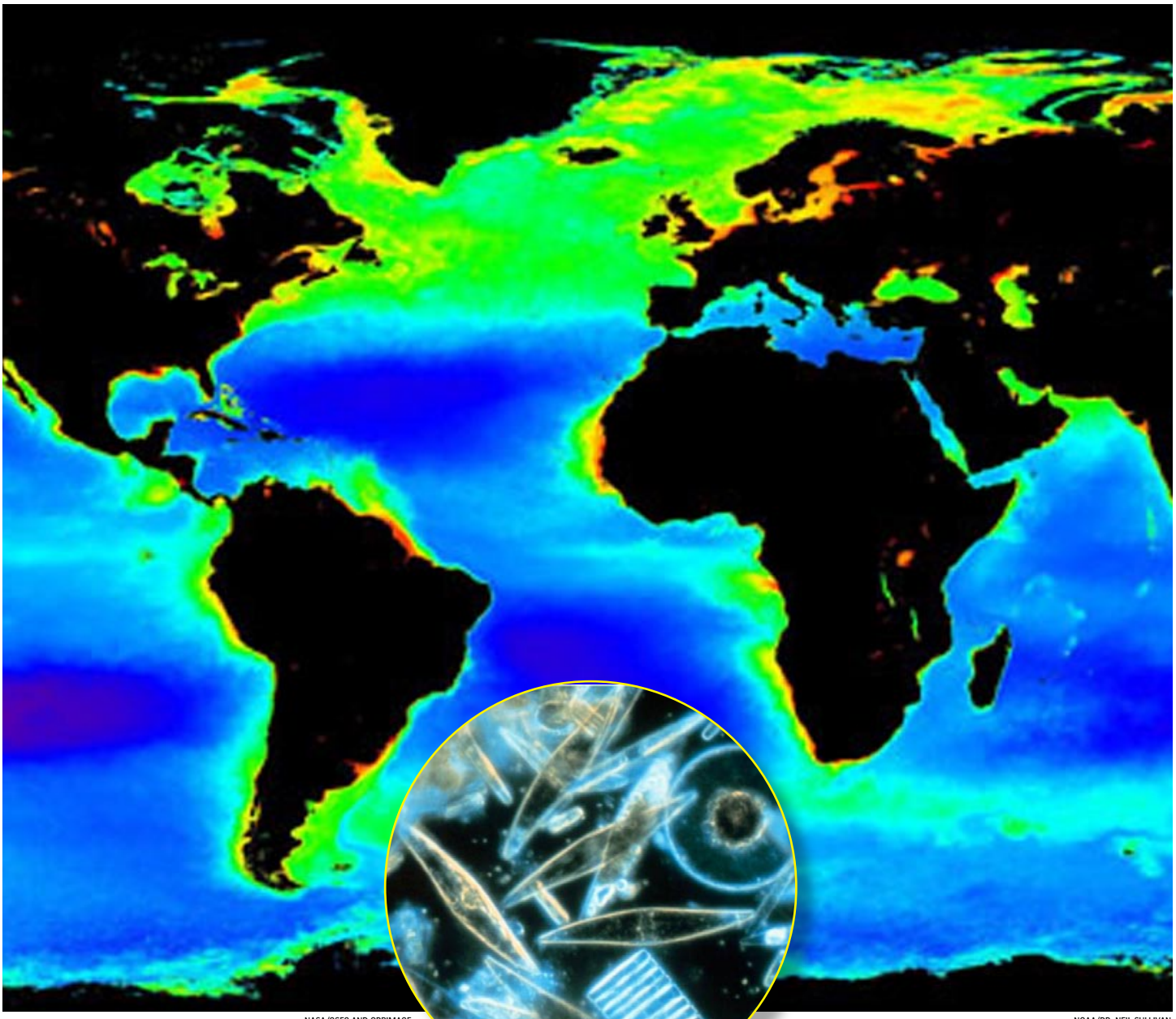
[The Washington Post]

VOLUME 7, ISSUE 2

Plankton—The Drifters



NASA/GSFC AND ORBIMAGE

Phytoplankton can be identified by satellite through their chlorophyll (light green).

NOAA/DR. NEIL SULLIVAN

Marine diatoms are seen through a microscope.

INSIDE

October 10, 2007

A Word About Plankton — The Drifters

From the oxygen we breathe to the food that we consume, we live on this planet at the courtesy of tiny drifting organisms called plankton. Fueled by the sun's energy, microscopic floating plants called phytoplankton convert inorganic compounds such as carbon dioxide into high-energy organic compounds that are consumed by drifting animals —the zooplankton. These in turn form the basis of the food chain from the smallest krill to the largest whale.

Whether it is the barnacle perched as sentinel on a rocky coast, the oyster cemented to a reef, millions of beautiful coral polyps, or the commercially important tuna, these denizens of the water world spend a portion of their life cycle drifting as plankton before settling to the bottom or swimming freely through the ocean.

These tiny organisms can be studied to learn more about the environment, global warming, greenhouse gases, and business ventures. Included in this guide is an article, written by *Washington Post* writer Steven Mufson, that focuses on a small California company that proposes a venture involving plankton, business, and carbon credits in the world of emissions trading.

The following activities are designed to address science as inquiry, as well as science in personal and social perspectives. By encouraging students to conduct research on issues and pose problems, they communicate their discoveries in ways that suit their purpose and audience.

Lesson: Plankton, at the bottom of the food chain, has emerged as an important component in scientific, technologic and economic efforts to slow climate change and confront global warming. Through lab reports, research papers, editorials, displays and debates, students explore the different modes of presenting their findings and perspectives to different audiences for different purposes.

Level: Middle to high
Subjects: Science, Economics
Related Activity: Art, Careers, Geography

NIE Online Guide
Editor — Carol Lange
Art Editor — Carol Porter

Contributing to this guide: Lisa Lyle Wu currently teaches marine biology and is the lab director for the oceanography/ geophysical systems lab at the Thomas Jefferson High School for Science and Technology (Alexandria, Va.). As a freelance science writer, she has developed curricular materials for Discovery Channel and worked on exhibit development for the Smithsonian Institution's National Museum of Natural History. She was a volunteer diver at the National Aquarium in Baltimore for ten years and served as Teacher at Sea for NOAA. Each year she takes students to study in, on, or under the sea surrounding Maryland's eastern shore, the Bahamas, Florida Keys, Galapagos Islands or Bermuda. She lives in Arlington, Va., with her husband and son.

Send comments about this guide to: Margaret Kaplow, Educational Services Manager, kaplowm@washpost.com

Plankton — The Drifters

Although the majority of activities suggested in this guide are designed for a science class, others are cross-disciplinary approaches. Science and Economics classes are a natural blend.

Observe Plankton

"Plankton — An Introduction to the Drifters," a PowerPoint presentation is provided for use with students. Teachers may download it from the Newspaper In Education site (http://www.washpost.com/nie/200710.ppt).

After a brief overview to plankton, students are presented varied examples to sketch. The third section of the PowerPoint presentation provides information about each of the examples. "Plankton Observations," a student activity sheet in this guide, may be used for the second step of this activity.

The sidebars of this guide provide additional resources to introduce students to plankton.

Teachers, Take Note

A note from Lisa Wu, creator of the PowerPoint presentation:

"Plankton: An Introduction to the Drifters" was created to supplement Steven Mufson's article and to help students visualize the world of plankton. It provides a sample of common organisms from different oceans and at different depths. The slide show can be used to help students make observations about the special adaptations of these organisms.

Although the presentation can be used by itself, it can also be followed by a lab using microscopes to view preserved or live specimens of plankton. Preserved plankton can be ordered from biological supply catalogs. For example, a vial that would be sufficient for 30 students (I have actually stretched this for all my classes) costs approximately $12 and includes collections from surface water with diatoms and zooplankton.

Just using droppers, microscope slides, microscopes and references, students can sketch, estimate size, classify, and identify specimens. Prepared slides of individual organisms can also be purchased and used.

If your school is near the water, you may wish to use resources in this guide that provide information on how to make your own plankton net. Students can have a "hands-on" "feet wet" experience as they do their own field work to collect samples for your lab. The experience doesn't need to be limited to the marine environment. Plankton can be collected in freshwater as well!

Prepare a Science Lab Report

Conduct a plankton lab. Preserved plankton samples can be ordered from scientific supply companies. Well or depression slides with coverslips and microscopes are

CONTINUED ON PAGE 4

In the Know

Bloom: A sudden increase in a plankton population

Carbon footprint: The measure of environmental impact you have on the world as a result of your actions such as driving a car or heating a home

Emissions trading: An approach to controlling pollution by providing economic incentives

Fe: Chemical symbol of the element iron used to stimulate plankton blooms

Holoplankton: Organisms that remain as plankton throughout their life cycles

Meroplankton: Organisms that spend a part of their lives as plankton and then live as free-swimming or crawling organisms

Nutrients: Chemicals required for organisms to live and grow, such as nitrogen and phosphorus

Ozone: Gas present in the upper atmosphere which helps prevent harmful Ultraviolet radiation from reaching the Earth's surface

Photic: Sunlit zone of the ocean where photosynthesis occurs

Planktivores: Animals that feed on plankton

Trace elements: Those elements required in very small amounts; for example, iron

Upwelling: The rise of nutrient rich bottom water to mix with surface water

CONTINUED FROM PAGE 3

used to observe and identify mixed plankton specimens.

