2, SC. 7.3.1)
   a. meroplankton
   b. copepods
   c. zooplankton
   d. diatoms

7. Which best defines the difference between holoplankton and meroplankton? (7.3.2)
   a. Meroplankton photosynthesize. Holoplankton don't.
   b. Meroplankton are smaller and more abundant than holoplankton.
   c. Meroplankton are only plankton when they are young. Holoplankton are always plankton.
   d. Meroplankton stay near the lit ocean surface. Holoplankton are found throughout the ocean.

8. Which best describes why plankton are important to people? (SC. 5.3.2, 7.3.2)
    a. Plankton create much of the oxygen that humans breathe.
    b. Plankton support all the marine organisms that humans eat.
    c. Plankton are a potential source of medicine.
    d. all of the above

9. Human activities can increase CO_2 in the ocean, and this increased CO_2 can be harmful to marine organisms. Which of the following may help decrease CO_2 in the ocean? (SC. 7.3.3, SC.BS. 3.1)
    a. phytoplankton blooms
    b. zooplankton migration
    c. meroplankton
    d. holoplankton

10. If you were a scientist who studied phytoplankton, which tool would <u>not</u> help you study these organisms? (SC7.1.1)
    a. a satellite photo
    b. a stethoscope
    c. a plankton net
    d. a microscope

11. If copepods disappeared, which would most likely increase? (SC. 5.3.2, 7.3.2, 7.3.3)
    a. fish
    b. diatoms
    c. humpback whales
    d. cnidarians

Key to notation:
Hawai'i Content and Performance Standards
The relevant benchmarks for each question are shown in red in parentheses, and refer to *Hawai'i Content and Performance Standards* Version III.

POWERPOINT SCRIPT

Slide 1 (Title slide):
Welcome to the amazing world of marine plankton. (click)

Slide 2:
So what exactly are plankton? The term plankton comes from the Greek word "Planktos" meaning wanderer or drifter. (click) Plankton are organisms that live in the water and cannot swim against major currents. Plankton can be classified into two main groups: plants (click) and animals (click). (click)

Slide 3:
The plant-like plankton are called phytoplankton. You can remember that phytoplankton are like plants because plants and phyto both begin with the letter p. Each phytoplankton is a single cell or a chain of cells (click). Phytoplankton are microscopic: that means they are incredibly small. The picture shown here (click) was taken through a microscope. The phytoplankton in this image has been magnified hundreds of times. As you can see, it doesn't look anything like plants that grow on land. Phytoplankton don't have roots, stems, or leaves. But like land plants, they are able to capture sunlight and convert it into food. This process, called photosynthesis, also makes the oxygen that we need to breathe. In fact, phytoplankton produce about 50% of the oxygen that you breathe every day! That's not an easy task, but fortunately there are plenty of phytoplankton to get the job done. (click) In a teaspoon of sea water, you can find over a million phytoplankton! (click) When conditions are just right, phytoplankton can grow in such large numbers that they are able to generate a bloom that can be seen from space. (click)

Slide 4:
The animal-like organisms that drift in the ocean are called zooplankton. You can remember that zooplankton are like animals because animals live in a zoo. These creatures are larger than phytoplankton, but most are still quite small. (click) You can view most zooplankton by using a magnifying glass. One notable exception (click) are jellyfish, which can be seen without a magnifying glass. Some jellyfish species can grow to over several meters in length – which of course requires no magnification at all. (click)

Slide 5:
Phytoplankton live near the surface of the ocean close to the sun because they need sunlight to make food. The shape of the phytoplankton keeps them from sinking too far below the surface of the ocean. Phytoplankton that are balled up will sink (click) just like you do when you jump into the pool as a cannonball. Phytoplankton that are long and spread out will float (click) just like when you float on your back with your arms and legs spread out. These (click) are some examples of long, spread out shapes that help phytoplankton stay near the surface. Some phytoplankton (click) even link together to form chains to stay afloat. (click)

Slide 6:
Two common types of phytoplankton that you will learn about today are dinoflagellates (click) and diatoms (click). (click)

Slide 7:
Phytoplankton have special adaptations, or modifications, for survival in the ocean. Most dinoflagellates have two flagella (click) that help them move through the water, and a hard shell (click) for protection. Dinoflagellates have pigments of various colors and, when there are a lot of them in one area, the ocean water appears to change color. This is called a bloom (click). Toxins are sometimes released into the surrounding waters during a bloom. Scientists believe that these toxins may protect dinoflagellates from predators. (click)

Diatoms are another type of plant-like plankton. They come in varying shapes that include zigzags, ribbons, and fans. They have a protective cell wall (click) made of glass, and their spines (click) help prevent them from sinking. Diatoms also form chains (click) which help keep them near the surface. (click)

Slide 8:

There are two types of zooplankton: temporary and permanent. The temporary zooplankton called meroplankton (click) only spend part of their life cycle as plankton. The permanent zooplankton called holoplankton (click) spend their whole life as plankton. You can remember that holoplankton spend their whole life as plankton because *holo* and *whole* sound similar. (click)

Slide 9:

Certain animals, such as crabs and fish, are plankton only when they are young larva. When they grow up, they transform into completely different forms. As a crab grows up (click), it sinks to the ocean floor which is the natural habitat for an adult crab. A fish larva (click) grows up to be a fish with excellent swimming capabilities. In both cases, they are plankton only when they are young. (click)

Slide 10:

The other type of zooplankton (called holoplankton) spends its whole life drifting around the ocean. Here are some examples of holoplankton. Copepods (click) are the most abundant animals in the ocean, and perhaps anywhere on Earth. (click)

Slide 11:

Plankton are really important because they form the base of the marine food web. Phytoplankton (click) obtain their energy from the sun through photosynthesis. Phytoplankton are eaten by zooplankton (click), which are then eaten by small fish (click). Small fish get eaten by medium fish (click), which are in turn eaten by large fish (click), such as tuna. Sharks (click) are at the top of the food web. Without plankton (click), none of the larger fish or animals in the ocean could survive. The entire marine food web would collapse. (click)

Slide 12:

So how do scientists study plankton? First, they conduct a plankton tow to collect the tiny organisms. Plankton are very common in the ocean, but they are often very spread out. Scientists tow plankton nets (click) slowly behind a boat to concentrate the plankton. These nets have small holes, which are large enough to allow water to pass through but small enough to trap the plankton inside. The phytoplankton and zooplankton get forced into a bucket (click) at the narrow end of the net. Scientists collect the plankton from the bucket, and investigate them with a magnifying glass or microscope. These pictures (click) show high school students collecting plankton with a net (click), and examining their findings under a microscope. (click)

Slide 13:

In summary, the plant-like plankton are called phytoplankton. Phytoplankton (click) cannot swim against major currents. All phytoplankton (click) spend their whole life as plankton. Phytoplankton (click) are important because they produce half of the oxygen that we breathe each day! Phytoplankton (click) have spines, chains, and hard shells. These adaptations protect them from predators and help them stay close to the surface where sunlight is most abundant. (click)

Slide 14:

Animal-like plankton are called zooplankton. (click) Like phytoplankton, zooplankton cannot swim against major ocean currents. Some zooplankton are plankton only when they are young. (click) They are called meroplankton or temporary plankton. For example, this zooplankton (click) becomes a crab when it grows up. Other zooplankton (click) called holoplankton spend their whole lives as plankton. Both zooplankton and phytoplankton (click) make up the base of the marine food web: without these tiny organisms, no fish could survive.

Name: _____ Period: _____

STUDENT WORKSHEET – POWERPOINT

Lesson 1: Introduction to Plankton

1. Plankton are organisms that live in the _____ and cannot _____ against major currents.

2. Plant-like plankton are called phytoplankton and are so small that a _____is needed to see them.

3. The animal-like organisms that drift in the ocean are called _____.

4. Phytoplankton make _____ using sunlight and carbon dioxide (CO_2), so they need to live near the _____of the ocean.

5. Two kinds of phytoplankton are _____ and _____. Each type has special adaptations to survive.

6. Dinoflagellates have _____ to help them move through the water and _____for protection. Dinoflagellates may increase in numbers during a _____, which colors the water and can be seen from space.

7. Diatoms are another type of plant-like phytoplankton that have a protective cell wall made of _____. They may form _____ and have _____to help them float.

8. There are two types of zooplankton: _____ and _____. The temporary zooplankton, called _____, only spend part of their life cycle as plankton. The permanent zooplankton, called _____, spend their whole life as plankton.

9. Meroplankton such as _____ and _____ are only plankton when they are young larvae. Copepods are examples of _____, living their entire life as plankton.

10. _____are the base the marine food web. Phytoplankton get their energy from _____ through photosynthesis. Zooplankton eat the phytoplankton. Without _____, none of the larger fish or animals could survive.

Name: _____ Period: _____

TEACHER ANSWER KEY to STUDENT WORKSHEET – POWERPOINT

Lesson 1: Introduction to Plankton

1. Plankton are organisms that live in the _____ and cannot _____ against major currents.

Email kits@soest.hawaii.edu to request a completed teacher answer key. Please include name, school and grade(s) taught in your request. Mahalo!

2. Plant-like plankton are called _____is needed to see them.

3. The animal-like organisms that drift in the ocean are called _____.

4. Phytoplankton make _____ using sunlight and carbon dioxide (CO_2), so they need to live near the _____of the ocean.

5. Two kinds of phytoplankton are _____ and _____. Each type has special adaptations to survive.

6. Dinoflagellates have _____ to help them move through the water and _____for protection. Dinoflagellates may increase in numbers during a _____, which colors the water and can be seen from space.

7. Diatoms are another type of plant-like phytoplankton that have a protective cell wall made of _____. They may form _____ and have _____to help them float.

8. There are two types of zooplankton: _____ and _____. The temporary zooplankton, called _____, only spend part of their life cycle as plankton. The permanent zooplankton, called _____, spend their whole life as plankton.

9. Meroplankton such as _____ and _____ are only plankton when they are young larvae. Copepods are examples of _____, living their entire life as plankton.

10. _____are the base the marine food web. Phytoplankton get their energy from _____ through photosynthesis. Zooplankton eat the phytoplankton. Without _____, none of the larger fish or animals could survive.

Name: _____ Period: _____

STUDENT WORKSHEET

Lesson 1: Phytoplankton Microscopy Lab

Instructions: Look at Slides 1–6 in the **SLIDES – Lesson 1: Phytoplankton Microscopy Lab**. Draw and identify as many organisms as you can on the slides by using the **PHYTOPLANKTON ID GUIDE – Lesson 1: Phytoplankton Microscopy Lab**, and then describe key features in Table 1.1. Number each organism in your drawing with its corresponding number from Table 1.1. An example is shown for *Chaetoceros.*

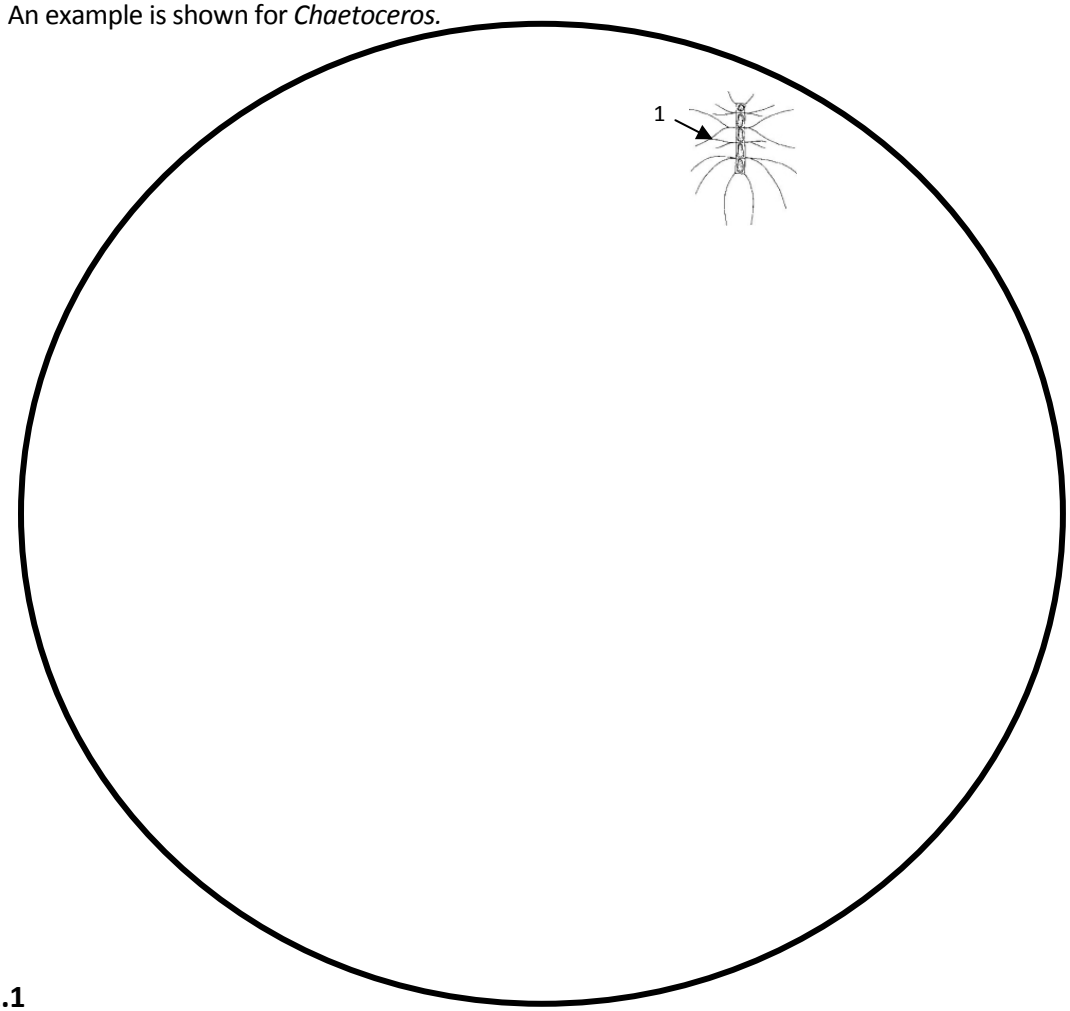


Table 1.1

Organism Name	Key Features
1. *Chaetoceros*	Lots of spines. Chain of cells.
2.	
3.	
4.	
5.	
6.	
7.	

