Decoding Diatoms

Paleo to present day water studies

Grade Level:

Pond Life Study: all ages

Diatoms Decoded and Build Your Own Core: Grades 7-12 (younger grades with modifications)

Activity Duration: 1-3 hours

Activities:

I. Water Study
II. Decoding Diatoms
III. Build Your Own Core

Summary: Diatoms are a type of algae. Their cell walls are made of silica (glass.) This unique structure preserves their shape, and makes them excellent species to study the condition of lakes over time. Scientists can collect core samples and identify diatoms in the layers of that sediment core that were living at various points in time. The presence or absence of certain diatoms can help us understand the history of a particular lake. Diatoms are ubiquitous and are found in most water. In this lesson, students will practice microorganism identification using local water samples and apply this understanding to a study of diatoms found in Lake George.

Topic: Freshwater microorganisms, diatoms, ecosystem, history

Theme: The presence or absence of diatoms in core samples from a lake bed can give clues to changing lake conditions over time.

Goals: To understand the use of diatoms as a tool for studying the health of a lake over time.

Objectives:

1. Students will view and identify microorganisms found in freshwater.
2. Students will identify diatoms found in pond water samples.
3. Students will explain the significance of finding specific diatoms in core samples.

Use in Conjunction with:

MinnAqua. (2010). "Water Habitat Site Study Identification Sheet: Microscopic Organisms." *MinnAqua Leader's Guide.* Minnesota DNR. From Lesson 1:4.

MinnAqua. (2010). "Water Habitat Site Study." *MinnAqua Leader's Guide.* Minnesota DNR. Lesson 1:4.

MinnAqua. (2010). "From Frozen to Fascinating." *MinnAqua Leader's Guide.* Minnesota DNR. Lesson 1:6.

Minnesota Science Standards

K-5th grade

0.4.2.1.1 Life Science – Interdependence Among Living Systems
Observe a natural system or its model, and identify living and nonliving components in that system.

1.1.3.1.1 The Nature and Science of Engineering – Interactions Among Science, Technology, Engineering, Mathematics, and Society
Recognize that tools are used by people, including scientists and engineers, to gather information and solve problems.

3.1.1.2.1 The Nature of Science and Engineering – The Practice of Science
Generate questions that can be answered when scientific knowledge is combined with knowledge gained from one's own observations or investigations.

3.1.1.2.3 The Nature and Science of Engineering – The Practice of Science
Maintain a record of observations, procedures and explanations, being careful to distinguish between actual observations and ideas about what was observed.

3.1.1.2.4 The Nature of Science and Engineering – The Practice of Science
Construct reasonable explanations based on evidence collected from observations or experiments.

5.3.4.1.3 Earth and Space Science – Human Interactions with Earth Systems
Compare the impact of individual decisions on natural systems.

5.4.2.1.2 Life Science – Interdependence Among Living Systems
Explain what would happen to a system such as a wetland, prairie or garden if one of its parts were changed.

5.4.4.1.1 Life Science – Human Interactions with Living Systems
Give examples of beneficial and harmful human interaction with natural systems.

6 -12th grade

6.1.3.1.1 The Nature of Science and Engineering – Interactions Among Science, Technology, Engineering, Mathematics, and Society
Describe a system in terms of its subsystems and parts, as well as its inputs, processes, and outputs.

8.3.4.1.2 Earth and Space Science – Human Interactions with Earth Systems
Recognize that land and water use practices can affect natural processes and that natural processes interfere and interact with human systems.

9.1.3.1.1 The Nature of Science and Engineering – Natural and designed systems are made up of components that act within a system and interact with other systems.
Describe a system, including specifications of boundaries and subsystems, relationships to other systems, and identification of inputs and expected outputs.

9.3.4.1.1 Earth and Space Science – Human Interactions with Earth Systems
Analyze the benefits, costs, risks and tradeoffs associated with natural hazards, including the selection of land use and engineering mitigation.

9.4.2.1.1 Life Science – Interdependence Among Living Systems
Describe factors that affect the carrying capacity of an ecosystem and relate these to population growth.