Draw the specimens (See reproducible, "Plankton Observations" for this activity.) to scale. Record magnification and estimate the size of each organism. Go to the Internet and classify each based on its characteristics as phytoplankton or zooplankton, holoplankton (organisms spending their entire life cycle as plankton) or meroplankton (organisms that become crawlers or swimmers). Note any special adaptations (transparency, projections, feeding appendages, small size).

Prior to making observations, teachers may prepare a PowerPoint slide show or print out pictures and discuss the following specimens concentrating on their adaptations and ecologic importance. Include examples of phytoplankton such as diatoms, dinoflagellates, and cocolithophores, silicoflagellates and zooplankton such as radiolarians, foraminiferans, copepods and krill. Pictures of larval samples of barnacles, crabs and fish will emphasize the differentiation of meroplankton and holoplankton. Pictures can be found in the photogallery of the NOAA Web site (http://www.photolib.noaa.gov/).

After completing the identification of examples, students should be asked to complete a lab report. Using their sketches for Data, students can add a Title, Purpose, Materials/Methods and Conclusion. The conclusion should include the restatement of their purpose and an elaboration of what they have learned concerning plankton using specific examples from the lab (adaptations, importance to ecosystems, differences between zooplankton and phytoplankton, meroplankton and holoplankton ...).

Do a Crossword Puzzle

Many of the terms in " A Microscopic Aggregate" crossword puzzle are related to plankton and marine science. The answer grid is found at the end of this section of the guide.

Read About Marine Life

Two *Washington Post* news articles written by Juliet Eilperin are provided in this guide to give background before reading "Iron to Plankton To Carbon Credits: Firm's Emission Plans Have Critics Aplenty." They may also be read on their own to give students a sense of the interdependency of marine life and to illustrate the importance of plankton in providing the primary food source in the marine food chain.

"World's Biggest Fish Is a Delicate Feeder" (Sept. 3, 2007) presents the whale shark. Questions to consider after reading the article include:

- What was the USF team studying?
- What technology is being used in the study?
- Why was the whale shark selected for study?
- How does the whale shark's filtering system work?
- What questions did the team hope to answer?

In "Growing Acidity of Oceans May Kill Corals" (front page, July 5, 2006), scientists' concern over the threat of increasing ocean acidification is reported. Questions that may be considered after reading this article include:

CONTINUED ON PAGE 5

Images on the Web

www.epa.gov/climatechange/kids/
Environmental Protection Agency Kids Site
Explore the Climate Change Kids Site and watch Climate Animations that bring to life the science and impact of climate change. Provides games that help students, parents and teachers learn about both the science of climate change and what actions they can take to reduce greenhouse gas emissions.

www.youtube.com/watch?v=yjTbPtv88sI
Cruise Cruise Baby
A three-minute You Tube broadcast related to plankton tows and research at sea — complete with rap music. Students love it.

www.imagequest3d.com/pages/plankton/plankton.htm
Image Quest 3-D
Site director has had more than 30 years of experience observing, collecting, photographing and writing about plankton. Includes "Picture of the Week," "3-D Plankton Imagery," "Ctenophore Imagery" as well as articles and image catalogue.

oceancolor.gsfc.nasa.gov/SeaWiFS/TEACHERS/sanctuary_4.html
Phytoplankton — All things great and small
This is a Sea WiFS NASA education site with links to sites related to studying the ocean from space. An excellent resource.

www.nmnh.si.edu/botany/projects/algae/
Algae Research
The Smithsonian Institution's National Museum of Natural History botany/algae site

http://earthobservatory.nasa.gov/Library/
Phytoplankton Earth Observatory
NASA's Earth Observatory mission is to provide an accessible publication on the Internet where the public can obtain new satellite imagery and scientific information about our home planet. Page is devoted to phytoplankton.

CONTINUED FROM PAGE 4

- How do increasing levels of carbon dioxide in the atmosphere affect the acidity of oceans?
- The issue might have been pushed to sell Lovejoy's book, but what other sources give credibility to the concern?
- In what ways do oceans mitigate the effects of global warming?
- Why do scientists monitor the pH level for the world's oceans?
- Why are legislators being briefed on scientific concerns?

This latter article was written in 2006. Students may be asked to do research to find more recent findings. Do more recent studies support the view of Prof. Loáiciga, the other scientists or provide new perspectives?

Use a Case Study

A small California company called Planktos is proposing to use science to chemically enrich a low nutrient area of the Pacific to increase plankton numbers. This increase in the plankton population would not only improve energy available in the food chain, but also help absorb greenhouse gases from the atmosphere. The proposed environmental benefits would also provide economic benefits by providing investors supporting this venture with "carbon credits" in the world of emissions trading.

Prior to reading the reprinted *Post* article, prepare students. If you have not completed the plankton lab with students, you may wish to give students a basic introduction to plankton or ask students to pool their knowledge of plankton. Locate the Galapagos Islands and the Vatican on a map or globe. You may wish to cover the E.U.'s cap-and-trade system and carbon offsets.

Give students "Iron to Plankton To Carbon Credits: Firm's Emission Plans Have Critics Aplenty." This July 2007 article from The Post's Business section clearly reflects the overlapping of environmental concerns, business ventures, economics, and technology.

Students may be given "Plankton to Carbon Credits" to focus on scientific and technological aspects, economic incentives and criticism of the proposal. Answers to the study questions are found at the end of this section of the guide.

The article discusses emissions trading as an approach to control pollution. What is meant by a cap-and-trade system? Visit the Planktos Web site and investigate what type of projects they are funding. What are voluntary credits? How do they differ from certified credits?

Expand on the Post Article

Explain the general patterns of primary production in temperate, polar, and tropical oceans. Limiting factors such as light and nutrients should be discussed as you compare the different areas.

Explain why the tropical equatorial region west of the Galapagos was selected for managing a plankton bloom. Why is the Atlantic Ocean between Africa and South America an anamoly? Relate this to the article, the natural source of iron in the ocean, and African weather patterns.

Meet a Post Reporter

Provide students with a copy of "Meet the Energy Correspondent: Steven Mufson." In this Q and A, Mufson tells of his career path, the impact of societal concerns on *Post* coverage and how he got the story, "Iron to Plankton To Carbon

CONTINUED ON PAGE 6

Emissions and Climate Change

http://epa.gov/climatechange/emissions/individual.html
Individual Emissions
Using EPA's Climate CHange Emission Calculator Kit, SafeClimate Calculator and other resources on this site, students can learn about climate change, estimate their school's greenhouse gas emissions and conceptualize ways to mitigate climate impact at home and school.

www.cleanair-coolplanet.org/action/getinvolved.php
Clean Air-Cool Planet
Encourages all levels of action that will result in effective and lasting changes in the battle against global climate change: Reduce your own footprint, help organize in your community, workplace or school.

www.climatecounts.org
Climate Counts
Learn the carbon footprint of your purchases. The Climate Counts Company Scorecard rates 56 major corporations across eight sectors – from apparel to electronics to fast food – on their commitment to reversing climate change.

www.epa.gov/climatechange/wycd/ORWKit.htm
Climate Change, Wildlife, and Wildlands Toolkit
Teach students about climate change and ecosystems. Use the toolkit for teachers and interpreters to learn about the science of climate change and its potential effects on our nation's wildlife and their habitats.

www.epa.gov/climatechange/downloads/ActivityKit.pdf
Global Warming Wheel Card
Classroom Activity Kit
Engage middle school students in estimating emissions and enhance critical thinking skills. Visit Educators' Link for lesson plans, videos, books and toolkits.

CONTINUED FROM PAGE 5

Credits." This handout can be used as a companion with the *Post* article in this guide, in a journalism class or as part of a career unit.

Mufson's career path clearly illustrates the importance of curiosity and being a life-long learner. Many journalists must be prepared to report on diverse subjects; few have the luxury of one beat in their careers.

Debate the Issue

The scientific and economic issues presented in Mufson's article can be quite complicated and difficult for students to understand. Teachers may wish to have students do research on one aspect of the issue from the perspective of a particular group. Either as a debate or in a symposium setting, the issues will be clarified through the information and points of view presented.

The following are some of the groups that students might research and represent:

- Planktos
- World Wildlife Fund or Friends of the Earth
- International Maritime Organization
- Environmental Protection Agency
- E.U.'s cap-and-trade system
- Academic community (earth and environmental sciences)

Take a Stand

In addition to science reports, news articles and research presentations, scientific issues that impact a community can be presented in the format of an editorial or letter to the editor. "Talk of the Town" (found at www.washpost.com/nie, January 28, 2003) provides teachers with all the information they need to guide students in writing an editorial or letter to the editor.

Have students select an environmental issue that they believe needs attention. Complete research and interviews, then write a letter to the editor or submit a guest editorial to the student newspaper or to a community newspaper.

Display the Drifters

Divide the class into small groups to research topics related to plankton. Create an exhibit that focuses on plankton. The exhibit may take the form of a display or a bulletin board. See "Museum Musings" (found at washpost.com/nie, September 2007) for display and exhibition resources.