SLIDES
Lesson 1: Phytoplankton Microscopy Lab

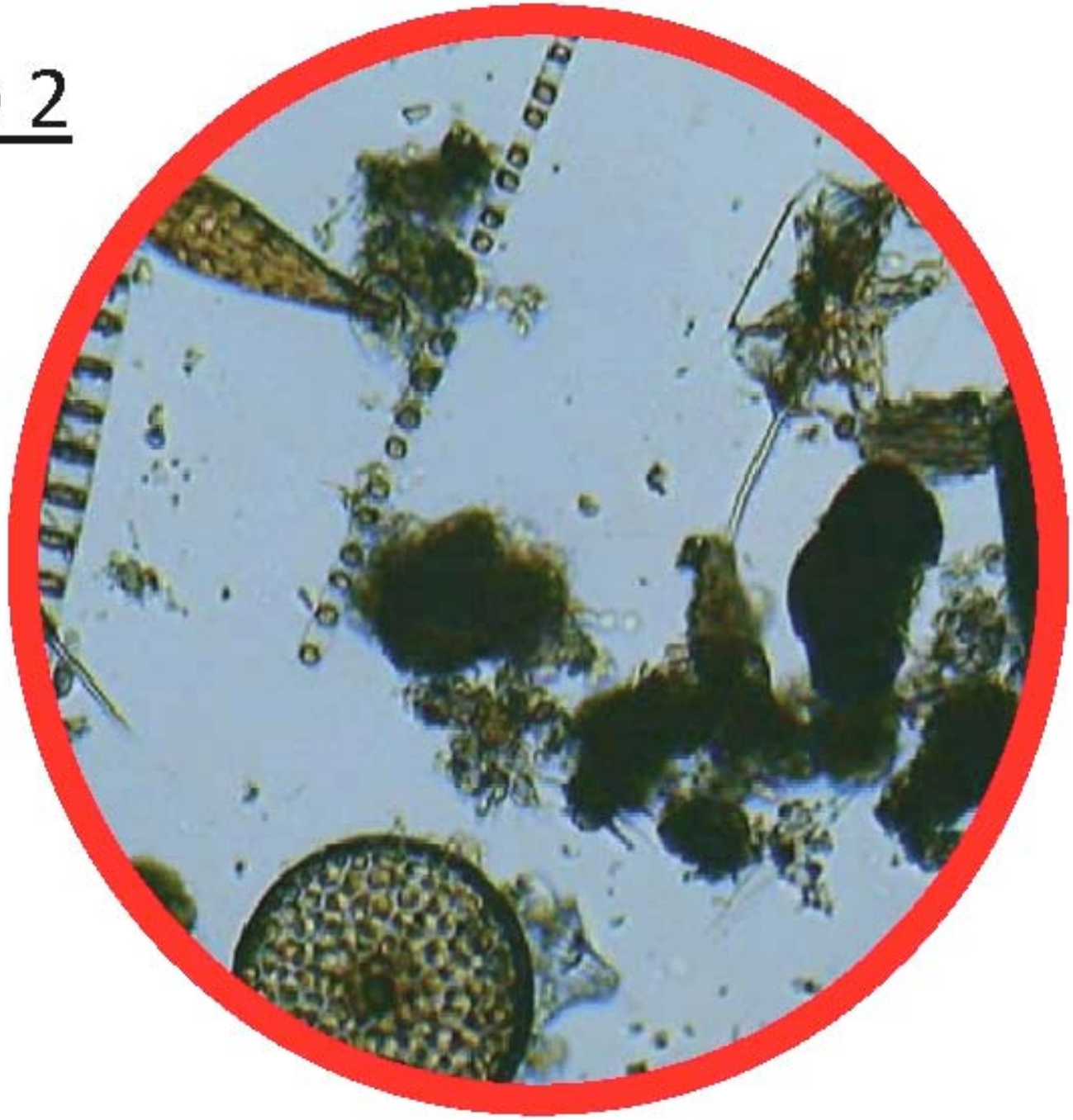
c·more

center for microbial oceanography:
research and education

Images from Southeast Phytoplankton Monitoring Network (SEPMN)

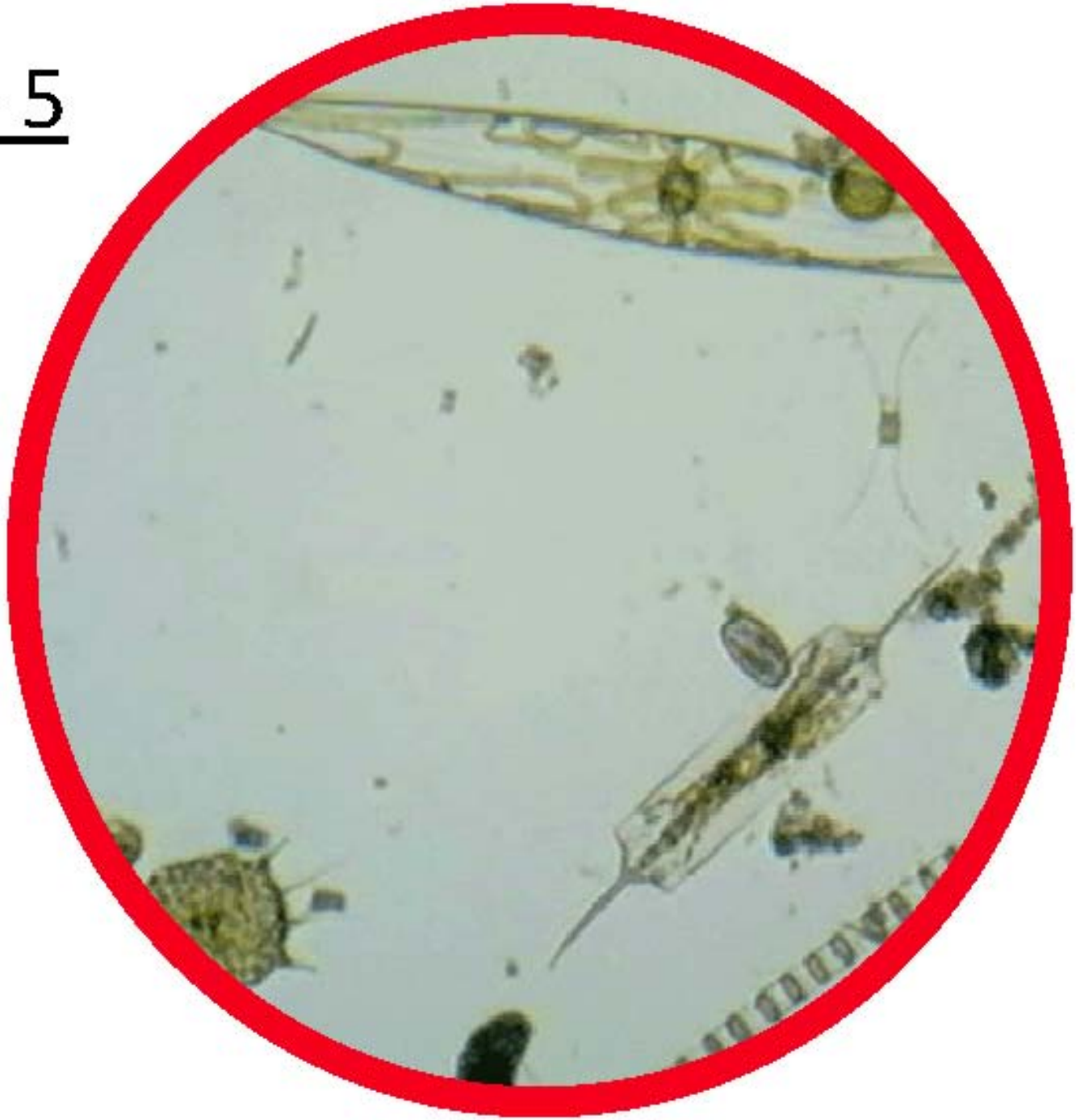
Slide 1

Slide 2

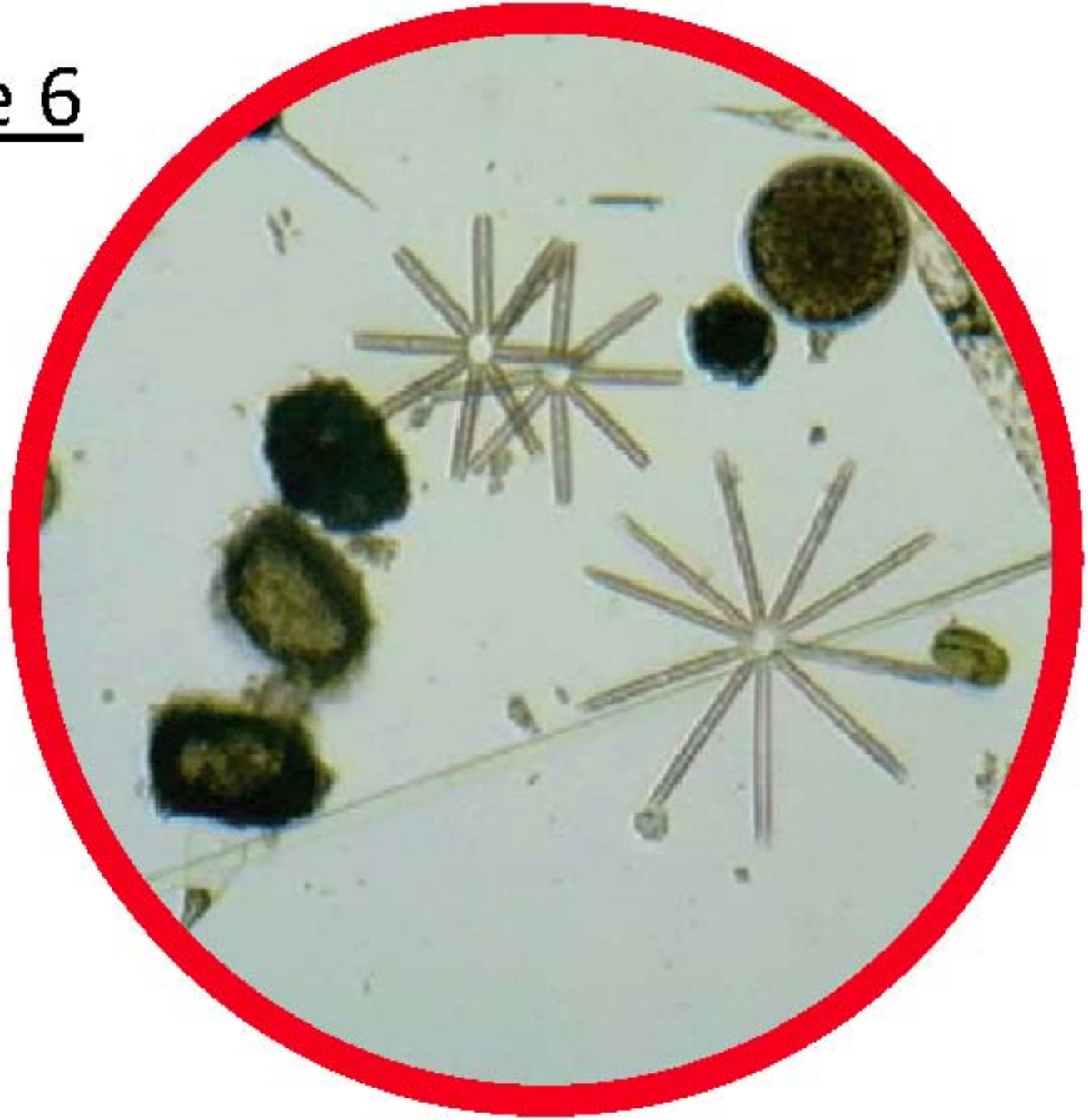


Slide 4

Slide 5



Slide 6



SLIDES
Lesson 1: Phytoplankton Microscopy Lab

ANSWER KEY

c·more

center for microbial oceanography:
research and education

Images from Southeast Phytoplankton Monitoring Network (SEPMN)

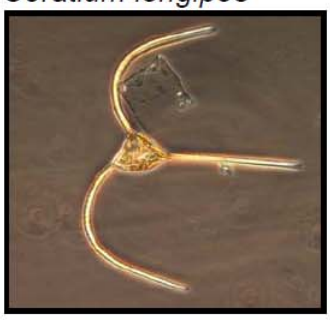
Pages 32-37 removed from web version Email kits@soest.hawaii.edu to request a completed teacher answer key or complete lesson plans including answer key. Please include name, school and grade(s) taught in your request. Mahalo!

PHYTOPLANKTON ID GUIDE – Lesson 1: Phytoplankton Microscopy Lab

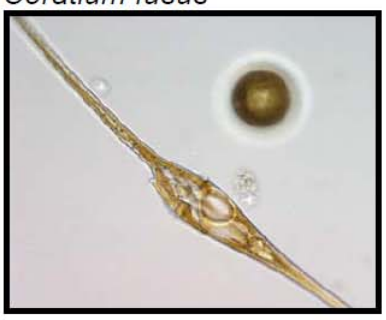
(SEPMN Species List)

DINOFLAGELLATES

Ceratium longipes



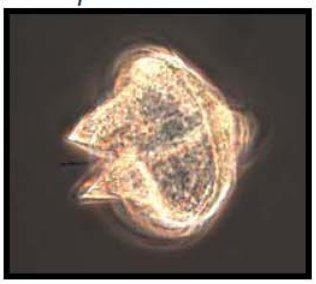
Ceratium fusus



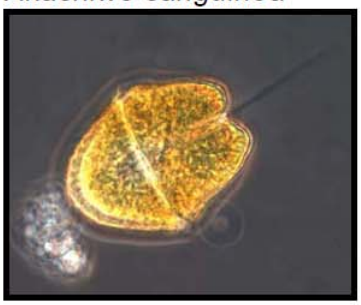
Ceratium furca

Dinophysis caudata

Protoperidinium

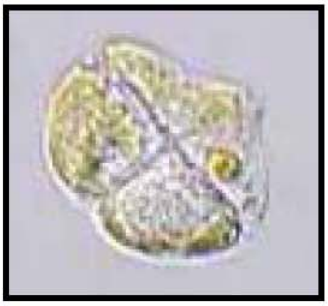


Akashiwo sanguinea



Prorocentrum micans

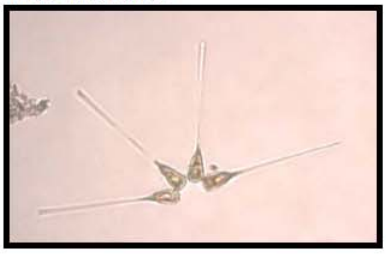
Karenia brevis



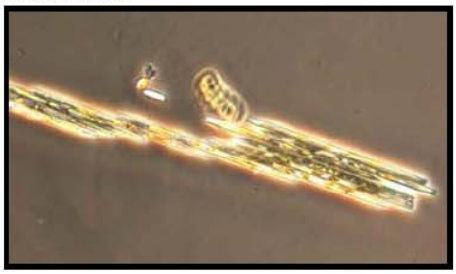
Prorocentrum lima

DIATOMS

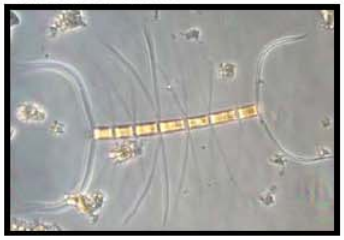
Asterionella



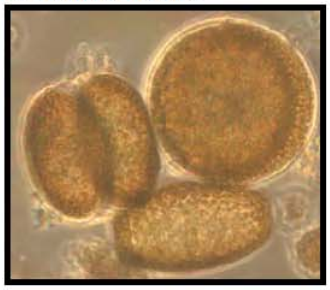
Bacillaria



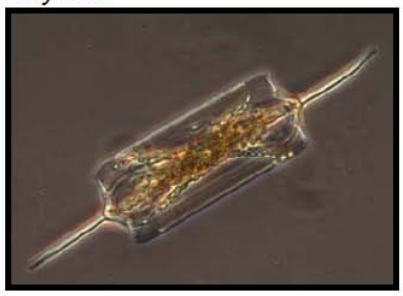
Chaetoceros



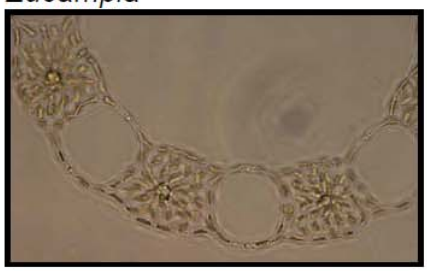
Coscinodiscus



Ditylum



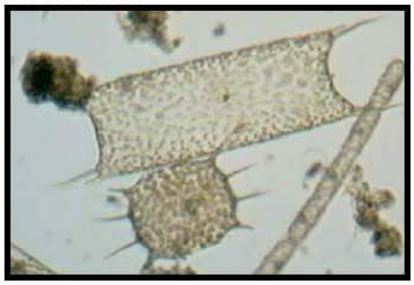
Eucampia



Guinardia

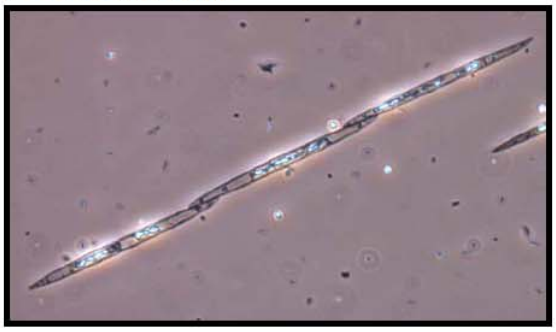
Nitzschia

Odontella



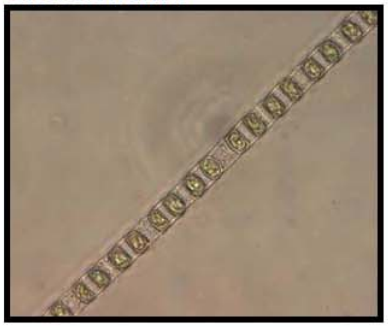
Pleurosigma

Pseudo-nitzschia

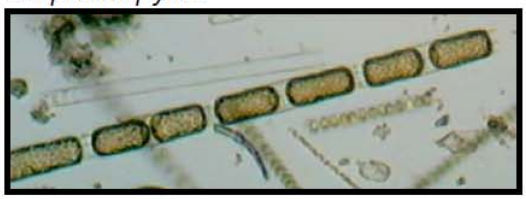


Rhizosolenia

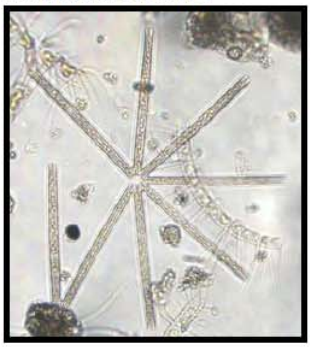
Skeletonema



Stephanopyxis



Thalassionema



ID Guide created by SEPMN

TEACHER GUIDE

Lesson 2: Design Your Own Phytoplankton

Time Required: 45 minutes.

Structure: This lesson enables students to creatively synthesize and reinforce the information learned during Lesson 1. Students design their own phytoplankton from direct observations and imagination (25 minutes). Students will then present their artwork to the class and receive feedback from other students (20 minutes). This lesson is designed to engage students with different learning styles.

Materials: (Paper materials contained in binder are shown in **BOLD CAPS**)
Materials are provided for 5 groups. We suggest 4–6 students per group.

1. **PHYTOPLANKTON ID GUIDE – Lesson 1: Phytoplankton Microscopy Lab** (10 in Inner Box), provided in Lesson 1
2. **GRADING SHEETS – Lesson 2: Design Your Own Phytoplankton** (optional)
3. Black construction paper
4. Oil pastels (5 packs)

Advance Preparation:

1. Make sure that you have enough black construction paper and oil pastels for your classes.

2. If you would like to grade your students on this lesson, photocopy or print the **GRADING SHEETS – Lesson 2: Design Your Own Phytoplankton** (one per 4 students). Cut copies into individual grading sheets.

Instructional Procedures:

1. Divide the students into five groups. Distribute one piece of construction paper to each student. Distribute two copies of the **PHYTOPLANKTON ID GUIDE – Lesson 1: Phytoplankton Microscopy Lab** and one pack of oil pastels to each group.

2. Tell the students that they will have 15–20 minutes to design/invent their own phytoplankton. Review the **PHYTOPLANKTON ID GUIDE – Lesson 1: Phytoplankton Microscopy Lab** with the class. First review that phytoplankton tend to stay near the surface of the water and close to their food source: the sun. To accomplish this task, phytoplankton have developed adaptations such as differences in size, shape, and the formation of chains. Also discuss that phytoplankton protect themselves with spines, bristles, and hard shells. After discussing these real-life adaptations, ask the students to use their imaginations to come up with new adaptations that would help phytoplankton survive. Examples of creative, fantastic adaptations include water wings, bubbles, inner tubes, and solar panels. Students can merge real-life adaptations with imaginary ones to create new species of phytoplankton adapted for survival in the ocean. As students share their ideas for the different adaptations, draw them and show how they can be combined into a unique phytoplankton creation.

3. The students can work in groups to discuss ideas and adaptations, but each student should produce his or her own phytoplankton creature. Instruct the students to press heavily with the pastels and fill in their work or the drawings will be difficult to see. Also, instruct the students to make large images that fill the entire paper.

4. Instruct the students to name their phytoplankton. The name should consist of an imaginative element and a scientific component derived from the **PHYTOPLANKTON ID GUIDE**, e.g., *Thalassiosira tubey.* In scientific nomenclature the genus name is capitalized in italics or underlined (i.e., *Thalassiosira or* Thalassiosira) and the species name is lowercase and in italics or underlined (i.e., *tubey or* tubey).

5. Table 2.1 below lists some ideas on the artistic process that students may wish to apply.
   Table 2.1

Artistic Skill	**Teaching Tool**
Size	Objects in proportion to one another
Color	Use of multiple colors on color wheel
Complementary colors	Use of opposite pairs of colors on color wheel
Harmony	Use of adjacent colors on color wheel, use of similar shapes
Unity	Visually appealing linkage of elements
2D object to 3D	Use of shading

6. During the last ~20 minutes of class, students will briefly present their drawings and describe why the selected adaptations are useful to the phytoplankton's survival. The students should also explain the name they chose for their phytoplankton. Encourage students to give positive and constructive feedback on each other's creations. Use the **GRADING SHEETS – Lesson 2: Design Your Own Phytoplankton** to score the students' work.

Assessment and Clean-up:

1. Collect the oil pastels and **PHYTOPLANKTON ID GUIDE – Lesson 1: Phytoplankton Microscopy Lab**.

2. If you plan to complete additional lessons from this kit, please do not have students complete the post-survey (this will be done after Lesson 3) and do not complete the **TEACHER EVALUATION** at this time.

3. If you are not completing additional lessons:
   - Please have students complete the post-survey found in Lesson 1 (you will need to make one photocopy per student). As the students are completing the post-survey, we would be grateful if you would complete the **TEACHER EVALUATION** of this kit. All comments, corrections, and suggestions are very welcome. If you prefer, you can complete the evaluation online (see **TEACHER EVALUATION** for website address).
   - Re-pack the kit. Double check that all the items are included and in their proper place by completing the **SUPPLY CHECKLIST**. Please make a note of missing, broken, or damaged items so that they can be replaced. Please pack the kit so that the materials are stored as they were when you received them.

Mahalo!

GRADING SHEETS

Lesson 2: Design Your Own Phytoplankton

Design your own phytoplankton!

Phytoplankton name with imaginary part and scientific part	____/ 2
At least two new adaptations for survival	____/ 2
Easy to see, image fills whole page	____/ 2
Presentation (appropriate, clear, etc.)	____/ 4
Total	____/ 10

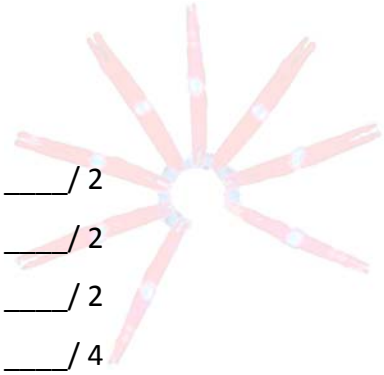
Design your own phytoplankton!

Phytoplankton name with imaginary part and scientific part	____/ 2
At least two new adaptations for survival	____/ 2
Easy to see, image fills whole page	____/ 2
Presentation (appropriate, clear, etc.)	____/4
Total	____/ 10

Design your own phytoplankton!

Phytoplankton name with imaginary part and scientific part	____/ 2
At least two new adaptations for survival	____/ 2
Easy to see, image fills whole page	____/ 2
Presentation (appropriate, clear, etc.)	____/ 4
Total	____/ 10

Design your own phytoplankton!



Phytoplankton name with imaginary part and scientific part	____/ 2
At least two new adaptations for survival	____/ 2
Easy to see, image fills whole page	____/ 2
Presentation (appropriate, clear, etc.)	____/ 4
Total	____/ 10

TEACHER GUIDE
Lesson 3: Zooplankton Microscopy Lab

Time Required: 50 minutes. Advance preparation requires another 1 to 2 hours.

Structure: Students will investigate and identify marine zooplankton using the digital dissecting microscope (45 minutes). We recommend students divide into small groups of 4–6 students. Materials are provided for five groups. Finally, they will complete a post-survey (5 minutes); the pre-survey was given at the beginning of Lesson 1.

Materials: (Paper materials contained in binder are shown in **BOLD CAPS**)
Materials are provided for 5 groups. We suggest 4–6 students per group.

1. **MATERIALS PHOTO GUIDE – Lesson 3: Zooplankton Microscopy Lab**
2. **STUDENT WORKSHEET – Lesson 3: Zooplankton Microscopy Lab**
3. **ZOOPLANKTON ID guide (Drifting Along) – Lesson 3: Zooplankton Microscopy Lab** (5 in Inner Box)
4. **PLANKTON SURVEY – Lessons 1, 2, and 3: Version 1 or 2** } provided in Lesson 1
5. **TEACHER ANSWER KEY to PLANKTON SURVEY – Lessons 1, 2, and 3: Version 1 or 2** } provided in Lesson 1
6. **GLOSSARY**
7. Plankton net with attached line
8. Plastic bottle to transport plankton to the classroom (1)
9. Squeeze bottle to rinse sample from net (1)
10. Plankton sieve (1)
11. Plastic beakers (5)
12. Plastic droppers (5)
13. Petri dishes (5)
14. Dissecting needles: straight (2) and curved (1)
15. Motic digital dissecting microscope (1) and cords (2) for microscope set-up
16. ThinkPad computer and power cord
17. Motic Images Plus CD
18. Motic Live Imaging Module: Quick Start Guide
19. Motic Instruction Manual SMZ-143
20. Extra microscope parts

Materials Not Included in this Kit but Needed for Lesson 3:

21. Projector

Advance Preparation:

1. Photocopy or print the **STUDENT WORKSHEET – Lesson 3: Zooplankton Microscopy Lab** (one per student).

2. Photocopy or print the appropriate version of the **PLANKTON SURVEY – Lessons 1, 2, and 3** (one per student; provided in Lesson 1) and the **GLOSSARY** (one per student; provided in the GLOSSARY tab).

3. Conduct a plankton tow to collect a zooplankton sample.
   a) You can either collect the sample on your own, or make this a class field trip. Grab the plankton net with attached line, plastic bottle, and squeeze bottle, and head down to the ocean. The plankton net has very small holes (80 µm), which are large enough to allow water to pass through but small enough to trap the zooplankton inside the collection cup (or cod end) at the end of the net.

   b) Fill the squeeze bottle with seawater.

   c) SLOWLY tow the plankton net through the water, either by attaching the line to the back of a kayak / boat or by walking along a pier. Best towing speed is about 2 knots (a slow walk). If the current is fast enough to stream the net (like a flag in the wind), you can just let the current flow through the net. *Caution: The net can tear easily so watch out for rocks, reefs, protrusions from piers, etc. Also, keep the net out of the shore break or you may get a net full of sand.*

d) Tow the net for 20–30 minutes.

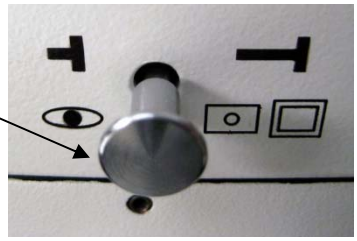
e) If any sample is stuck in the net, use the squeeze bottle filled with seawater to flush the sample into the cod end jar. Unscrew the cod end jar from the net and look at your sample. Pour the sample into the plastic bottle for transport back to the classroom. If any sample remains in the cod end jar, use the squeeze bottle.