Possible topics to include in the exhibit would be sections on the

- Commercial importance of plankton (including products such as chalk, toothpaste whitener, diatomaceous earth, filters);
- Ecologic importance of plankton (including production of oxygen, impact on climate change, importance in food webs, fisheries, harmful algal blooms or HABs);
- Adaptations of plankton (transparency, small size, spines, oil droplets);
- Technology and tools for studying, observing, and collecting plankton (net tows such as bongo, and PairoVET tows, CUFES, satellites, microscopes, sidescan SONAR).

The display should include diagrams, photographs, labels, and wall text. Original artwork should be encouraged.

CONTINUED ON PAGE 7

Plankton on the Web

www.livingclassrooms.org/lbo/popest/algae.html
Population Estimation
Here is a game and activity to learn how plankton is counted under a microscope to estimate population size in a sample.

www.mos.org/sln/sem/mic_life.html
Microscopic Life in Water
A single page with information on building a plankton net, collecting samples from a pond and making observations

http://www.indiana.edu/~diatom/diatom.html
Diatom Home Page
Intended as a central Web resource for those interested in, or actively conducting research on, diatoms and related algae. Information of general interest to diatomists and other phycologists along with links to other useful Internet resources.

www.biosci.ohiou.edu/faculty/currie/ocean/index.htm
The Plankton Net
Academics homepage for plankton ecology, marine biology and biological oceanography. Includes how to make your own plankton net and links to journals.

www.calacademy.org/research/diatoms/
The CAS Diatom Collection
An ongoing project to present taxonomic information, images, records of collections, and references pertaining to diatoms, including diatom identification resource

www.njmsc.org/Education/Lesson_Plans/Plankton.pdf
Plankton
From the Education Program at the New Jersey Marine Science Museum a plankton lab for grades 6-12

CONTINUED FROM PAGE 6

Design a Planktonic Organism

Divide students into pairs or teams to design a planktonic organism. See "Design a Planktonic Organism" in this guide. Teachers may wish to provide a box of materials from which the class is to select materials to fashion their organisms. Materials could include straws, clay, toothpicks, aluminum foil, pipecleaners, paper clips, twist ties, coffee stirs, corks, biodegradable packing pellets, metal washers or pennies.

Aquariums or buckets filled with water should be used to test the designs. You will need a stop watch. This could be done as a competition between pairs or groups.

You may ask students to record their observations of the different designs of their classmates, to compare the different designs and to summarize the results. Based on what they observed, how might they modify their design?

Write a Research Proposal

Doing scientific research requires money. Students will be asked to write a research proposal of their own to obtain the funding for studying the effects of human activity on plankton communities. Teachers may find articles related to plankton research or have students do all the securing of background research.

See "Write a Research Proposal," a student handout in this guide. It provides guidelines for content to be included in a proposal.

During this time period, you may wish to invite a guest speaker from a local university or organization. The speaker would share his or her experience in writing grants, why grants are needed and who supports scientific research through grants.

Read the Cartoon

On Sunday, Oct. 7, 2007, a Tom Toles cartoon featuring a Cap 'N Trade cereal box was published. This editorial commentary could be used with Steven Mufson's article or in an art, economics, government or journalism class. One of the free response questions on the AP English Language and Composition Examination requires a synthesis of sources. Using the articles, graphics and Toles cartoon in this guide, teachers can give students practice in responding to such a prompt. After students "read" the cartoon, questions for discussion might include:

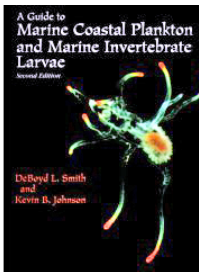
- Why did Toles feature a cereal box? To what does the name allude?
- You may need to explain the cap-and-trade system. What is its purpose?
- Why is the seafaring "Cap'n" on the box appropriate on several levels?
- What is the news peg for the promo blurb on the box, "Sweetened Climate Change Legislation"?
- What do the phrases "to sweeten" and a "sweet deal" mean? [To make sweet or sweeter by adding sugar, honey, saccharin or another sweet substance. To enhance the attractiveness or financial desirability of. The American Heritage Dictionary of the English Language]
- The figure eating from the bowl of cereal is Toles' caricature of President George Bush. What does his comment in the balloon reflect?
- What is indicated by the additional comment of the smaller figure below the cereal box? In what way is "substance" another word play by the commentator?
- What is Toles' point of view of current climate change legislation?

For more about the art of editorial cartooning and Washington Post's Herblock and Tom Toles, download INSIDE Journalism: Editorial Cartoons (www.washpost.com/nie, 2/25/2003)

CONTINUED TO PAGE 8

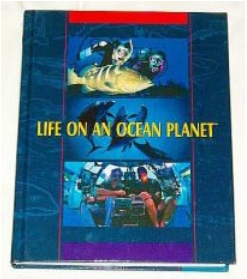
By the Book

Beakley, John and Others. *The Source Book of Marine Sciences.* Florida Oceanographic Society, Inc.: Stuart Florida. 1980.



Smith, Deboyd and Others. *A Guide to Marine Coastal Plankton and Marine Invertebrate Larvae.* Kendall/ Hund. Second Ed. 2003.

Stevens, Betsy T. *Sea Soup Teacher's Guide: Discovering the Watery World of Phytoplankton and Zooplankton.* Tilbury House, Publishers. Gardiner, Maine.1999.



Wohlers, Bob and Lesley Alexander. *Life on an Ocean Planet.* Current Publishing Corp.: Rancho Santa Margarita, California. 2006.

CONTINUED FROM PAGE 7

Another Outlook

•An excerpt from a guest commentary originally published October 7, 2007

We have to rediscover the middle ground, where we can have a sensible conversation. We shouldn't ignore climate change or the policies that could attack it. But we should be honest about the shortcomings and costs of those policies, as well as the benefits. ...We must accept that climate change is real and that we've helped cause it. There is no hoax. But neither is there a looming apocalypse. To some people, cutting carbon emissions has become the answer, regardless of the question. Cutting emissions is said to be our "generational mission." But don't we want to implement the most efficient policies first? ...

I formed the Copenhagen Consensus in 2004 so that some of the world's top economists could come together to ask not only where we can do good, but at what cost, and to rank the best things for the world to do first. The top priorities they've come up with are dealing with infectious diseases, malnutrition, agricultural research and first-world access to third-world agriculture. For less than a fifth of Kyoto's price tag, we could tackle all these issues.
Obviously we should also work on a long-term solution to climate change. Solving it will take the better part of a century and will require a political will spanning political parties, continents and generations. ...

Bjorn Lomborg, an adjunct professor at the Copenhagen Business School, is the author of Cool It: The Skeptical Environmentalist's Guide to Global Warming.

Answers: Plankton to Carbon Credits

1. Iron is a nutrient for phytoplankton, which absorb carbon dioxide from the air and convert it to carbon and oxygen through the process of photosynthesis. Adding iron will stimulate the growth of phytoplankton.

2. Traversing the ocean in a 62-mile square grid pattern, water will be removed from the ocean, enriched with iron, and pumped back into the ocean. Plankton blooms will occur within days and last six months, increasing the uptake of carbon dioxide from the air.

3. In this area of the Pacific, there is relatively little iron-rich dust as well as lower populations of marine life.

4. Increased uptake of carbon dioxide will reduce this greenhouse gas, impact global climate change and increase carbon available for marine food webs.

5. Accuracy of measuring the presence and storage of carbon; may reduce the incentive for more reliable efforts to reduce greenhouse gases; the use of international waters for profit; and unforeseen impacts of stimulating blooms of plankton

6. Answers will vary; get to the core of science as inquiry.

7. Answers will vary; look for a thoughtful explanation.

Crossword Puzzle Answer Grid

A Microscopic Aggregate

Have Standards

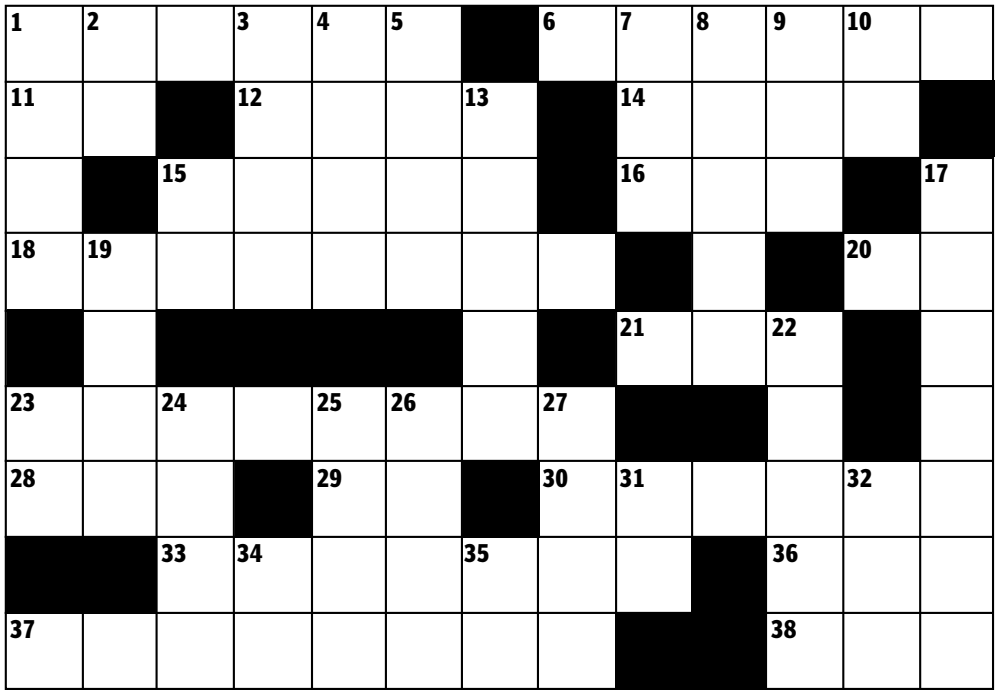
The activities in this guide address many of the standards across the disciplines. See "Academic Content Standards" for some of the local standards that are relevant to activities featuring plankton. Specific standards will depend upon the activity and the extent to which you would like to engage your students. For example, different standards would apply for activities that involve collecting plankton from the ocean and a plankton lab that examines preserved slides.