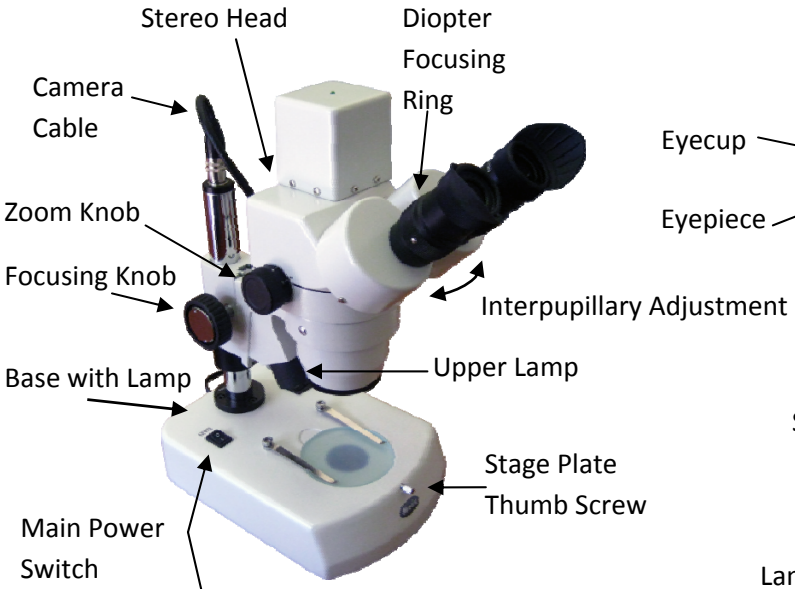
f) Thoroughly rinse the plankton net, attached line, and cod end jar with fresh water as soon as possible after collecting the sample. Reattach the cod end to the plankton net and allow the net to dry completely before storing. If necessary, gently scrub the net with baking soda, then rinse and dry thoroughly.

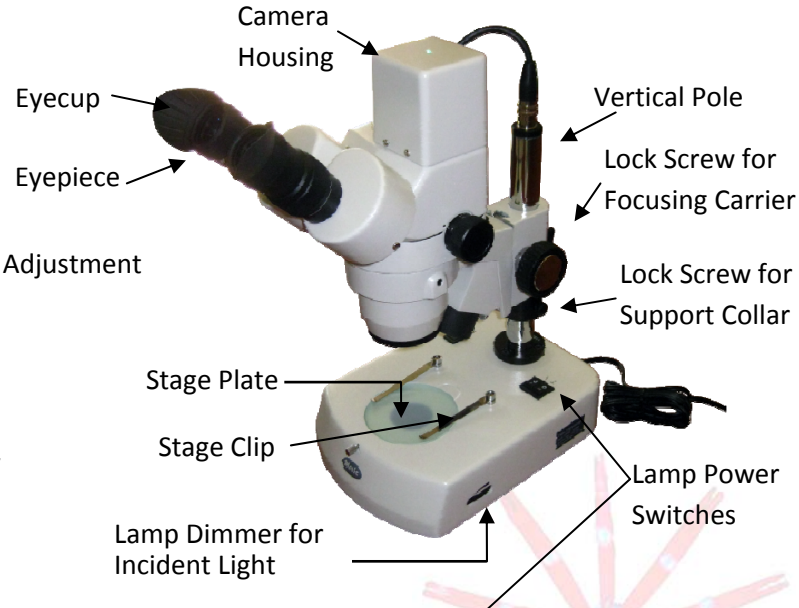
g) Note: It is extremely important to minimize the time from sample collection to analysis. If the sample must be stored overnight, be aware that a large portion of the zooplankton will not survive. However, there will still be plenty of organisms to observe so, if collecting the sample the day before is the only option, it will still be worthwhile. To increase the lifespan of the zooplankton, dilute the sample by adding it to a bucket of seawater (you will need to re-concentrate the sample prior to analysis, which can be done by pouring the water through the sieve). Alternatively, you can prolong the life of the zooplankton by storing the sample in the refrigerator overnight. Make sure the cap is loosened to allow air flow to the sample.

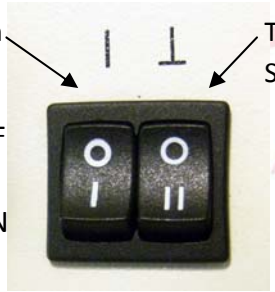
4. Familiarize yourself with the dissecting microscope.

a) Parts of the microscope









b) Overview of the dissecting microscope
   i. The microscope eyepieces have 10X magnification. Coupled with 1.0X to 4.0X zoom lenses, the microscope offers a total magnification of 10X to 40X.
   ii. The microscope has a main power switch as well as a power switch for the incident (upper) and transmitted (lower) light source. The intensity of the incident lamp can be adjusted with the lamp dimmer on the right side of the base.
   iii. There is a built-in camera with a USB cable that connects to the computer included with the kit. You can also use the Motic Images Plus software to capture, annotate, and store images in .jpg, .bmp, .sfc, or .tiff graphical format. To share the display with your entire class, connect the computer to a projector or video monitor.

5. Set up the microscope and computer
   a) Carefully remove the microscope from the action packer (see guide in microscope box for instructions).
   b) Plug in one end of the power cord into the back of the microscope and the other end into a power outlet.
   c) Plug one end of the USB cable into the back of the microscope and the other into a USB port on the computer provided. *Note: If you prefer to use your own computer, install the software prior to connecting USB cable.*
   d) Connect the computer to a projector.

6. Focus the microscope
   a) Plug in the microscope, turn on the main power switch, and turn on the incident light.
   b) Place a piece of paper with writing on it flat on the stage plate.
   c) Look through the eyepieces and adjust the distance between your eyepieces by rotating the bases of the eyepieces (shown above as "Interpupillary Adjustment") so that you see only one circle of light comfortably. *Note: If you can only see through the left eyepiece, carefully slide the prism bar in.*
   d) Carefully turn the zoom knob to the highest magnification.
   e) Adjust the focusing knob until your specimen is clear and sharp.
   f) The height of the microscope is set for plankton viewing. If you try to view different items or if you cannot focus clearly, you may need to adjust the height of the microscope along the vertical post.
      i. Turn main power OFF.
      ii. Loosen the lock screw on the black support collar and lower the collar to the base.
      iii. While holding the head of the microscope, carefully loosen the lock screw on the focusing carrier and adjust the height of the microscope.
      iv. Tighten the lock screw on the focusing carrier.
      v. Slide the support collar up to the base of the focusing carrier and tighten the lock screw.
   g) Zoom in to the highest magnification and focus until the image is clear and sharp.
   h) Zoom out to the lowest magnification. Adjust the diopter focusing ring on the right eyepiece until the image in the right eyepiece is clear and sharp.
   i) Repeat steps g and h for the left eyepiece.
   j) Check the focus for the entire zoom range. The microscope should now be parfocal, maintaining focus for the whole zoom range.

7. Viewing plankton sample
   a) Use a plastic dropper to put a small amount of sample in a Petri dish.
   b) Place the Petri dish on the stage plate of the microscope and look through the eyepieces. *NEVER place a sample directly on the stage plate.*
   c) Turn on the transmitted light.
   d) Zoom out to the lowest magnification and focus on the sample
   e) Now you can move the Petri dish and zoom to specimens of interest. Use the dissecting needles to move the plankton around for easier viewing.

Tip: More water in the Petri dish means that the plankton will move around more and you may be able to observe them swimming. Less water in the dish makes for easier viewing as the plankton will not move around as much. You can use the sieve to help remove some of the water, but may need to gently rub the bottom of the sieve to get the water to drain through.

f) You may need to switch between incident and transmitted light to get the best view. Additionally, the microscope comes with two different stages. The frosted stage tends to be most effective for observing transparent specimens like plankton. Use the black and white stage plate for macroscopic objects that require light from the top. *Note: If you change out the stage plate, make sure to retighten the stage plate thumb screw so the plate does not fall out during transport.*

8. Viewing plankton on the computer
   a) Turn on the computer and log in. Password = plankton
   b) Turn on the projector and project the computer display onto the screen for class viewing.
   c) Open the Motic Images Plus program by double clicking on the desktop shortcut.
   d) Observe your sample and adjust the light and focus to get the best image.
   e) Click on "Capture" to start the camera.
   f) Pull the prism bar on the back of the microscope out to direct light to the camera.
   g) The image in the microscope should now appear on the right side of the computer with an image adjustment panel on the left side of the screen. To get the best image, some of the settings need to be adjusted. *NOTE: Please be patient when working with the video camera. There is a time delay between any adjustments made with the microscope and the image displayed on the screen.*
      i. Remove the Petri dish with your sample from the microscope stage without changing the light and focus.
      ii. In the left hand panel of the Motic Live Imaging Module, check the "Auto" box next to "Exposure" for auto exposure. You can also manually adjust the exposure by un-checking "Auto" and moving the slider bar under the exposure box.
      iii. Click on "Background Balance" to reduce the effects of uneven illumination.
      iv. Click on "White Balance" to obtain the best color similar to what you see through microscope.
      v. Place the Petri dish with your sample back on the stage for viewing.
      vi. For the best image, you may need to repeat steps iii-iv when you change light intensity or magnification.
      vii. Additional adjustments can be made using the Motic Images Plus program. See the Motic Live Imaging Module: Quick Start Guide for details. This guide can be found in the back of the binder or on the computer [go to Start, All Programs, Motic].

   The Motic software CD is included if you would prefer to attach the microscope to a different computer. To install the program, insert the CD into your computer and follow the instructions that pop up. The instructions in the kit are written for using the program in plus mode. Refer to the Motic Live Imaging Module: Quick Start Guide for reference.

9. Capturing and saving an image
   a) At the far left of the Motic Live Imaging Module, click on the camera icon.
   b) Click the "Capture" button. You may also capture a video by selecting the "Record" button.
   c) Your captured image will appear on the side panel of the Motic Image Plus 2.0 ML window and can be adjusted and measured within the program. See the Motic Live Imaging Module: Quick Start Guide for details. This guide can be found in the back of the binder or on the computer [go to Start, All Programs, Motic].
   d) Captured images will be saved to the "Capture Folder" folder under the Motic program. You can access this folder while in the program by selecting the "File" dropdown menu, then "Open", and scrolling until you find the "Capture Folder".
   e) Save your captured images to a memory stick or similar device prior to returning the computer.
      i. Open a captured image in the Motic Images Plus 2.0 ML program.
      ii. Attach external storage device to computer.
      iii. Click on "Save As" and change the location.

iv. Name your file.
v. Change the file type to .jpg, .bmp or .tiff (We recommend .jpg).
vi. Click "Save" and repeat as necessary.

10. Microscope care
    a) Turn off the light switches and main power switch when not in use.
    b) Cover the microscope with the dustcover when not in use.
    c) Keep the microscope dry.
    d) Cleaning the lenses
        i. DO NOT WIPE ANY LENS SURFACE WITH DRY COTTON SWAB, CLOTH, OR LENS PAPER.
        ii. Breathe lightly on the glass surface and wipe with a clean, lint free cloth, lens paper, or cotton swab.
        or
        iii. Dip a lint free cloth, cotton swab or lens paper with a few drops of ethanol and carefully clean the lens surface. No other solvents should be used.
    e) Changing the light bulb (If necessary)
    Caution: Use a tissue or latex glove to handle the new bulb. Oils from the skin will shorten the life of the bulb, so please DO NOT touch the new bulb with your bare fingers. Make sure the main power is switched off and the power supply has been unplugged.
        i. For incident light: a) unscrew the black collar and silver lens. b) Carefully remove the old bulb, and plug in the new light bulb. c) Reattach the silver lens and black collar.
        ii. For transmitted light: a) make sure that the lock screw for the focusing carrier is tight, then turn the microscope 90° on its side so that you can access the bottom plate. a) Remove the bottom plate by using a small Phillips screwdriver to remove the four rubber feet. c) Carefully remove the old bulb, and plug in the new light bulb. d) Reattach the bottom plate.

11. Computer care and maintenance
    a) Please use the computer solely in association with the Plankton kit.
    b) If you connect to the Internet, please update the McAfee software.
        i. Open up McAfee AntiVirus Plus by double clicking on the desktop shortcut or by going to Start -> All Programs->McAfee-> McAfee AntiVirus Plus
        ii. At the McAfee home screen, click on "Updates", then click "Check for updates".
        iii. Wait until updates have completed installation, then you can close the home screen.
    c) If you connect to the Internet, please update Windows.
        i. Open Windows Updated by going to Start -> All Programs -> Windows Update
        ii. Click on "Check for Updates".
        iii. Please install any important or critical updates. Do not install optional updates.
    d) Please contact kits@soest.hawaii.edu with any questions about the computer.

Instructional Procedures:

1. Explain to your students that they will be completing a zooplankton lab. You will work with the students to handle the microscope and take pictures of organisms.

2. Split the students into five groups, and distribute a **ZOOPLANKTON ID GUIDE (Drifting Along) – Lesson 3: Zooplankton Microscopy Lab** to each group.

3. Distribute a **STUDENT WORKSHEET – Lesson 3: Zooplankton Microscopy Lab** to each student.

4. Stir the sample and pour a small amount into 5 plastic beakers. Give one beaker to each group of students and instruct the students to view the zooplankton without the aid of a microscope. Ask them what they observe (e.g., cloudy water with small organisms).

5. Now the class will prepare samples for viewing under the dissecting microscope. Have one student from each group bring their beaker to the front of the room. Give each of these five students a Petri dish and a plastic dropper. Instruct these students to stir their samples with the plastic dropper, and immediately place one dropper full of sample onto the Petri dish. Have the students return to their seats and leave the beakers, droppers, and Petri dishes at the front of the room.

6. Turn on the microscope and the projector so the class can view the sample. You may need to fine-tune the microscope focus to project the sharpest image. One at a time, place each Petri dish on the stage and move the dish around to show the various fields of view. Select (or ask the students to select) a Petri dish and field of view which shows many diverse zooplankton. *Note: Unless you properly train your students on how to use the microscope and software, please do not allow students to handle the equipment. If you have additional microscopes at your school, allow your students to observe the plankton in smaller groups.*

7. Review the **ZOOPLANKTON ID GUIDE (Drifting Along) – Lesson 3: Zooplankton Microscopy Lab** with the students. Explain that the guide has two parts: A. Meroplankton (temporary zooplankton) and B. Holoplankton (permanent zooplankton). Review that meroplankton are only plankton when they are young, and assume very different forms as adults. Both larval and adult forms for meroplankton are shown in the guide. Holoplankton look similar throughout their life cycle; therefore only one image of each holoplankton is shown.

8. Review the **STUDENT WORKSHEET – Lesson 3: Zooplankton Microscopy Lab.** Part 1 asks students to identify and draw the marine zooplankton that are projected on the screen. Part 2 asks students to select a meroplankton from part A. of the ZOOPLANKTON **ID GUIDE (Drifting Along) – Lesson 3: Zooplankton Microscopy Lab** that was <u>not</u> viewed under the microscope and draw both of its life stages.

9. As you continue to explore the zooplankton sample, you may want to save (or print) some images using the Motic software.

Assessment & Clean-up:

1. Pass out **PLANKTON SURVEY – Lessons 1, 2, and 3** (one per student). Have students check the post-survey box and answer the questions (allow 5 minutes). A **TEACHER ANSWER KEY** is provided in Lesson 1.

2. Thoroughly rinse all of the zooplankton lab supplies with fresh water. These include the plankton net and line, plastic bottle, plastic beakers, plastic droppers, and Petri dishes. Please allow these items to dry completely prior to repacking.

3. Switch off the individual bulbs and main power switch. Save any images you captured and wish to keep on a memory stick. Shut down the computer.

4. Unplug the cords attached to the microscope, and place them into the bag designated for the microscope cords.

5. Eject the Motic CD from your computer (if used), and place it in the back pocket of the binder along with the Motic Live Imaging Module: Quick Start Guide and Motic Instruction Manual SMZ-143.

6. Carefully re-pack the microscope and computer for transport, ensuring that there is ample padding on all sides.

7. If you are not completing additional lessons:
    - We would be grateful if you would complete the **TEACHER EVALUATION** of this kit. All comments, corrections, and suggestions are very welcome. If you prefer, you can complete the evaluation online (see **TEACHER EVALUATION** for website address).
    - Re-pack the kit. Double check that all the items are included and in their proper place by completing the **SUPPLY CHECKLIST**. Please make a note of missing, broken, or damaged items so that they can be replaced. Please pack the kit so that the materials are stored as they were when you received them.

Mahalo!

MATERIALS PHOTO GUIDE

Lesson 3: Zooplankton Microscopy Lab

 cod end **Plankton Net**	 **Plastic Bottle**	 **5 Plastic Beakers**
 **Squeeze Bottle**	 **Plankton Sieve**	 **Digital Dissecting Microscope**
 **5 Plastic Droppers**	 **5 Petri Dishes with Covers**	 **3 Dissecting Needles**

Name: _____ Period: _____

STUDENT WORKSHEET

Lesson 3: Zooplankton Microscopy Lab

Part 1 Instructions: Look at the zooplankton sample under the microscope (or projected on the screen). Draw and identify as many organisms as you can by using the **ZOOPLANKTON ID GUIDE (Drifting Along) – Lesson 3: Zooplankton Microscopy Lab**, and describe their key features in Table 3.1. Number each organism in your drawing with its corresponding number from Table 3.1. An example is shown for crab larva. When you are done, continue to the next page.

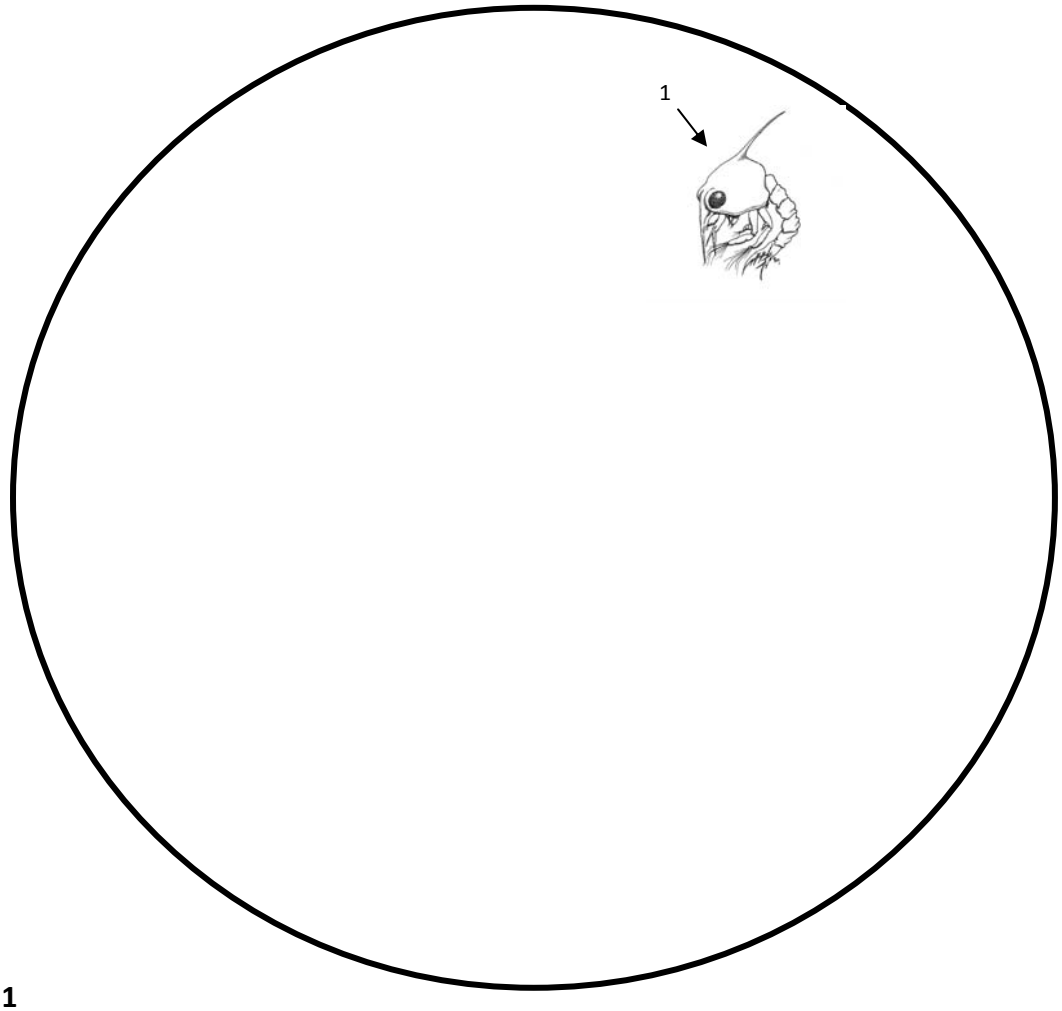


Table 3.1

Organism Name	Key Features
1. Crab larva	Large compound eye. Spine on back side.
2.	
3.	
4.	
5.	
6.	

<u>Part 2 Instructions</u>: Using the **ZOOPLANKTON ID GUIDE (Drifting Along) – Lesson 3: Zooplankton Microscopy Lab**, select a meroplankton that you did <u>not</u> see under the microscope and draw both its larva and adult form. Fill in the organism's name and its key features in Table 3.2.

Table 3.2

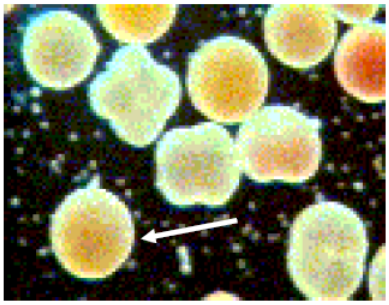
Organism Name	Key Features

ZOOPLANKTON ID GUIDE (Drifting Along)
Lesson 3: Zooplankton Microscopy Lab

A. MEROPLANKTON (only part of the life cycle spent as plankton)

Phylum Cnidaria (corals, anemones, jellyfish)

1. Coral (ko'a)

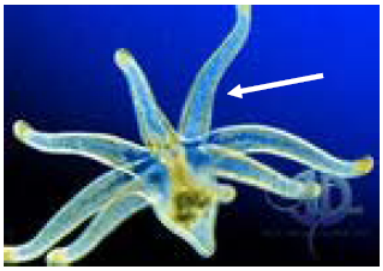


Larvae

Coral larvae are packed with fatty lipids that allow them to float near the water surface.

Adult

2. Anemone ('okole emiemi)

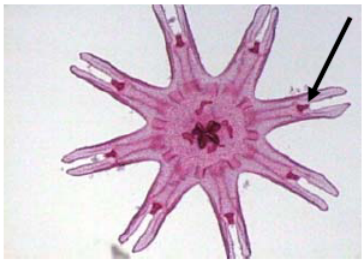


Larva

Anemone larvae have 8 sticky tentacles that they use to pick up symbiotic algal cells from the water.

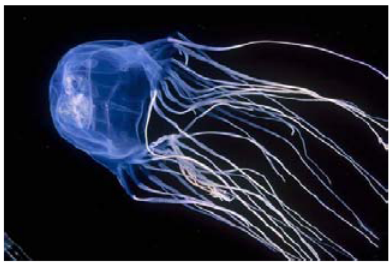
Adult

3. Jellyfish (polo lia)



Larva

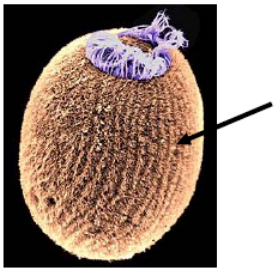
Jellyfish larvae have 8 forked extensions. The dark pink bulbs at the base of the forks are called rhopalia, and help the animal to balance.



Adult

Phylum Porifera (sponges)

4. Sponge (‘upi)



Larva

Sponge larvae are covered in rows of cilia (thin projections) that they use to move through the water and collect food particles.

Adult

Phylum Annelida (segmented worms)

5. Polychaete (fire worm)

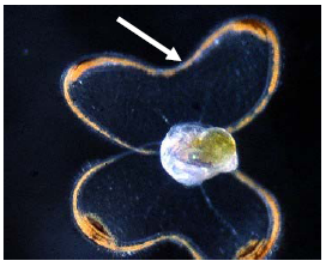
Larva

What could the larva’s bristles be used for?

Adult

Phylum Mollusca (snails, squid, clams, octopuses, limpets, etc.) - Group larval features include a soft transparent body, sometimes contained in a thin shell.

6. Cone snail (pai)

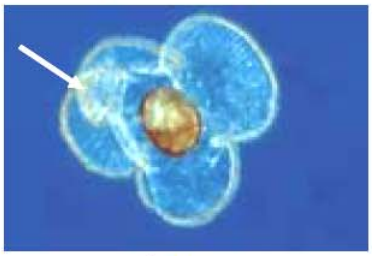


Larva

A snail larva has ciliated flaps called a velum that is used for locomotion and feeding.

Adult shells

7. Limpet (opihi)



Larva

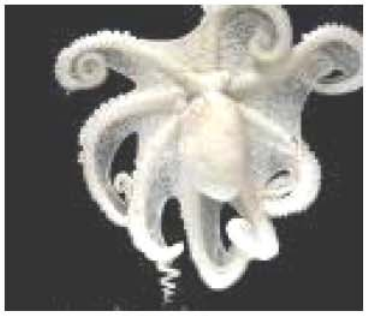
Limpets are another type of snail. Their velum, used for locomotion and feeding, has many folds.

Adult

8. Octopus (he'e)

Larva

Octopuses have well-developed eyes and brains.



Adult

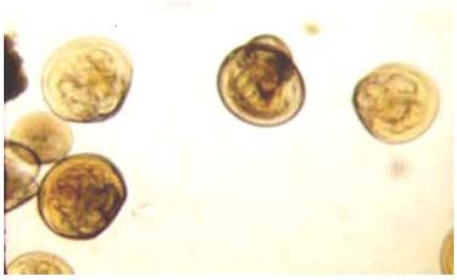
9. Squid (mu he'e)

Larvae

Like octopuses, squid larvae don't have a shell, but their transparent bodies help them avoid detection by predators.

Adult

10. Oyster ('olepe)



Larvae

Oysters belong to the group of mollusks known as bivalves because they have two hinged shells.

Adult encrusted with coral

Phylum Echinodermata (sea stars, sea urchins, sea cucumbers)

11. Sea star (ope'ape'a)

Larva

Sea star larvae use their ciliated arms to help pass food into their mouth as they move through the water.

Adult

12. Sea cucumber (loli)

Larva

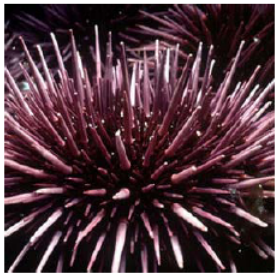
The cilia on the edges of the body lobes enable sea cucumber larvae to move through the water.

Adult

13. Sea urchin (wana)

Larvae

The 4 spiny projections on the sea urchin larvae keep them upright in the water.

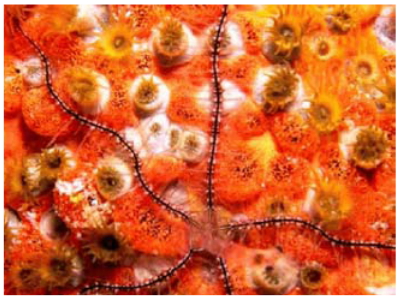


Adult

14. Brittle star

Larva

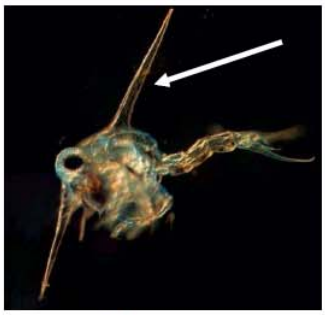
Brittle star larvae are similar to urchin larvae, but have more larval arms.



Adult on coral polyps

Phylum Arthropoda (crab, lobster, barnacles, shrimp, etc.)

15. Crab (papa'i)



Larva

This crab zoea has two long spines on its carapace (a shell that covers the head and upper body) that protect it from predators.

Adult on coral polyps

16. Spiny lobster (ula)

Larva

Lobster larvae are called phyllosoma (Greek for "leaf-like") because they are flat and thin. Why might they be this shape?

Adult

17. Barnacle (pi'oe)

Larva

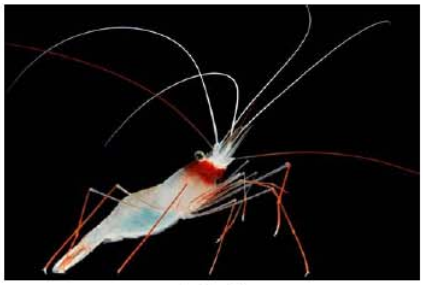
Barnacle larvae only have a single central ocellus (eye), which is too simple to form images but is a good light detector.

Adult

18. Shrimp (‘opae)

Larva

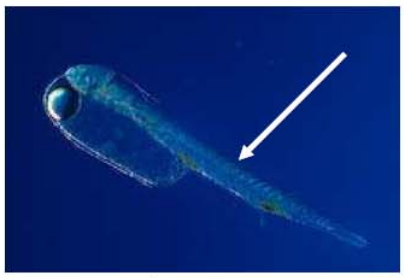
Shrimp larvae have well developed, stalked eyes.