Below are some of the national standards (National Research Council) that apply to the suggested activities in this guide:

- Science as Inquiry (Content Standard A): Abilities necessary to do scientific inquiry (1) and Understanding about scientific inquiry (2).
- Life Science (Content Standard C): An understanding of the interdependence of organisms (1) and An understanding of matter, energy, and organization (2).
- Science in Personal and Social Perspectives (Content Standard F): An understanding of environmental quality (1), An understanding of natural, human-induced hazards (2), and An understanding of science and technology in local, national and global challenges (3).
- History and Nature of Science (Content Standard G): An understanding of science as a human endeavor (1) and An understanding of historical perspectives (2).

Name _____ Date _____

Crossword Puzzle: A Microscopic Aggregate



BY CAROL LANGE

Across

1. Visible marks or footprints left by persons, animals or things
6. Abilities to act or produce
11. Rhode Island (abbrev.)
12. Two words: We could do this _____ that _____ she would let us do either one.
14. One of the 5 Ws of journalism
15. Small, shrimplike crustaceans eaten by baleen whales
16. Latitude (abbrev.) Most plankton are found in the middle and high latitudes in the northern hemisphere.
18. Microscopic or small plants and animals that drift in the currents (fresh and salt water, usually near or at the surface)
20. I am (contraction)
21. Plankton are at the bottom of the food _____.
23. A body (plant, animal, bacterium) whose parts work together to maintain life processes
28. Third person, objective, singular pronoun
29. Article
30. Neither moral or immoral
33. Somber, stern disposition
36. Alice in Through the Looking Glass saw two figures, one with "DUM" embroidered on his collar, and the other with "_____" on his.
37. Central, supporting element. Plankton is a _____ in the food chain.
38. Polite way to address a man

Down

1. A net or means to collect specimen and sediment
2. Robotics Institute (abbrev.)
3. Maize
4. Leif _____son is believed to be the first European to land in North America
5. About 90% of the ___ on the floor of the Indian Ocean consists of the remains of plankton that bloomed during the summer monsoon. _____ provides scientists with a climatologic "archive."
7. Symbol of wisdom
8. Large marine mammal
9. Consume
10. Right (abbrev.)
13. Masses or aggregations of suspended particles
15. Kansas (postal code)
17. Opposite of "larger"
19. Accumulated facts, traditions and beliefs about a subject
20. First person, singular, nominative pronoun
22. Warm-blooded, egg-laying feathered vertebrates
23. Ohio (postal code)
24. Shade of black
25. Cartoonist who created the symbols of the Democrat and Republican parties
26. A preposition
27. Female horse
31. First person, singular, objective pronoun
32. __ __ __ o u
34. First person, plural, objective pronoun
35. Prefix and suffix meaning "in"

An Integrated Curriculum For The Washington Post Newspaper In Education Program

B6 SUNDAY, OCTOBER 7, 2007

The Washington Post

AN INDEPENDENT NEWSPAPER

An Integrated Curriculum For The Washington Post Newspaper In Education Program

Meet the Energy Correspondent: Steven Mufson

1. What do you cover?

I cover energy for *The Washington Post*. So I am in the financial section, not in the national staff's science pod. But science is an essential element of many articles I write. For example, geology is useful for understanding how long oil reserves might last. A bit of chemistry can help you understand why BP pipelines in Alaska might spring leaks, or the different ways companies go about making ethanol for motor fuel. Engineering can help understand how a coal plant works and how it might become more efficient.

When I started covering energy in April 2006, our focus was on political stories about world tensions that were driving the price of oil to new highs or about the response of politicians here in Washington. I still write about the politics of energy. But our coverage has turned more and more toward the business of climate change, because the energy industries — coal-fired electric utilities, energy intensive manufacturing, and the oil and gas industries — are the businesses that are emitting greenhouse gases. We're also writing more about wind, solar and nuclear.

2. Do you have a background in science?

I studied science in high school. In college, I briefly considered going to medical school and took a year of biology.

3. Have your other journalism assignments been science oriented?

Not really. At *The Post,* I have covered economic policy, China and foreign policy, and I was deputy editor of the weekly Outlook section. Earlier at *The Wall Street Journal,* I covered the oil industry, then I covered Africa.

THE WASHINGTON POST

Steve Mufson

4. You wrote "Iron to Plankton To Carbon Credits: Firm's Emission Plans Have Critics Aplenty." How did you hear about this story?

As I recall, I heard about Planktos and its idea of seeding the ocean with iron from an environmental group. It isn't unusual to get story ideas from individuals or groups with strong viewpoints; some of the ideas are worthwhile, some aren't. I thought this one was worth pursuing.

First, it was an unusual idea. Second, it illustrated the growing controversy about the worthiness of carbon offsets. Many companies are coming up with ways of generating carbon credits that can be sold to companies trying to offset their emissions. But many of those credits are of questionable value.

5. How do you decide whom to call?

I called a friend who teaches environmental science at George Mason University. She sent me to a professor at Harvard University, who sent me to a professor at Columbia University. I looked up the bios of these people on the Web and read some of what they have written or said. The one at Columbia in particular seemed to be extremely well respected.

I also called someone at a big hedge fund which invests in carbon credits or carbon offsets. He wants these projects to be real because if a lot of flimsy ideas are accepted, they can flood the market (pun intended) and reduce the value of the more solid, real ones (which are the ones he says he's buying).

I interviewed a scientist at a European firm that audits projects that companies are eager to sell in the more rigorous, mandatory emissions trading scheme in Europe. I also contacted the Environmental Protection Agency and some members of Congress who have taken an interest in this area. And I spoke with people from the company; they were very open and helpful.

6. After interviewing experts and doing research to learn about the different perspectives, what did you decide was the main topic for the article?

The essence of this issue seemed to be: Yes, spreading iron on the ocean will stimulate phytoplankton, which take carbon dioxide from the atmosphere. There's no disputing that. But then what? How much of that carbon dioxide gets stored in the ocean? Many marine biologists argue that the phytoplankton are eaten up by fish or other organisms that just emit the carbon dioxide back into the air. Many experts estimated that as little as one percent of the carbon dioxide

CONTINUED ON PAGE 12

CONTINUED FROM PAGE 11

captured would be stored deeper down in the ocean. Measuring that would be a tough task, at best.

7. Does luck matter to a reporter?

Luck helps in journalism. Sometimes after you start reporting a story, it gets better. In this case, Rep. Markey of Massachusetts held a hearing and invited the chief executive of Planktos and some other people in the carbon offset business. Morever, after I started reporting the story, Planktos announced that it would offset the emissions from the Vatican. So there was another news peg for the article, another promotional effort, and another project whose value some people have questioned.

8. How do you learn what you need to know?

Journalism in general is a bit like a series of tutorials from whatever professor/teacher/expert you choose to call.

I have had the top executives and engineers of utilities explain how coal plants work and how they can be made more efficient.

On my way to Alaska to write about BP's leaks, I had the good luck of getting a seat next to a petroleum geologist who had just returned from Iraq and who was happy to talk about pipeline corrosion for a couple of hours.

The founder of an Israeli solar company went over his firm's technology with me. Chief geologists at major oil companies have delivered lectures (with slides) charting the expected lives of Saudi oil fields and what could be done to extend them. Former members of the Nuclear Regulatory Commission (and other nuclear experts) have spent hours talking about radioactive isotopes, cooling systems, and the structural integrity of reactor buildings. A microbiologist spent most of a day telling me about a microbe that she believes can break down cellulosic material more efficiently than genetically engineered enzymes.

9. What role will science play in future articles?

Assuming that the forecasts of climatologists are even partly correct, then climate change will be one of, if not the biggest, stories of our time.

Figuring out which solutions are real and which aren't will be an important part of journalism. For example, does ethanol reduce greenhouse gas emissions of cars that use gasoline with ethanol mixed in, or does the energy and fertilizer used to make the ethanol offset the savings? (Answer: ethanol from corn gives slight savings, ethanol from sugar or cellulosic materials could save more.)

About the Correspondent

My first real journalism job was covering labor for *The Yale Daily News*. Summers I worked at a weekly called *The Cranford Citizen & Chronicle* (mostly graduation and wedding news), then at the Gannett-owned *Bridgewater Courier News* (known by some in the Gannett chain as Bilgewater), and then at *The Wall Street Journal*.