Adult

Phylum Vertebrata (fish)

19. Reef fish (i‘a)



Larva

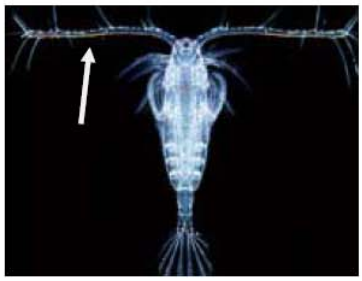
Fish larvae have bilateral symmetry and a distinctive spinal cord.

Adult

B. HOLOPLANKTON (entire life cycle spent as plankton)

Phylum Arthopoda - Group features include segmented body parts and exoskeletons.

20. Copepods



Copepods are easily identified by their two antennae.

21. Amphipod

Amphipods lack a carapace, so their bodies appear to be tucked or folded.

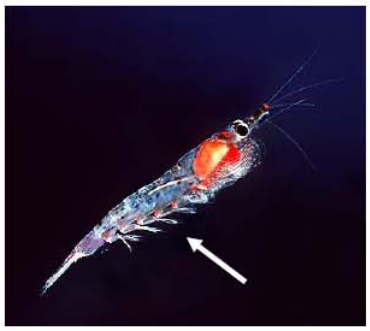
22. Ostracod

Ostracods have a hinged carapace that resembles the shells of bivalves.

23. Cladoceran

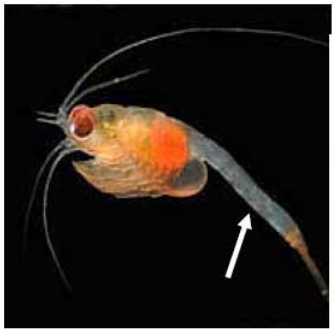
Cladocerans have a hinged carapace that resembles the shells of bivalves.

24. Euphausiid



Euphausiids have 5 pairs of swimming legs.

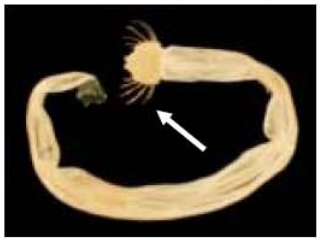
25. Mysid



Compared to euphausiids, the swimming legs are reduced and barely visible.

Phylum Chaetognatha

26. Chaetognath (arrow worm)



Chaetognaths might be small, but they are fierce predators; they use the large spines on their heads for grasping prey.

Phylum Mollusca

27. Pteropod

Pteropods are planktonic mollusks that have modified their foot into wings!

TEACHER GUIDE
Lesson 4: Phytopia

Time Required: 60 minutes. Advance preparation time is an additional 15 minutes (more time may be required for software installation).

Structure: Students use *Phytopia: Discovery of the Marine Ecosystem* (an educational CD) to complete three computer-based activities to investigate various phytoplankton species and common environmental factors that contribute to the development of phytoplankton blooms (~50 minutes total). These activities were designed for students to work independently, without much guidance from a teacher. A pre- and post- survey specific to Lesson 4 is administered at the beginning and end of the lesson (~5 minutes each).

Materials:

1. **PLANKTON SURVEY – Lesson 4**
2. **TEACHER ANSWER KEY to PLANKTON SURVEY – Lesson 4**
3. **STUDENT WORKSHEET – Lesson 4a: Introduction to Phyto Files**
4. **TEACHER ANSWER KEY to STUDENT WORKSHEET – Lesson 4a: Introduction to Phyto Files**
5. **STUDENT WORKSHEET – Lesson 4b: Phytoplankton in the Water Column**
6. **TEACHER ANSWER KEY to STUDENT WORKSHEET – Lesson 4b: Phytoplankton in the Water Column**
7. **STUDENT WORKSHEET – Lesson 4c: Can You Make a Bloom?**
8. **TEACHER ANSWER KEY to STUDENT WORKSHEET – Lesson 4c: Can You Make a Bloom?**
9. *Phytopia: Discovery of the Marine Ecosystem* CD-ROM (20)
10. Headphones (30)
11. Headphone adapters (15)

Materials Not Included in this Kit but Needed for Lesson 4:

12. Student computers with CD-ROM drive

Advance Preparation:

1. Reserve a computer lab (the *Phytopia* CD is compatible with both Macintosh and Windows). Check to see if QuickTime and Adobe Acrobat Reader are installed by inserting the *Phytopia* CD into a computer. If the computer does not have these programs installed, *Phytopia* will prompt you to install the software. *Note: You may need administrator level access to install these programs on the computers, so plan accordingly.*

2. Each computer should have a CD-ROM drive and, if possible, a headphone jack.

3. Photocopy or print **PLANKTON SURVEY – LESSON 4** (two per student). This is given as a pre-survey at the beginning of this lesson and a post-survey at the end of the lesson.

4. Photocopy or print the **STUDENT WORKSHEET – Lesson 4a: Introduction to Phyto Files**, **STUDENT WORKSHEET – Lesson 4b: Phytoplankton in the Water Column**, and **STUDENT WORKSHEET – Lesson 4c: Can You Make a Bloom?** (one of each per student).

Instructional Procedures:

1. Pass out **PLANKTON SURVEY – LESSON 4** (one per student). Have students check the pre-survey box and answer the questions (allow 5 minutes). After this lesson is completed, the students will answer these same questions as a post-survey. A **TEACHER ANSWER KEY** is provided for your convenience.

2. Explain to the students that they will work individually or in pairs (depending on the number of available computers) to investigate phytoplankton using the *Phytopia* program. There are three main modules on *Phytopia*: "Phyto Files", "Phyto Factors", and "Special Topics." Lesson 4a explores the "Phyto Files" component, whereas Lesson 4b and Lesson 4c use the "Phyto Factors" module. If you have Internet access and additional

class time, encourage your students to investigate the "Special Topics." Below are descriptions quoted from the Bigelow Laboratory website (www.bigelow.org/phytopia/phytopia.pdf) that explain each module:

Phyto Files: "The core technology of *Phytopia* is a first-ever searchable database of many important phytoplankton from the world's temperate oceans: The Phyto Files. Also included in this module are three-dimensional cell models and a virtual microscope tool that allows for the viewing of organisms at various magnifications, under various epifluorescence techniques, and by scanning electron microscopy. Users can better understand each species' unique form and function including cell wall type, motility, and potential harmfulness."

Phyto Factors: "[This] module promotes discovery of the ties between physical forcing and marine ecosystem response, focusing on how environment affects the chlorophyll content and species composition of the upper ocean. It also helps users connect ocean primary productivity patterns with environmental factors in several geographic areas. Innovative tools allow investigation of co-registered temperature, wind, current, nutrient, and ocean color data."

Special Topics: "[This component] provides a link from *Phytopia* to related resources on the Bigelow Laboratory website (www.bigelow.org/phytopia). This module will provide access to material that is developed after the CD-ROM is distributed, including interesting topics such as harmful algal blooms."

3. There is sound associated with the *Phytopia* program, but it is not essential to complete the lessons. If the computers have headphone jacks, we recommend using sound to make the lessons more engaging. If two students are sharing a computer, have them use a headphone adapter. Plug both sets of headphones into the adapter, and then plug the adapter into the headphone jack on the computer. If headphone jacks are not available, the sounds may be distracting. Have the students turn off the sound in the *Phytopia* program by clicking on the "Menu" icon, highlighting "Sound On/Off", then clicking on "Music-ON", or they can simply turn off the speakers directly.

4. Distribute a set of three student worksheets to each student, and have them complete the lessons in sequential order (i.e., starting with Lesson 4a).

5. If there is an Internet connection available, encourage students that finish early to explore the "Special Topics" module. The link on the "Menu" icon will take students directly to the online resources.

Assessment and Clean-up:

1. Pass out **PLANKTON SURVEY – LESSON 4** (one per student). Have students check the post-survey box and answer the questions (allow 5 minutes). A **TEACHER ANSWER KEY** is provided for your convenience.

2. As the students are completing their surveys, we would be grateful if you would complete the **TEACHER EVALUATION** in this kit. All comments, corrections, and suggestions are very welcome. If you prefer, you can complete the evaluation online (see **TEACHER EVALUATION** for website address). If you are completing the optional extension activity, please complete the evaluation at the end of that activity.

3. Collect the *Phytopia* CDs from the students. Please double check that the CDs are actually in the cases.

4. To prevent the cords from becoming entangled, repackage the headphones and adapters into sets. Each set should contain 2 headphones connected to a headphone adapter. Put the 15 complete sets in the Audio bag.

5. Re-pack the kit for return to C-MORE. Double check that all the items are included by completing the **SUPPLY CHECKLIST**. Please make a note of missing, broken, or damaged items so that they can be replaced. Please pack the kit so that the materials are stored as they were when you received them.

Mahalo!

PLANKTON SURVEY – LESSON 4

Check one:

_____ Pre-survey Name: _____

_____ Post-survey

Directions:

This survey is both a pre- and post- survey. Put a check mark at the top of this paper next to the survey you are doing (pre- or post- survey). Please answer each question to the best of your ability. Circle the most correct answer.

1. Nutrients are more abundant in (the) _____.
    a. upper ocean
    b. deep ocean
    c. coral reefs

2. Phytoplankton are found in the upper part of the ocean because there is a lot of _____.
    a. oxygen
    b. nutrients
    c. sunlight
    d. all of the above

3. Blooms of phytoplankton will _____ nutrients in the upper part of the ocean.
    a. decrease
    b. increase

4. Tropical oceans appear very blue because there _____ a lot of phytoplankton in the water and the photic zone is _____.
    a. are/shallow
    b. aren't/shallow
    c. are/deep
    d. aren't/deep

5. Nutrients are brought up to the surface ocean by_____.
    a. winds
    b. currents
    c. tides
    d. all of the above

TEACHER ANSWER KEY
PLANKTON SURVEY – LESSON 4

Check one:
_____ Pre-survey
_____ Post-survey

Email kits@soest.hawaii.edu to request a completed teacher answer key. Please include name, school and grade(s) taught in your request. Mahalo!

Name: _____

Directions:
This survey is both a pre- and post- survey. Put a check mark at the top of this paper next to the survey you are doing (pre- or post- survey). Please answer each question to the best of your ability. Circle the most correct answer.

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   b. nutrients
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   d. all of the above

3. Blooms of phytoplankton will _____ nutrients in the upper part of the ocean.
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   b. increase

4. Tropical oceans appear very blue because there _____ a lot of phytoplankton in the water and the photic zone is _____.
   a. are/shallow
   b. aren't/shallow
   c. are/deep
   d. aren't/deep

5. Nutrients are brought up to the surface ocean by_____.
   a. winds
   b. currents
   c. tides
   d. all of the above

Name: _____ Period:_____

STUDENT WORKSHEET

Lesson 4a: Introduction to Phyto Files

Note: This lesson was developed by Susan Richman, South Portland High School, Maine and is available at http://www.bigelow.org/phytopia/ideas.html. It was reformatted and slightly modified by C-MORE for this kit.

Directions:

1. Insert your CD. This CD has sound, so you will need to wear your headphones. Insert the headphones into the headphone jack on the computer. If you are sharing a computer with another student, insert both headphones into the headphone adapter and then plug the adapter into the headphone jack on the computer.

2. After the introduction, select "Phyto Files" (located in the bottom left hand corner). The Phyto Files allow you to view different types of phytoplankton. A list of the species included on this CD is located in the lower right corner. This CD profiles 36 species. Thousands of species exist, so this is merely a sampling of the organisms. You can view these organisms in a variety of ways, but not all options are available for every species.

   Some Viewing Suggestions:
   - Give the images and the program time to load. If you click too quickly, you will run into trouble.
   - If you cannot see the entire organism, or you wish to see a larger image, click ⊕.
   - You may also change the magnification from 10X to 20X to 40X to 100X. If you would like, you can use the controls to change your field of view and/or center the specimen.
   - To rotate the image, left click on the picture and hold the button down as you move the mouse.
   - Remember to "Clear Search" between questions to ensure that all organisms are listed.

3. First search by attribute. Below the Quick Search box, you will find five different attributes: Shape, Class, Morphotype, Harmful, and Protrusions. Once you have selected an attribute, the choices associated with that feature are listed to the left. For example, if you select "Shape", the choices are circular, feather-shaped, and other.

   a) View two circular species and list their scientific names.

   b) View two feather-shaped species and list their scientific names.

   c) Select "other" and see what pops up. Describe or sketch one of these species.

   d) Click "Clear Search" (above "Shape"). Next, go to "Class." How many diatom species are on this CD?

      How many dinoflagellate species are on this CD?

   e) What are the options under Morphotype? View examples of each morphotype.

f) Click “Clear Search.” How many harmful species are included on this CD?

How many species on this CD are not harmful?

g) Click “Clear Search.” List the types of “Protrusions”. Describe how they look and their possible functions.

4. The image options are Blue, Green, UV, SEM (scanning electron microscope), View, 3D View, and In Action. Answer the three questions below by clicking on the ? near epifluorescence.

   a) What can you see with blue light? Which cellular features are highlighted?

   b) What can you see with green light? Which cellular features are highlighted?

   c) What can you see with UV light? Which cellular features are highlighted?

5. For each statement below, write the scientific name of the species. Choose a different species for each view.

   a) Find a species that offers a 3D view.

   b) Find a species that offers a SEM view.

   c) Find a species that offers a blue view.

   d) Find a species that offers a green view.

   e) Find a species that offers a UV view.

   f) Which view do you like best? Why?

6. Choose three organisms and read about them. If you need help with some of the vocabulary, go to the glossary.

   a) List the species that you examined.

   b) Describe three similarities among these phytoplankton species

   c) Describe three differences among these phytoplankton species.

TEACHER ANSWER KEY to STUDENT WORKSHEET

Lesson 4a: Introduction to Phyto Files

Note: This lesson was developed by Susan Richman, South Portland High School, Maine and is available at http://www.bigelow.org/phytopia/ideas.html. It was reformatted and slightly modified by C-MORE for this kit.

Directions:

1. Insert your CD. This CD has sound, so you will need to wear your headphones. Insert the headphones into the headphone jack on the computer. If you are sharing a computer with another student, insert both headphones into the headphone adapter and then plug the adapter into the headphone jack on the computer.

2. After the introduction, select "Phyto Files" (located in the bottom left hand corner). The Phyto Files allow you to view different types of phytoplankton. A list of the species included on this CD is located in the lower right corner. This CD profiles 36 species. Thousands of species exist, so this is merely a sampling of the organisms. You can view these organisms in a variety of ways, but not all options are available for every species.

   Some Viewing Suggestions:
   - Give the images and the program time to load. If you click too quickly, you will run into trouble.
   - If you cannot see the entire organism, or you wish to see a larger image, click ⊕.
   - You may also change the magnification from 10X to 20X to 40X to 100X. If you would like, you can use the controls to change your field of view and/or center the specimen.
   - To rotate the image, left click on the picture and hold the button down as you move the mouse.
   - Remember to "Clear Search" between questions to ensure that all organisms are listed.

3. First search by attribute. Below the Quick Search box, you will find five different attributes: Shape, Class, Morphotype, Harmful, and Protrusions. Once you have selected an attribute, the choices associated with that feature are listed to the left. For example, if you select "Shape", the choices are circular, feather-shaped, and other.

   a) View two circular species and list their scientific names.

   Email kits@soest.hawaii.edu to request a completed teacher answer key. Please include name, school and grade(s) taught in your request. Mahalo!

   b) View two feather-shaped species and list their scientific names.

   c) Select "other" and see what pops up. Describe or sketch one of these species.

   d) Click "Clear Search" (above "Shape"). Next, go to "Class." How many diatom species are on this CD?

   How many dinoflagellate species are on this CD?

   e) What are the options under Morphotype? View examples of each morphotype.

f) Click "Clear Search." How many harmful species are included on this CD?

How many species on this CD are not harmful?

Email kits@soest.hawaii.edu to request a completed teacher answer key. Please include name, school and grade(s) taught in your request. Mahalo!

g) Click "Clear Search." List the types of "Protrusions". Describe how they look and their possible functions.

4. The image options are Blue, Green, UV, SEM (scanning electron microscope), View, 3D View, and In Action. Answer the three questions below by clicking on the ? near epifluorescence.

   a) What can you see with blue light? Which cellular features are highlighted?

   b) What can you see with green light? Which cellular features are highlighted?

   c) What can you see with UV light? Which cellular features are highlighted?

5. For each statement below, write the scientific name of the species. Choose a different species for each view.

   a) Find a species that offers a 3D view.

   b) Find a species that offers a SEM view.

   c) Find a species that offers a blue view.

   d) Find a species that offers a green view.

   e) Find a species that offers a UV view.

   f) Which view do you like best? Why?

6. Choose three organisms and read about them. If you need help with some of the vocabulary, go to the glossary.

   a) List the species that you examined.

   b) Describe three similarities among these phytoplankton species

   c) Describe three differences among these phytoplankton species.

Name: _____ Period: _____

STUDENT WORKSHEET

Lesson 4b: Phytoplankton in the Water Column

Note: This lesson was created by Phytopia and is available at http://www.bigelow.org/phytopia/ideas.html. It has been reformatted and slightly modified by C-MORE for this science kit.

Directions:

1. Click on the menu at the bottom of the screen, and select "Phyto Factors."
2. You will view an introductory movie. While watching this movie, take notes on the important environmental conditions that affect phytoplankton growth. We've helped you with your note-taking by providing the guide below. As you take notes below, you can pause, rewind, or forward the movie with the control buttons below the movie screen.

Notes:

1. Environmental Factors that Affect Phytoplankton Growth and Distribution
   a. Sunlight
   b. Wind-driven _____ *(noun)* which can impact:
      i. Temperature
      ii. _____ *(noun)*
2. Phytoplankton Survival Requirements
   a. Carbon – *Choose one:* abundant *OR* can be limited
   b. _____ – *Choose one:* abundant *OR* can be limited
   c. _____ – *Choose one:* abundant *OR* can be limited
3. Sunlight
   a. Define "photic zone"
      _____
      _____
   b. Depth of photic zone is determined by
      _____ and
      _____
   c. Tropical oceans appear very blue because there aren't a lot of _____ *(noun)* in the water and the photic zone is _____ *(adjective)*.
   d. More productive waters have more _____ *(noun)* which scatter and absorb the sunlight, making the photic zone _____*(adjective)*.
   e. Ocean colors during a bloom can be _____, _____, _____, or _____.
4. Nutrients
   a. Nutrients accumulate in deeper waters.
   b. Nutrients are brought up to the photic zone by _____ *(noun)*, _____ *(noun)*, and _____ *(noun).*
5. Blooms
   a. Adequate sunlight and nutrients can cause blooms of _____ *(noun)*.
   b. Blooms of phytoplankton will deplete _____ *(noun)* in the photic zone.
   c. Continued heating by the sun causes the upper ocean to become _____ *(adjective)*.
   d. Define "thermocline"
      _____
      _____
   e. _____ *(noun)* can swim through the thermocline so they can travel between the sunlit surface waters and the deeper nutrient-rich waters.
   f. _____ *(noun)* feed on phytoplankton.
   g. All organisms eventually die and decompose, and contribute to the pool of _____ *(noun)* in the ocean.

TEACHER ANSWER KEY to STUDENT WORKSHEET

Lesson 4b: Phytoplankton in the Water Column

Note: This lesson was created by Phytopia and is available at http://www.bigelow.org/phytopia/ideas.html. It has been reformatted and slightly modified by C-MORE for this science kit.

Directions:

1. Click on the menu at the bottom of the screen, and select "Phyto Factors."
2. You will view an introductory movie. While watching this movie, take notes on the important environmental conditions that affect phytoplankton growth. We've helped you with your note-taking by providing the guide below. As you take notes below, you can pause, rewind, or forward the movie with the control buttons below the movie screen.

Notes:

1. Environmental Factors that Affect Phytoplankton Growth and Distribution
   a. Sunlight
   b. Wind-driven _____ *(noun)* which can impact:
      i. Temperature
      ii. _____ *(noun)*
2. Phytoplankton Survival Requirements
   a. Carbon – *Choose one:* abundant *OR* can be limited
   b. _____ – *Choose one:* abundant *OR* can be limited
   c. _____ – *Choose one:* abundant *OR* can be limited
3. Sunlight
   a. Define "photic zone"
      _____
      _____
   b. Depth of photic zone is determined by
      _____ and
      _____
   c. Tropical oceans appear very blue because there aren't a lot of _____ *(noun)* in the water and the photic zone is _____ *(adjective)*.
   d. More productive waters have more _____ *(noun)* which scatter and absorb the sunlight, making the photic zone _____*(adjective)*.
   e. Ocean colors during a bloom can be _____, _____, _____, or _____.
4. Nutrients
   a. Nutrients accumulate in deeper waters.
   b. Nutrients are brought up to the photic zone by _____ *(noun)*, _____ *(noun)*, and _____ *(noun).*
5. Blooms
   a. Adequate sunlight and nutrients can cause blooms of _____ *(noun)*.
   b. Blooms of phytoplankton will deplete _____ *(noun)* in the photic zone.
   c. Continued heating by the sun causes the upper ocean to become _____ *(adjective)*.
   d. Define "thermocline"
      _____
      _____
   e. _____ *(noun)* can swim through the thermocline so they can travel between the sunlit surface waters and the deeper nutrient-rich waters.
   f. _____ *(noun)* feed on phytoplankton.

All organisms eventually die and decompose, and contribute to the pool of _____ *(noun)* in the ocean.

Email kits@soest.hawaii.edu to request a completed teacher answer key. Please include name, school and grade(s) taught in your request. Mahalo!

Name: _____ Period: _____

STUDENT WORKSHEET

Lesson 4c: Can You Make a Bloom?

Note: This lesson was created by Phytopia and is available at http://www.bigelow.org/phytopia/ideas.html. It has been reformatted and slightly modified by C-MORE for this science kit.

Directions:

1. You should be in the "Phyto Factors" section at this point. (If you do not see "Phyto Factors" in the upper right hand corner of the screen, click on the menu at the top of the screen, and select "Phyto Factors." If you have already viewed the introductory movie for this section, you can skip ahead by clicking twice on the "Next" arrow at the bottom right corner of your screen.)
2. Select "Use Bloom Activation Tool."
3. View the brief movie to learn how to control the Bloom Activation Tool.
4. Use the Bloom Activation Tool to complete the exercise below.

Bloom Activation Tool:

Step #1: Use the Bloom Activation Tool to try to create a phytoplankton bloom in the Gulf of Maine. Push the "Activate" button to start the simulation. Keep track of the conditions you choose and your results in the tables below. Once you have successfully created a bloom, move on to Step #2 below.

Trial #1:

Conditions Chosen	
Sunlight	
Temperature	
Wind	
Results	
Number of Blooms Formed	

Trial #2:

Conditions Chosen	
Sunlight	
Temperature	
Wind	
Results	
Number of Blooms Formed	

Trial #3:

Conditions Chosen	
Sunlight	
Temperature	
Wind	
Results	
Number of Blooms Formed	

Step #2: Let's look back at the conditions you needed to choose to create a bloom. Using your knowledge of phytoplankton needs, can you hypothesize why those conditions favored a bloom in the Gulf of Maine? Write your answer in the box below.

Step #3: Now that you have created at least one bloom, investigate it! Drag your cursor over either the false color image or the true color image of the Gulf of Maine. When you see a blue number appear, click on it and learn more about the bloom in that area. Use the table below to take notes on what you learn.

Bloom Analysis	
Bloom Number	
Region of Bloom	
Temperature	
Depth	
Conditions	
Organisms Present	
Other Information	

Step #4: Now let's take a closer look at one of the organisms you found in your bloom. Click on the organism name, and you will be taken to either the "Glossary" or "Phyto File" associated with that organism. If you are taken to the "Glossary", choose another organism to investigate. Use the table below to take notes on what you learn.

Organism Analysis	
Organism Name	
Sketch	
Trophic Type	
Shape	
Harmful?	
Swim or Suspend?	
Other Facts You Find Interesting	

Step #5: Finally, let's use our knowledge of phytoplankton characteristics to further our understanding of your organism.

A. Look at your organism's "trophic type." Is your organism **photo**trophic, **hetero**trophic, or **mixo**trophic? What does this tell you about how your organism gets its nutrition? (If you need help with any of the terms, go back to your "Bloom Activation Results", click on the "menu" button at the top of the screen, and then select the "glossary".)

B. Does your organism swim or suspend? What does this tell you about how your organism would respond to the development of a **thermocline**?

C. What other "cool characteristics" does your organism have that you think make it interesting?

TEACHER ANSWER KEY to STUDENT WORKSHEET

Lesson 4c: Can You Make a Bloom?

Note: This lesson was created by Phytopia and is available at http://www.bigelow.org/phytopia/ideas.html. It has been reformatted and slightly modified by C-MORE for this science kit.

Email kits@soest.hawaii.edu to request a completed teacher answer key. Please include name, school and grade(s) taught in your request. Mahalo!

Directions:

1. You should be in the "Phyto Factors" section at this point. (If you do not see "Phyto Factors" in the upper right hand corner of the screen, click on the menu at the top of the screen, and select "Phyto Factors." If you have already viewed the introductory movie for this section, you can skip ahead by clicking twice on the "Next" arrow at the bottom right corner of your screen.)
2. Select "Use Bloom Activation Tool."
3. View the brief movie to learn how to control the Bloom Activation Tool.
4. Use the Bloom Activation Tool to complete the exercise below.

Bloom Activation Tool:

Step #1: Use the Bloom Activation Tool to try to create a phytoplankton bloom in the Gulf of Maine. Push the "Activate" button to start the simulation. Keep track of the conditions you choose and your results in the tables below. Once you have successfully created a bloom, move on to Step #2 below.

Trial #1:

Conditions Chosen	
Sunlight	
Temperature	
Wind	
Results	
Number of Blooms Formed	

Trial #2:

Conditions Chosen	
Sunlight	
Temperature	
Wind	
Results	
Number of Blooms Formed	

Trial #3:

Conditions Chosen	
Sunlight	
Temperature	
Wind	
Results	
Number of Blooms Formed	

Step #2: Let's look back at the conditions you needed to choose to create a bloom. Using your knowledge of phytoplankton needs, can you hypothesize why those conditions favored a bloom in the Gulf of Maine? Write your answer in the box below.

Email kits@soest.hawaii.edu to request a completed teacher answer key. Please include name, school and grade(s) taught in your request. Mahalo!

Step #3: Now that you have created at least one bloom, investigate it! Drag your cursor over either the false color image or the true color image of the Gulf of Maine. When you see a blue number appear, click on it and learn more about the bloom in that area. Use the table below to take notes on what you learn.

Bloom Analysis	
Bloom Number	
Region of Bloom	
Temperature	
Depth	
Conditions	
Organisms Present	
Other Information	

Step #4: Now let's take a closer look at one of the organisms you found in your bloom. Click on the organism name, and you will be taken to either the "Glossary" or "Phyto File" associated with that organism. If you are taken to the "Glossary", choose another organism to investigate. Use the table below to take notes on what you learn.

Organism Analysis	
Organism Name	
Sketch	
Trophic Type	
Shape	
Harmful?	
Swim or Suspend?	
Other Facts You Find Interesting	

Step #5: Finally, let's use our knowledge of phytoplankton characteristics to further our understanding of your organism.

D. Look at your organism's "trophic type." Is your organism **photo**trophic, **hetero**trophic, or **mixo**trophic? What does this tell you about how your organism gets its nutrition? (If you need help with any of the terms, go back to your "Bloom Activation Results", click on the "menu" button at the top of the screen, and then select the "glossary".)

Email kits@soest.hawaii.edu to request a completed teacher answer key. Please include name, school and grade(s) taught in your request. Mahalo!

E. Does your organism swim or suspend? What does this tell you about how your organism would respond to the development of a **thermocline**?

F. What other "cool characteristics" does your organism have that you think make it interesting?

TEACHER GUIDE
Extension: Let's Build a Plankton Net

Time Required: 30 minutes. Additional time is required to obtain materials.

Structure: This extension activity enables students to construct their own plankton nets using common household materials. This can be completed as a classroom activity or for students to complete at home.

Materials:

1. **STUDENT INSTRUCTIONS – Extension: Let's Build a Plankton Net**
2. Example of a handmade plankton net

Materials Not Included in this Kit but Needed for Extension Activity:

Common supplies (per group of ~4 students):

3. Duct tape
4. Stapler
5. Scissors
6. Hole punch
7. Measuring tape or ruler

Student supplies (per student):

8. Metal wire or clothes hanger about 15 inches
9. Key ring
10. 2 short pieces of rope (1/8" wide x 16" long)
11. 1 long piece of rope (1/8" wide x 24" long)
12. Rubber band
13. Baby food jar (or small vial)
14. Nylon knee high stocking
15. Small weight (or sinker for fishing line)

Advance Preparation:

1. Obtain (or have students provide) the above materials.
2. Photocopy the **STUDENT INSTRUCTIONS – Extension: Let's Build a Plankton Net** (one per student or one per pair of students).