The Wall Street Journal hired me back after graduation in 1980 and I spent six years there. I covered the oil and gas industry from New York then moved in early 1984 to cover Africa from London and later from Johannesburg. I left the *Journal* in mid-1986 to stay in South Africa longer. I worked for *Business Week* and a Dutch newsweekly, *Elseviers,* and freelanced to *The New Republic, LA Times, London Independent,* and others. I also made my *Post* debut with an article for the Outlook section. I ended up spending two years in South Africa altogether, and was there for the 1985 and 1986 states of emergency. I was expelled in May 1987 otherwise I might have stayed a long time.

When I returned to the U.S., I wrote a book about black politics in South Africa with support from the Council on Foreign Relations, the Ford Foundation and a 1988 Alicia Patterson Foundation fellowship. The book, published by Beacon Press in 1990, was called *Fighting Years: Black Resistance and the Struggle for a New South Africa*. During this time I also contributed pieces to *Foreign Affairs,* the *Village Voice, Mother Jones* and other publications.

I joined *The Post* in May 1989 in the New York bureau to cover financial news. In early 1990, I moved to D.C. to cover the first Bush administration's economic policy. One major bonus of coming to Washington for *The Post* was that I met a lawyer named Agnes Tabah. We're now married with two great kids.

The Post gave me ten months off starting mid-1993 to study Chinese and from mid-1994 until mid-1998 I was based in Beijing. It was a wonderful job. When I came back I spent a few months working in the financial section, then covered foreign policy for the national section, and then moved over to Outlook in January 2002 first as assistant editor and then deputy editor.

An Integrated Curriculum For The Washington Post Newspaper In Education Program

Iron to Plankton To Carbon Credits

Firm's Emission Plans Have Critics Aplenty

By Steven Mufson
Washington Post Staff Writer

• *Originally published July 20, 2007*

A small California company is planning to mix up to 80 tons of iron particles into the Pacific Ocean 350 miles west of the Galapagos Islands to see whether it can make a splash in the markets where people seek to offset their greenhouse gas emissions.

Planktos — with 24 employees, a Web site and virtually no revenue — has raised money to send a 115-foot boat called the *Weatherbird II* on a voyage to stimulate the growth of plankton that could boost the ocean's ability to absorb carbon dioxide from the air. The company plans to estimate the amount of carbon dioxide captured and sell it on the nascent carbon-trading markets.

The boat is still in Florida, but the plan has already stirred the waters in Washington. Environmental groups say the Planktos project could have unforeseen side effects, and the Environmental Protection Agency has warned that the action may be subject to regulation under the Ocean Dumping Act.

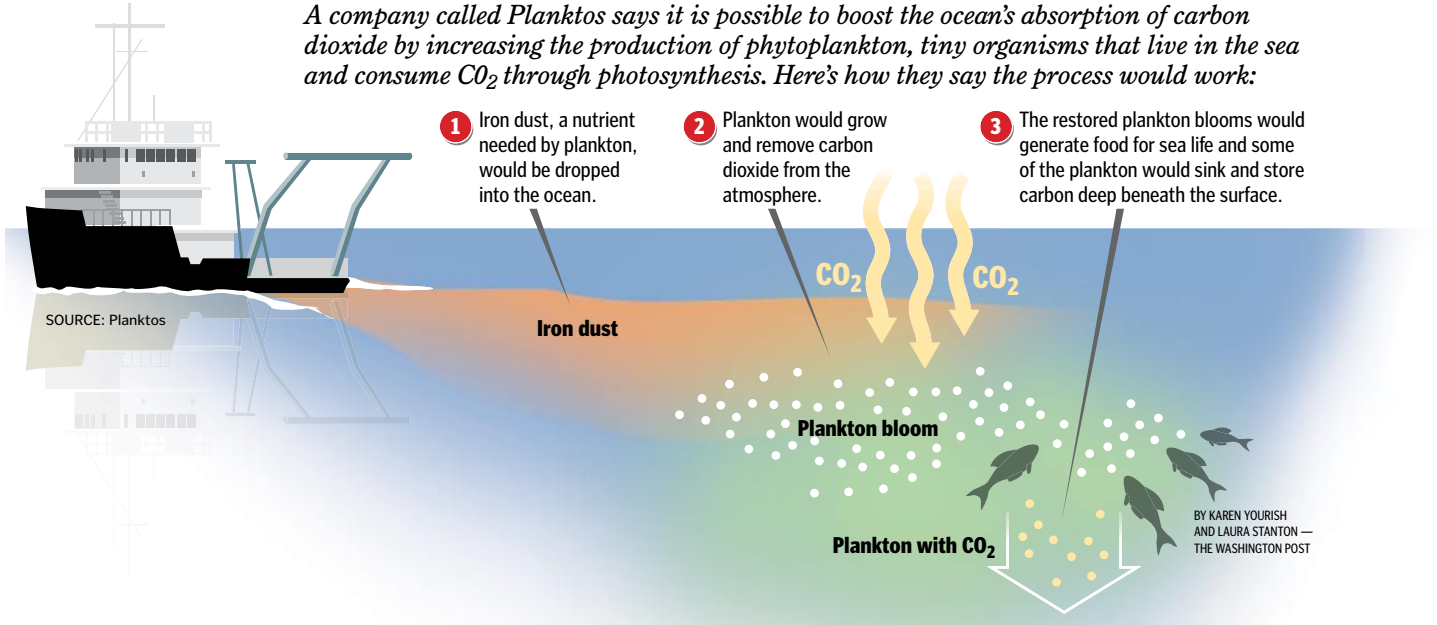
Disputes like the one over Planktos may be the wave of the future in the new carbon-conscious era. As countries and companies seek to slow climate change, taking carbon dioxide out of the atmosphere can be financially rewarding.

In a bid for attention for another of its projects, Planktos said earlier this month it would offset the Vatican's carbon emissions by donating credits from trees being planted in a Hungarian national forest. The company said it would make the Holy See "the world's first carbon-neutral sovereign state." It released a video that panned across St. Peter's Square to music from Johann Sebastian Bach's "St. Matthew Passion" and then cut to Cardinal Paul Poupard, who thanked Planktos chief executive Russ George.

Other groups have looked on the company with less indulgence. The Surface Ocean Lower Atmosphere Study, an international research group, said last month that "ocean fertilization will be ineffective and potentially deleterious,

CONTINUED ON PAGE 14

A company called Planktos says it is possible to boost the ocean's absorption of carbon dioxide by increasing the production of phytoplankton, tiny organisms that live in the sea and consume CO_2 through photosynthesis. Here's how they say the process would work:



CONTINUED FROM PAGE 13

and should not be used as a strategy for offsetting CO2 emissions." The International Maritime Organization scientific group, the Friends of the Earth and the World Wildlife Fund have condemned it. And a group called the Sea Shepherd Conservation Society said its own ship would monitor the Planktos vessel and possibly "intercept" it.

On Wednesday, George appeared before the House Select Committee on Energy Independence and Global Warming and lashed back at his critics. The EPA was working with "radical environmental groups," he said. In written submissions, he said his firm's work had been "falsely portrayed" to "generate public alarm."

Planktos's Web site boasts that it "offers investors the single most powerful, profitable, and planet-friendly tool in the worldwide battle against global warming." Though its revenue amounts to a few thousand dollars, raised by selling "a few thousand tons" of credits to individuals and small businesses largely through its online "store," the Foster City, Calif., company has a market value of $91.4 million.

Serious science is involved in the company's ocean concept. Planktos plans to suck water from the ocean, insert the equivalent of a teaspoon of iron into a volume equal to an Olympic-size pool, and pump the water back into the ocean as the ship makes a grid about 62 miles by 62 miles — "like plowing a field," one Planktos official said.

Iron is a nutrient for phytoplankton, which absorb carbon dioxide from the air and convert it to carbon and oxygen through photosynthesis. The plankton blooms form within a day or two and last six months. The tropical Pacific Ocean is widely regarded as a good spot to experiment because there is relatively little iron-rich dust carried from land, but there are other nutrients. George said "it's the clearest ocean on Earth because it's lifeless, and it's not supposed to be that way."

George asserts that the potential is enormous. He said that the annual drop in ocean plant life was like losing all the rain forests every year. "If we succeed, we'll have created an industry," he told the House committee. "If we don't succeed, we'll have created a lot of great science."

But leading ocean and climate experts have poured cold water on the Planktos plan by saying that the company can't accurately measure how much additional carbon would be stored in the ocean or for how long. One reason: Some organisms sink and store carbon deep below the surface. But the overwhelming majority are eaten by fish or other organisms that convert the carbon back into carbon dioxide.

"Actually knowing how much carbon stays down there is a really hard thing," says Daniel Schrag, director of the Harvard University Center for the Environment.

Schrag said the Planktos project could also generate new algae, which could reduce the amount of oxygen at depths that would endanger other ocean life. "Doing a large-scale ecological experiment before you understand the system is a dangerous thing," he said.

Others doubt the benefits. "I think iron fertilization in the ocean is not going to make a significant difference to the CO2" problem, said Wally Broecker, a professor of earth and environmental sciences at Columbia University.

There are other issues. The area is in international waters, so some critics ask why Planktos or any company should be able to reap profits there. And if the company started selling large amounts of ocean-based carbon credits, it could flood the market, reducing incentives for more reliable and measurable projects aimed at reducing greenhouse gases in the atmosphere.