Instructional Procedures:

1. Divide the students into groups of four. Deliver one set of common supplies to each group and one set of student supplies to each student.
2. Have students build a plankton net by following the **STUDENT INSTRUCTIONS – Extension: Let's Build a Plankton Net**.

Assessment and Clean-up:

1. We would be grateful if you would complete the **TEACHER EVALUATION** in this kit. All comments, corrections, and suggestions are very welcome. If you prefer, you can complete the evaluation online (see **TEACHER EVALUATION** for website address).
2. Re-pack the kit for return to C-MORE. Double check that all the items are included by completing the **SUPPLY CHECKLIST**. Please make a note of missing, broken, or damaged items so that they can be replaced. Please pack the kit so that the materials are stored as they were when you received them.

Mahalo!

STUDENT INSTRUCTIONS

Extension: Let's Build a Plankton Net

In this lesson, you will be creating your own miniature plankton net using common household materials. The plankton net will be made out of a nylon stocking, which has an approximate mesh size of 100 to 300 micrometers. This mesh size is small enough to collect zooplankton. After you have finished building your plankton net, go to the beach and conduct a plankton tow by dragging the net through the water. You can use a magnifying glass or a microscope to examine the plankton that you catch! *Note: This plankton net is intended for single use only, or as a keepsake to share with your friends and family.*

Materials

Per student:
- Metal wire or clothes hanger
- Key ring
- 2 short pieces of rope
- 1 long piece of rope
- Rubber band
- Baby food jar (or small vial)
- Nylon knee high stocking
- Small weight or sinker

Per group:
- Duct tape
- Stapler
- Scissors
- Hole punch
- Measuring tape or ruler

Instructions

1. Bend the metal wire into a circle that is about 4 inches in diameter, and overlap the loose ends by a couple of inches.

2. Use duct tape to fasten the ends together.

3. Put the nylon stocking on the metal circle that you just created. Make sure the hole in the stocking is in the center of the circle.

4. Secure the nylon stocking by using staples.

5. Place 4 staples at an equal distance around the circle.

6. Tie a knot in the bottom of the stocking.

7. Put the weight into the stocking. This will help the end of the net sink during a tow.

8. Put a small vial or baby food jar inside the stocking. This will become your collection bucket (or cod end).

9. Put the rubber band around the stocking so that it is around the rim of the jar.

10. Cut 4 strips of duct tape, each about 1 inch in width. Put the pieces of duct tape around the top of the net so that they are evenly spaced. Do not put any duct tape where the metal ring overlaps.

11. Put a hole in each piece of duct tape (as close to the edge as possible) using the hole punch. You may need to use scissors to finish creating the hole.

12. Locate the two shorter pieces of rope and the key ring. These items will be used to make the bridle. Line up the two pieces of rope and put them through the key ring. Put the key ring in the center of the pieces of rope.

13. Now take the ends of both pieces of rope together and tie them in a knot, so that the key ring stays in the center.

14. Attach the bridle to the plankton net by placing each end of the bridle through the holes in the duct tape, making sure the key ring is facing away from the net. Attach it by tying a knot at the end of each piece of rope. Make sure your knot is bigger than the hole.

15. Take the long piece of rope and put a loop at the end.

16. Now attach the long piece of rope (which will be your handle) to the key ring. Attach the rope by tying the end of the rope without the loop to the key ring.

17. Congratulations – you have a plankton net!

GLOSSARY

algae	(al–jee); Plant-like organisms in the ocean. Example: seaweed.
bilateral symmetry	(bye-lat-er-ill sim-ah-tree); The arrangement of a body which can be divided into two halves that are mirror images of one another.
carapace	(kah-rup-ess); A shell that covers the head and upper body.
cilia	(sill-ee-ah); Fine hair-like projections extending from the animal's body. (Ciliated is the adjective.)
cod end	The narrow end of a **plankton net** where the collection bucket is found.
diatom	(dye-uh-tom); A type of **phytoplankton**. Diatoms are single-celled **algae** whose cell walls contain silica, which is the main component of most types of glass.
dinoflagellate	(dye-noh-flaj-uh-lit); A type of **phytoplankton** found in the upper ocean. Dinoflagellates can move short distances using their two tail-like projections.
food web	The predator-prey relationships within an ecosystem or habitat.
holoplankton	(hole-oh-plank-ton); A type of **zooplankton** (animal-like) that spend their entire lives as **plankton.** Holoplankton are permanent **zooplankton**.
larva	The early, free-living immature form of an animal. (Larvae is the plural form of **larva**. Larval is the adjective.)
marine	Relating to the ocean or sea.
meroplankton	(mer-oh-plank-ton); A type of **zooplankton** that only spend part of their lives as **plankton.** Meroplankton are temporary zooplankton.
organism	A living thing.
photosynthesis	(foe-toe-sinth-uh-sis); The way that plants make food. Photosynthesis requires sunlight, carbon dioxide and water, and produces sugar and oxygen.
phytoplankton	(fight-o-plank-ton); Microscopic plant-like **organisms** that live in the ocean.
phytoplankton bloom	A fast increase in the numbers of one or more kinds of **phytoplankton**.
plankton	**Organisms** that drift in water and cannot swim against major currents. Plankton are found in both marine and fresh water environments. Zooplankton and phytoplankton are both plankton.
plankton net	A cone-shaped nylon net with small holes that are large enough to allow water to pass through but small enough to trap **plankton**.
plankton tow	The process of towing or pulling a **plankton net** through the water behind a boat or ship in order to catch and concentrate **plankton**.

symbiotic (sim–by–ah–tick); A type of relationship between two or more species that live closely together, for example, anemone and **algae**. The **algae** provide food for the anemone and the anemone provide a habitat for **algae**.

velum A part of the body covered with **cilia**.

zoea (zoh-a); Free-swimming crab **larva**.

zooplankton (zoh-plank-ton); Animal-like organisms that drift in water and cannot swim against major currents.

TEACHER EVALUATION

http://www.surveymonkey.com/s/CMORE-kit-evaluation

1. Please circle the C-MORE science kit used:

Marine Debris	**Ocean Acidification**	**Plankton**
Marine Mystery	**Ocean Conveyor Belt**	**Random Sampling**
Nautical Knots and Maritime Careers		

2. I borrowed this science kit from_____.

3. Please rate how strongly you agree or disagree with each of the following statements.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Online kit reservation was easy.	1	2	3	4	5
Picking up this science kit was difficult.	1	2	3	4	5
This science kit was easy to use.	1	2	3	4	5
The Teacher Guide was difficult to follow.	1	2	3	4	5
My students enjoyed using this science kit.	1	2	3	4	5
I would not borrow this science kit in the future.	1	2	3	4	5
I will borrow other C-MORE science kits.	1	2	3	4	5

Comments:

4. Are the time estimates given for each lesson reasonable? If not, please explain.

5. How did you use this science kit? (Example: in a 6th grade public school classroom to introduce a unit on…)

6. Did you use the entire science kit? If you omitted any lessons or activities, please list which ones and explain why you skipped them.

7. Were your students involved and interested in the science kit activities?

8. Please suggest two things that could be improved.

9. Any other comments?

10. Please tell us about your students. As we are committed to serving underrepresented populations, please estimate the number of your students in the following categories:

School (optional): _____

Grade(s) kit was used with:_____

___ **Total number of students**

___ African American
___ Filipino
___ Hispanic
___ Native American
___ Native Hawaiian or Pacific Islander
___ Other (please specify)

___ Learning disabled
___ Eligible for free or reduced lunch
___ Neither parent attended college
___ Physically disabled

11. Please fill out the following information if you would like to be notified of other C-MORE programs (workshops, grant opportunities, teachers aboard research ships, etc).

Name_____

City/Town_____

State_____

Zip_____

Email Address_____

Thank you for your feedback.

SUPPLY CHECKLIST
Plankton

Use the boxes to check off each item as you reassemble this kit.
Note: This checklist is three pages.

Contents of Binder:

- ☐ Front pocket
  - ☐ CD (contains narrated PowerPoint and electronic versions of everything in binder)
  - ☐ C-MORE *Key Concepts in Microbial Oceanography* brochure
  - ☐ C-MORE *Microbial Oceanography: Resources for Teachers* brochure
- ☐ Front Materials
  - ☐ **PLANKTON** (provides a general overview & standards addressed)
- ☐ Lesson 1 Tab
  - ☐ **TEACHER GUIDE – Lesson 1: Introduction to Plankton**
  - ☐ **PLANKTON SURVEY – Lessons 1, 2, and 3: Version 1** (geared towards elementary school standards)
  - ☐ **TEACHER ANSWER KEY to PLANKTON SURVEY – Lessons 1, 2, and 3: Version 1**
  - ☐ **PLANKTON SURVEY – Lessons 1, 2, and 3: Version 2** (geared towards middle school standards)
  - ☐ **TEACHER ANSWER KEY to PLANKTON SURVEY – Lessons 1, 2, and 3: Version 2**
  - ☐ **POWERPOINT SCRIPT**
  - ☐ **STUDENT WORKSHEET – POWERPOINT – Lesson 1: Introduction to Plankton**
  - ☐ **TEACHER ANSWER KEY to STUDENT WORKSHEET – POWERPOINT – Lesson 1: Introduction to Plankton**
  - ☐ **STUDENT WORKSHEET – Lesson 1: Phytoplankton Microscopy Lab**
  - ☐ **SLIDES – Lesson 1: Phytoplankton Microscopy Lab**
  - ☐ **ANSWER KEY – Lesson 1: Phytoplankton Microscopy Lab**
  - ☐ **PHYTOPLANKTON ID GUIDE – Lesson 1: Phytoplankton Microscopy Lab**
- ☐ Lesson 2 Tab
  - ☐ **TEACHER GUIDE – Lesson 2: Design Your Own Phytoplankton**
  - ☐ **GRADING SHEETS – Lesson 2: Design Your Own Phytoplankton**
- ☐ Lesson 3 Tab
  - ☐ **TEACHER GUIDE – Lesson 3: Zooplankton Microscopy Lab**
  - ☐ **MATERIALS PHOTO GUIDE – Lesson 3: Zooplankton Microscopy Lab**
  - ☐ **STUDENT WORKSHEET – Lesson 3: Zooplankton Microscopy Lab**
  - ☐ **ZOOPLANKTON ID GUIDE (Drifting Along) – Lesson 3: Zooplankton Microscopy Lab**
- ☐ Lesson 4 Tab
  - ☐ **TEACHER GUIDE – Lesson 4: Phytopia**
  - ☐ **PLANKTON SURVEY – Lesson 4**
  - ☐ **TEACHER ANSWER KEY to PLANKTON SURVEY – Lesson 4**
  - ☐ **STUDENT WORKSHEET – Lesson 4a: Introduction to Phyto Files**
  - ☐ **TEACHER ANSWER KEY to STUDENT WORKSHEET – Lesson 4a: Introduction to Phyto Files**
  - ☐ **STUDENT WORKSHEET – Lesson 4b: Phytoplankton in the Water Column**
  - ☐ **TEACHER ANSWER KEY to STUDENT WORKSHEET – Lesson 4b: Phytoplankton in the Water Column**
  - ☐ **STUDENT WORKSHEET – Lesson 4c: Can You Make a Bloom?**
  - ☐ **TEACHER ANSWER KEY to STUDENT WORKSHEET – Lesson 4c: Can You Make a Bloom?**
- ☐ Extension Tab
  - ☐ **TEACHER GUIDE – Extension: Let's Build a Plankton Net**
  - ☐ **STUDENT INSTRUCTIONS – Extension: Let's Build a Plankton Net**
- ☐ Glossary Tab
  - ☐ **GLOSSARY**

- ☐ Teacher Evaluation Tab
  - ☐ Completed **TEACHER EVALUATION**
- ☐ Supply Checklist Tab
  - ☐ Completed **SUPPLY CHECKLIST**
- ☐ Back Pocket
  - ☐ Motic Images Plus CD
  - ☐ Motic Live Imaging Module: Quick Start Guide
  - ☐ Motic Instruction Manual SMZ-143

Lesson 2 Supplies:

- ☐ Black construction paper
- ☐ Oil pastels (5 packs)

Lesson 3 Supplies:

- ☐ Plankton net with attached line
- ☐ Zooplankton Lab Supply Bag
  - ☐ Plastic bottle to transport plankton back to the classroom (1)
  - ☐ Squeeze bottle to rinse sample from net (1)
  - ☐ Plankton sieve (1)
  - ☐ Plastic beakers (5)
  - ☐ Plastic droppers (5)
  - ☐ Petri dishes (5)
  - ☐ Dissecting needles: straight (2), curved (1)

INNER BOX (put in bottom of kit):

Lesson 1 Supplies

- ☐ Speakers
- ☐ **SLIDES – Lesson 1: Phytoplankton Microscopy Lab** (5 in File Folder)
- ☐ **PHYTOPLANKTON ID GUIDE – Lesson 1: Phytoplankton Microscopy Lab** (10 in File Folder)
- ☐ Reference books (4)
  - ☐ The Invisible ABCs
  - ☐ Sea Soup Phytoplankton
  - ☐ Sea Soup Zooplankton
  - ☐ Sea Soup Teacher's Guide
- ☐ Giant Microbes (5)
  - ☐ Krill, Red Tide, Sea Sparkle, Algae, T4 Virus

Lesson 3 Supplies

- ☐ **ZOOPLANKTON ID GUIDE (Drifting Along) – Lesson 3: Zooplankton Microscopy Lab** (5 in File Folder)

Lesson 4 Supplies

- ☐ *Phytopia: Discovery of the Marine Ecosystem* CD-ROM (20)
- ☐ Audio Bag
  - ☐ Headphones (30)
  - ☐ Headphone adapters (15)

Extension Activity Supplies

- ☐ Example of a handmade plankton net

MICROSCOPE BOX:

Lesson 3 Supplies

- ☐ Motic digital dissecting microscope (1)
- ☐ ThinkPad computer (1)
- ☐ Bag of Power Cords
  - ☐ Microscope power supply cord
  - ☐ Computer power supply cord
  - ☐ Beige USB cord
- ☐ Dust cover
- ☐ Extra microscope parts
  - ☐ Black and white stage plate
  - ☐ Calibration slide
  - ☐ Spare microscope bulb