In addition, the benefits of reforestation projects are almost as hard to measure as ocean plankton, and people at funds that trade carbon credits are raising questions about Planktos's Hungarian forest project. Although the project is in Europe, it remains unclear whether any forest projects will meet the strict standards for credits that can be sold in the European Union's cap-and-trade system, where credits currently sell for $26.85 per ton of carbon dioxide.

"So how is Planktos going to offset the Vatican's emissions? The Vatican doesn't emit much — about as much as 500 U.S. households, says David Kubiak of Planktos. To offset the Vatican's current emissions, Planktos is using credits that it expects to receive from its Hungarian tree-planting venture — in the future. Those new seedlings won't produce carbon benefits for eight years, Kubiak said.

The Vatican isn't part of the E.U. cap-and-trade system, so Planktos can use the credits even if they do not meet E.U. standards. These are called voluntary credits because the buyers, like those in the United States, are not required to offset emissions. The voluntary credits trade at a fraction of the price that E.U.-certified credits do.

Many companies are calling for Congress to set standards for voluntary credits if it does not establish a U.S. version of Europe's more rigorous cap-and-trade rules.

"The global market for voluntary carbon offsets is currently unregulated," said Derik Broekhoff, senior associate at the World Resources Institute, "which has led to growing concerns about whether buyers are really getting what they are paying for."

Many companies are calling for Congress to set standards for voluntary credits if it does not establish a U.S. version of Europe's more rigorous cap-and-trade rules.

"The global market for voluntary carbon offsets is currently unregulated," said Derik Broekhoff, senior associate at the World Resources Institute, "which has led to growing concerns about whether buyers are really getting what they are paying for."

Name _____ **Date** _____

Plankton to Carbon Credits

After reading the Washington Post Business article by energy correspondent Steven Mufson, answer the following questions.

1. A company called Planktos is preparing to mix iron into the Pacific Ocean. What is the scientific basis for this project?

2. Describe the method proposed for adding iron to the ocean. What is the expected outcome of this method?

3. Why has the equatorial Pacific Ocean been chosen as the location for the iron enrichment?

4. What is the global impact that Planktos expects to achieve by the increased uptake of carbon dioxide by a plankton bloom?

5. What criticisms have been launched by ocean scientists and climate change experts concerning managed plankton blooms?

6. What does Planktos chief executive Russ George mean when he says, "If we don't succeed, we'll have created a lot of great science."

7. From what this article has presented about the issues and different points of view, with whom do you agree and why?

Name ______________________________ Date ________________

Plankton Observations

Specimen # ____________________

Characteristics: Description
Body shape/Tail/flagella/appendages/eyes
transparency/gills/other features

____
____
____

What is this specimen?
Select one from each category:
❑ Phytoplankton or ❑ Zooplankton
❑ Holoplankton or ❑ Meroplankton

Specimen # ____________________

Characteristics: Description
Body shape/Tail/flagella/appendages/eyes
transparency/gills/other features

____
____
____

What is this specimen?
Select one from each category:
❑ Phytoplankton or ❑ Zooplankton
❑ Holoplankton or ❑ Meroplankton

Specimen # ____________________

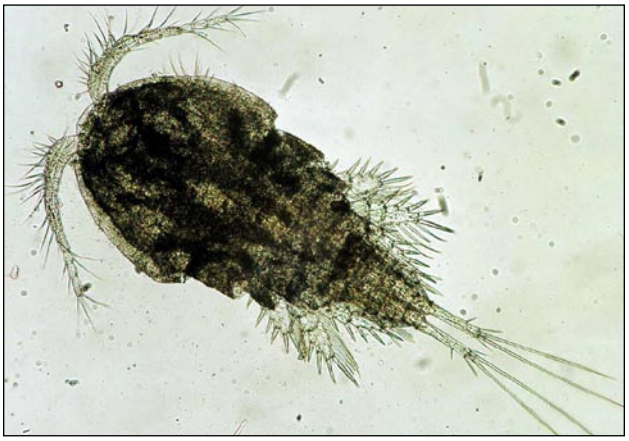
Characteristics: Description
Body shape/Tail/flagella/appendages/eyes
transparency/gills/other features

____
____
____

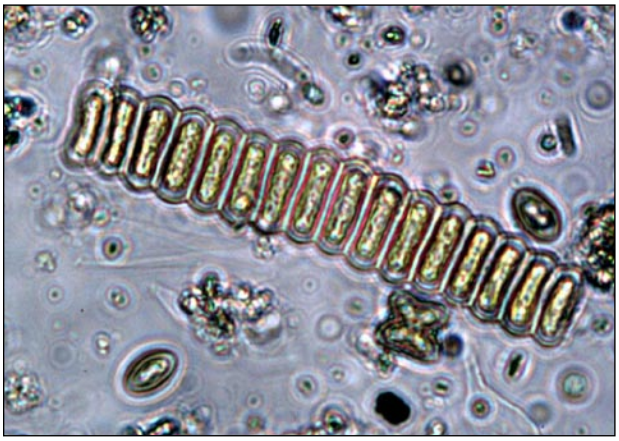
What is this specimen?
Select one from each category:
❑ Phytoplankton or ❑ Zooplankton
❑ Holoplankton or ❑ Meroplankton

Name _____ Date _____

Design a Planktonic Organism

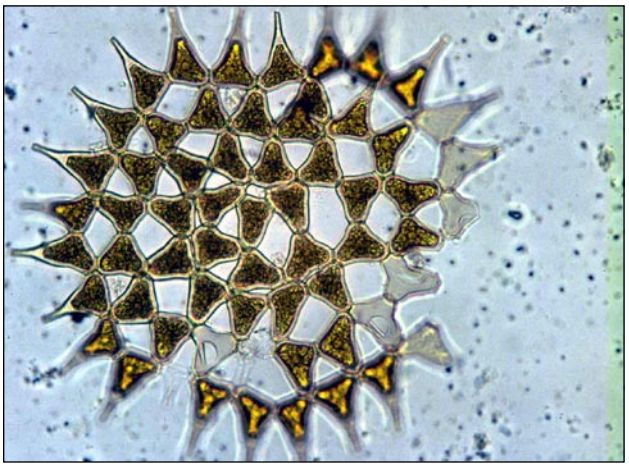


Cyclops



Scenedesmusbijunga

SOURCE: PLANKTON IMAGES FROM EPA.GOV



Pediastrumsimplex

Crucigenia

Phytoplankton must stay in the epipelagic zone to utilize the sun's light for energy to photosynthesize. Adaptations that enable plankton to remain in the photic zone without sinking include small size (the rate of sinking is slowed by an increase in the surface to volume ratio increasing the frictional drag in the water column), a decrease in internal density through storage of oil droplets, and modified shape — long, thin, disk-shaped organisms will spiral as they sink.

Zooplankton may remain deeper in the water column during the day and vertically migrate to the surface at night to feed on phytoplankton. For zooplankton, specialized appendages increase the surface area, droplets of oil or wax decrease their density, and treading water, jelly layers, and airfloats keep the organisms in the upper pelagic zone.

Your Assignment

- Design a planktonic organism that will remain neutrally buoyant in the water. The organism cannot float at the surface, but must remain for as long as possible under the surface without sinking to the "depths."
- Using materials of your choice — straws, clay, toothpicks, aluminum foil, pipecleaners, paper clips, twist ties, coffee stirs, corks, biodegradable packing pellets, metal washers or pennies — design and build an organism.
- Your designs will be tested.
- Be ready to explain the adaptations of your specimen.
- Observe the designs of your classmates. How do they differ from your design?

An Integrated Curriculum For The Washington Post Newspaper In Education Program

Write a Research Proposal

Doing scientific research requires money. Most scientists are not independently wealthy and most universities are not endowed with unlimited funds for research. Scientists must be able to write grant proposals to support their projects.

Write a research proposal of your own to obtain the funding for studying the effects of human activity on plankton communities.

Before you begin your proposal, you need to know what has been studied. Find and read articles related to plankton research.

Write your proposal

Begin with an Introduction. Provide background information for the research you are proposing and establish the area that your research will address. This is known as providing the "framework" for the research. In the introduction you need to grab your readers' interest — you want the persons who will fund your project to think you are addressing them while you are using the third person voice. Use the present tense throughout the proposal.

After an introductory statement, include the following in your proposal:

1. A clear, direct statement of the Problem. The reader easily recognizes the problem. You should be answering the unstated question "Why does this research need to be conducted?" You may need to define some of the technical terms for the reader.

2. Goals and Objectives

3. A statement of why your proposed project is a significant improvement over current practice. What are the broader impacts of the research?

4. Resources that you will need and why these are essential to the success of your research project. Why are they suitable?
   a. People (academic or field experience, paid or volunteer),
   b. Credentials of those needed to work on the project
   c. Time (number of months or years)
   d. Equipment, and
   e. Technical support (within the school and from outside institutions)

5. Evidence of preliminary work on the topic by others. Here is where the background reading you did will be included. Be sure to include the title of articles, papers and books as well as the authors' names.

6. Since getting funding is the primary reason for writing the research proposal, this section should be itemized and include justification.
   a. Budget request for equipment and supplies
   b. Budget request for salaries, travel, food and housing as needed

7. Describe how the research project will be assessed.

8. Describe how the research will be communicated to others in the scientific community as well as to the general public.

An Integrated Curriculum For The Washington Post Newspaper In Education Program

World's Biggest Fish Is a Delicate Feeder

By Juliet Eilperin
Washington Post Staff Writer

•Originally published September 3, 2007

ISLA HOLBOX, Mexico — The whale shark — a massive, polka-dotted creature stretching about 23 feet long — slowly swam up alongside the scientists' boat. As it neared, they tossed a handful of pre-soaked rice in front of its enormous mouth. The rice rushed in along with the seawater, and the whale shark made a shuddering motion.

"There's the cough!" exclaimed Philip Motta, a University of South Florida biology professor, using the catchphrase he and his colleagues coined recently to describe the shark's abrupt way of swallowing.

Cruising the waters off the Yucatan for hours in the broiling sun, Motta and doctoral student Kyle Mara, along with several other researchers, repeated the ritual again and again. Hoping to figure out in detail the complex feeding mechanism of the biggest fish in the sea, the scientists trailed whale sharks of different ages, sizes and sexes, using a laser beam to measure each gigantic mouth and videotaping as the rice flowed in.

Whale sharks are not mammals but got their name because of their immense size and whalelike tendency to filter-feed on the ocean surface. Most sharks are known for their intimidating teeth, but whale sharks fascinate scientists for the opposite reason: They have a unique, three-part filtering system that is more complex than those of whales and other filter-feeding sharks. The setup is so effective that modern bottling plants employ it.

Until recently, it was difficult to study their filter feeding in detail, since whale sharks can be elusive. Then researchers discovered that hundreds of the animals come to Isla Holbox each summer to feast on plankton carried to the surface by an upwelling of water between the Gulf of Mexico and the Caribbean. Scientists began making annual pilgrimages to this former pirates' lair about 90 miles northwest of Cancun, where the fish are called domino sharks because of their spots.

Then, just this year, the deaths of two whale sharks at the Georgia Aquarium gave scientists the opportunity to study the anatomy of the sharks' feeding systems.

Motta's work, part of a research program directed by the Sarasota, Fla.-based Mote Marine Laboratory and the Mexico-based conservation group Project Domino, is coming closer to answering a question that has eluded scientists for years: How did a fish weighing thousands of pounds and stretching the length of a school bus develop its unusual feeding apparatus?

"How do you go from an animal that sits on the bottom and eats fish and crustaceans to one that swims on the surface and consumes a large volume of water to eat some of the smallest creatures of the sea?" asked Robert Hueter, who directs Mote's Center for Shark Research. "That's a huge evolutionary step."

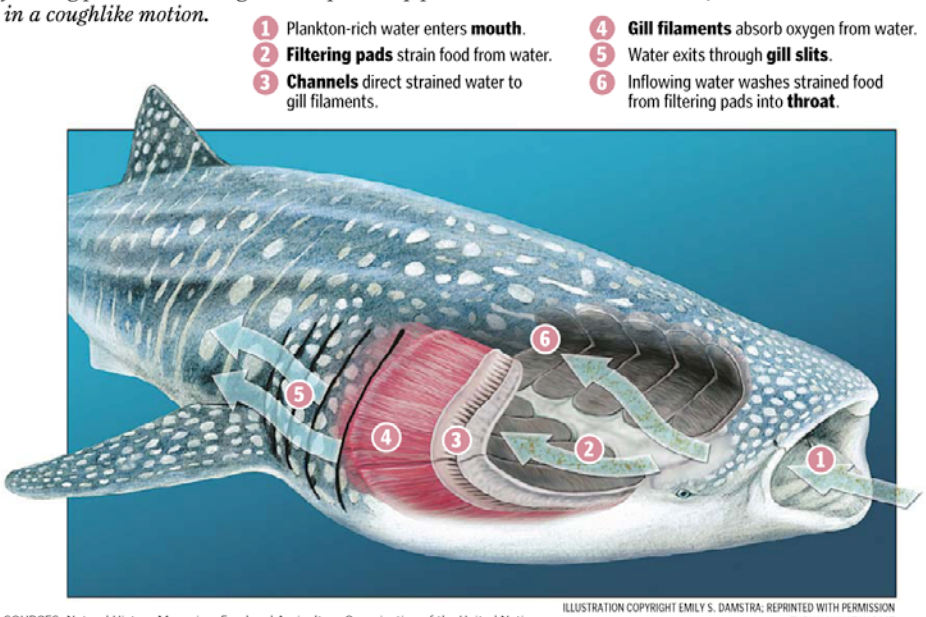
The still-unexplained deaths at the aquarium have also contributed to the research. The two males — imported from Taiwan and dubbed Ralph and Norton by aquarium staff — died within the past year, one as recently as June. Motta and Hueter helped perform head dissections on the dead sharks, allowing them to examine the sharks' filtering system up close.

The aquarium, which has given scientists $250,000 to study whale

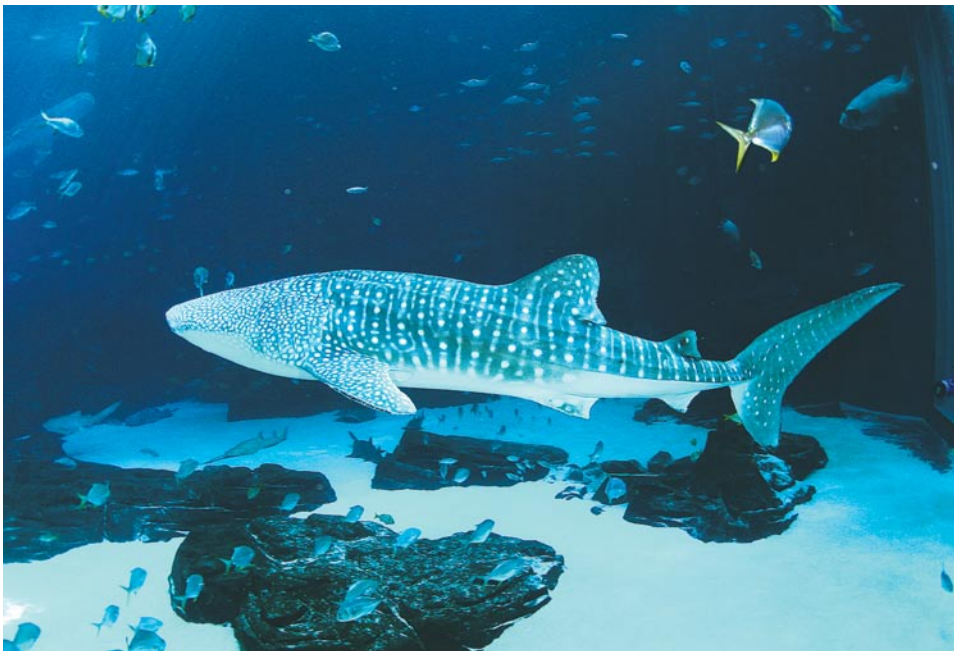
CONTINUED ON PAGE 20

A Shark With No Bite

Largest of all fish, the whale shark is a filter feeder with a mouth that opens almost five feet wide. While feeding, the shark gulps in a large volume of water, closes its mouth and forces water through filtering pads and out its gills. The pads trap plankton and small vertebrates, which are swallowed in a coughlike motion.



SOURCES: Natural History Magazine, Food and Agriculture Organization of the United Nations



COURTESY GEORGIA AQUARIUM

A whale shark at the Georgia Aquarium. The slow-moving fish approach 40 feet in length and inhabit the world's warmer latitudes.

CONTINUED FROM PAGE 19

sharks off the tiny island of Holbox, still has two male and two female whale sharks in its 6.3 million-gallon Ocean Voyager tank.

Motta and his colleagues have observed them from the top of the tank and by entering the water with them during routine veterinary exams.

Aquarium officials are also planning to test radio-tagging equipment on the captive whale sharks, to ensure that the technology scientists want to use in the wild will work properly. Ray Davis, the aquarium's senior vice president of zoological operations, said officials are talking with wildlife tagging manufacturers to develop devices that will monitor whale sharks' physiological changes as they dive and will transmit the data back.

"We're able to start ground-truthing these things," Davis said. "We're able to test out some of these techniques."

The marriage of research on the captive animals and real-time observations of the hundreds of whale sharks that gather in the wild each summer near Holbox allowed the scientists to discover that whale sharks apparently have what Motta calls a unique "cross-flow filtration system" that lets them consume massive amounts of plankton each day without clogging their gills.

The scientists found that the sharks ingest about nine pounds of plankton an hour while swimming through a dense plankton bloom. The tiny sea creatures and massive amounts of water flow into a whale shark's throat, where 20 filtering pads with tiny holes lie. The pads take up more than 6.5 square feet, but the pads' pores are tiny, just 0.07 inches across. The water hits the pads at an angle, which ensures that as it flows through the pads and the shark's gill apparatus, the food particles are swept into the back of the throat, near the opening to the stomach.

As a result, the plankton does not clog the filtering pads as the water moves through and returns to the ocean. When the whale shark accumulates enough plankton "slurry," as Motta describes it, the whale shark swallows in the "cough" motion.

It is only coincidence that beverage companies use a similar approach to reducing clogging in their commercial operations, Motta said, but the fact that engineers rely on cross-flow filtration testifies to its effectiveness.

Other researchers are exploring whether some bony fishes, which share a distant common ancestor with whale sharks, have developed the same sort of filtration system. If they have, Motta said, it would demonstrate "convergent evolution," whereby two radically different species of fishes that are only distantly related have independently developed a similar solution to filter feeding. Baleen whales separately evolved their own form of filter feeding.

Some animal rights activists have challenged the use of the aquarium-held whale sharks for research.

"Whatever you learn by keeping these animals in captivity, whether it's a marine mammal or a whale shark, is of very limited value," said Naomi Rose, a marine mammal scientist at the Humane Society of the United States. The fact that two whale sharks died at the aquarium, Rose added, is "a pretty high price to pay for what they've learned."

But David Santucci, a spokesman for the two-year-old Georgia facility, said the Holbox project demonstrates that the aquarium is contributing to science. The aquarium's nutritionist, Mike Maslanka, journeyed to Holbox in August to help identify the types of plankton in the water so that he and other researchers could get a better sense of what the whale sharks eat.

"A year ago people were asking, 'What's the Georgia Aquarium going to do for science?'" Santucci said. "It was a difficult question to answer. Science takes a lot of time. We're just starting to reach that point where we're starting to do science."

An Integrated Curriculum For The Washington Post Newspaper In Education Program

Growing Acidity of Oceans May Kill Corals

By Juliet Eilperin
Washington Post Staff Writer

• *Originally published July 5, 2006*

The escalating level of carbon dioxide in the atmosphere is making the world's oceans more acidic, government and independent scientists say. They warn that, by the end of the century, the trend could decimate coral reefs and creatures that underpin the sea's food web.

Although scientists and some politicians have just begun to focus on the question of ocean acidification, they describe it as one of the most pressing environmental threats facing Earth.

"It's just been an absolute time bomb that's gone off both in the scientific community and, ultimately, in our public policymaking," said Rep. Jay Inslee (D-Wash.), who received a two-hour briefing on the subject in May with five other House members. "It's another example of when you put gigatons of carbon dioxide into the atmosphere, you have these results none of us would have predicted."

Thomas E. Lovejoy, president of the H. John Heinz III Center for Science, Economics and the Environment, has just rewritten the paperback edition of Climate Change and Biodiversity, his latest book, to highlight the threat of ocean acidification. "It's the single most profound environmental change I've learned about in my entire career," he said last week.

A coalition of federal and university scientists is to issue a report today describing how carbon dioxide emissions are, in the words of a press release from the National Center for Atmospheric Research and the National Oceanic and Atmospheric Administration, "dramatically altering ocean chemistry and threatening corals and other marine organisms that secrete skeletal structures."

CONTINUED TO PAGE 22

ASSOCIATED PRESS

A new report says carbon dioxide emissions are affecting ocean chemistry and threatening corals and other organisms that secrete skeletal structures.

CONTINUED FROM PAGE 21

For decades, scientists have viewed the oceans' absorption of carbon dioxide as an environmental plus, because it mitigates the effects of global warming. But by taking up one-third of the atmosphere's carbon dioxide — much of which stems from exhaust from automobiles, power plants and other industrial sources — oceans are transforming their pH level.

The pH level, measured in "units," is a calculation of the balance of a liquid's acidity and its alkalinity. The lower a liquid's pH number, the higher its acidity; the higher the number, the more alkaline it is. The pH level for the world's oceans was stable between 1000 and 1800, but has dropped one-tenth of a unit since the Industrial Revolution, according to Christopher Langdon, a University of Miami marine biology professor.

Scientists expect ocean pH levels to drop by another 0.3 units by 2100, which could seriously damage marine creatures that need calcium carbonate to build their shells and skeletons. Once absorbed in seawater, carbon dioxide forms carbonic acid and lowers ocean pH, making it harder for corals, plankton and tiny marine snails (called pteropods) to form their body parts.

Ken Caldeira, a chemical oceanographer at Stanford University who briefed lawmakers along with NCAR marine ecologist Joan Kleypas, said oceans are more acidic than they have has been for "many millions of years."

"What we're doing in the next decade will affect our oceans for millions of years," Caldeira said. "CO2 levels are going up extremely rapidly, and it's overwhelming our marine systems."

Some have questioned global-warming predictions based on computer models, but ocean acidification is less controversial because it involves basic chemistry. "You can duplicate this phenomenon by blowing into a straw in a glass of water and changing the water's pH level," Lovejoy said. "It's basically undeniable."

Hugo A. Loáiciga, a geography professor at the University of California at Santa Barbara, is one of the few academics to question the phenomenon. A groundwater hydrologist, Loáiciga published a paper in the May edition of the American Geophysical Union's journal that suggested the oceans may not become so acidic, because enough carbonate material will help restore equilibrium to them.

Loáiciga wrote that although seawater in certain regions may become more acidic over time, "on a global scale and over the time scales considered (hundreds of years), there would not be accentuated changes in either seawater salinity or acidity from the rising concentration of atmospheric CO2."

Two dozen scientists have written a response questioning this assumption, since it would take thousands of years for such material to reach the oceans from land.

"The paper by Loáiciga ignores decades of scholarship, presents inappropriate calculations and draws erroneous conclusions that simply do not apply to real ocean," they wrote. They added that, unless carbon dioxide levels in the atmosphere stabilize soon, the seas will soon exceed the Environmental Protection Agency's recommended acidity limits.

Scientists have conducted a few ocean acidification experiments in recent years. All have shown that adding carbon dioxide to the water slows corals' growth rate and can dissolve pteropods' shells.

Langdon, who conducted an experiment between 1996 and 2003 in Columbia University's Biosphere 2 lab in Tucson, concluded that corals grew half as fast in aquariums when exposed to the level of carbon dioxide projected to exist by 2050. Coupled with the higher sea temperatures that climate change produces, Langdon said, corals may not survive by the end of the century.

"It's going to be on a global scale and it's also chronic," Langdon said of ocean acidification. "Twenty-four/seven, it's going to be stressing these organisms. ... These organisms probably don't have the adaptive ability to respond to this new onslaught."

Stanford University marine biologist Robert B. Dunbar has studied the effect of increased carbon dioxide on coral reefs in Israel and Australia's Great Barrier Reef. "What we found in Israel was the community is dissolving," Dunbar said.

Caldeira has mapped out where corals exist today and the pH levels of the water in which they thrive; by the end of the century, no seawater will be as alkaline as where they live now. If carbon dioxide emissions continue at their current levels, he said, "It's say goodbye' to coral reefs."

Although the fate of plankton and marine snails may not seem as compelling as vibrantly colored coral reefs, they are critical to sustaining marine species such as salmon, redfish, mackerel and baleen whales.

"These are groups everyone depends on, and if their numbers go down there are going to be reverberations throughout the food chain," said John Guinotte, a marine biologist at the Marine Conservation Biology Institute. "When I see marine snails' shells dissolving while they're alive, that's spooky to me."

Rep. Rush D. Holt (D-N.J.), a scientist by training, attended the congressional briefing on ocean acidification. He said these developments are "new to me, which was surprising because I usually keep up with things."

"The changes in our climate are severe and urgent even if it weren't for this, but this just adds impact and urgency to the situation," Holt said.

Academic Content Standards

This lesson addresses academic content standards of Maryland, Virginia and the District of Columbia.

Maryland

Science: The student will carry out scientific investigations effectively and employ the instruments, systems of measurement, and materials of science appropriately. (Grades 3-5, Skills and Processes, Expectation 3)

Science: The student will use science-appropriate methods of communicating in writing and orally the processes and results of scientific investigation. (Grades 3-5, Skills and Processes, Expectation 5)

Science: The student will investigate the interdependence of diverse living organisms and their interactions with the components of the biosphere. (Grades 5-6, Biology, Expectation 5)

Science: The student will investigate a biological issue and develop an action plan. (Grades 5-6, Biology, Expectation 6)

The Maryland Voluntary State Curriculum Content Standards can be found online at http://mdk12.org/mspp/vsc/index.html.

Virginia

Science: The student will plan and conduct investigation in which
- observation of living things are recorded in the lab and in the field
- hypotheses are formulated based on observation
- conclusions are drawn based on recorded quantitative and qualitative data (Biology 1)

Science: The student will investigate and understand the bases for modern classification systems. Key concepts include
- structural similarities in organisms
- examination of local flora and fauna where applicable (Biology 7)

Science: The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems. Key concepts include:
- interactions within and among populations including carrying capacities, limiting factors, and growth curves
- the effects of natural events and human influences on ecosystems
- analysis of local ecosystems (Biology 9)

Standards of Learning currently in effect for Virginia Public Schools can be found online at www.pen.k12.va.us/VDOE/Superintendent/Sols/home.shtml.

Washington, D.C.

Science: Students understand and develop abilities to do scientific inquiry by asking questions based on current knowledge, performing investigations and devising logical explanations (1, Scientific Inquiry)

Science: Students observe, investigate, describe and classify living things; explain life cycles, diversity, adaptations, structure and function of cells and systems reproduction, heredity, interdependence, behavior, flow of energy and matter and changes over time (2, Life Science)

Reading/English Language Arts:
Create multi-paragraph essays that
- present effective introductions and concluding paragraphs and
- guide and inform the reader's understanding of key ideas and evidence. (Grade 5, 5.W-E.3)

Learning Standards for DCPS are found online at www.k12.dc.us/dcps/Standards/standardsHome.htm.