9.4.4.1.2 Life Science – Human Interaction with Living Systems
Describe the social, economic and ecological risks and benefits of changing a natural ecosystem as a result of human activity.

Environmental Literacy Scope and Sequence
Benchmarks:

- Social systems and natural systems are made of parts. (K-2)
- In social systems that consist of many parts, the parts usually influence each one another. (3-5)
- Social and natural systems are connected to each other and to other larger or smaller systems. (6-8)

Concepts addressed in this lesson: biotic factors, abiotic factors, group, cause and effect, ecosystem, habitat, accumulation

For the full Environmental Literacy Scope and Sequence, see:
www.seek.state.mn.us/eemn_c.cfm

Materials:

- Clean bottle (for water sample)
- Microscopes and slides
- Pipettes or eye droppers
- Plankton identification sheets
- Diatom species ID cards
- Lake George core model
- Decoding Diatoms worksheet

Background:

Introduction to diatoms

Diatoms are a type of algae (class Bacillariophytae). Diatoms are characterized by a cell wall (frustule) made of silica (glass) which protects diatoms from predation, parasites and disease. Each frustule is made of two halves, known as valves, which fit together like a box with one side larger than the other. The two valves are held together by girdle bands. Each valve has intricate designs of stripes (striae) and dots (punctae) which act like a fingerprint for each diatom species.

There are estimated to be over 300 million species of diatoms in the world! We are still discovering several new species every year. Some species are believed to be found everywhere in the world; these are ubiquitous or cosmopolitan species. Other species are only found in one region or even one lake; these are indigenous or endogenic species. Different kinds of diatoms are found in oceans and freshwater lakes in temperate (cold) and tropical regions. Diatoms have amazing diversity. Diatoms are very important to the ecosystems where they are found. They photosynthesize (produce energy from light) and help to produce oxygen for us to breathe. They also form the base of many food chains, so they provide high quality food for zooplankton and fish.

Diatoms are very diverse in their morphology and ecology. Some diatoms are centric (round) or very long and skinny; these often live floating in the water column and are called planktonic. Other diatoms are pennate (not round) and are shaped like ovals, lemons, Pringles, and several other shapes. Most pennate diatoms are benthic, which means they do not float in water but instead live attached to or on top of a solid surface. Diatoms can live on rocks, plants and other algae, sediment (mud), even individual sand grains. Some diatoms grow stalks like a plant to attach to a rock; others have one or two raphes which they use to move around. Diatoms can form colonies of several individuals living together; they can form long chains or star-shapes in the water column, or live together on stocks, in mats, or in tubes made of mucus in benthic areas.

When diatoms were first discovered, scientists thought they were animals because they move! DNA analysis shows that diatom DNA is 1/3 animal, 1/3 plant, and 1/3 unique. Humans use diatoms in their everyday lives. Diatoms' frustules preserve well as fossils and can form a rock known as diatomite, which we use as filters for alcohol and French fry grease, pesticides, and abrasives (diatoms used to be in our toothpaste!). There is currently research for using diatoms as renewable energy sources of electricity and car fuel. Diatoms can even be used to create microscopic art!

Human activity can impact diatoms; we can decrease, increase or change their growth by adding nutrients or removing habitat. There is evidence we have caused some endogenic diatom species to go extinct in the Great Lakes. We have also begun to introduce some diatoms as invasive species to habitats where they were not found before (for example, 'rock snot'). Diatoms are important to nature because they provide food, oxygen and energy. Humans and diatoms interact more than we realize.

Introduction to Paleolimnology

Paleolimnology comes from two words: 'paleo' which means 'ancient', and 'limnology' which is the study of lakes, rivers and wetlands. So, **paleolimnology** is literally 'the study of ancient lakes or, rather, the study of environmental change in lakes and their watersheds. Paleolimnology studies various impacts on lakes like nutrients, **eutrophication**, deforestation, industry, mining, weather, temperature, lake level, climate change, ice cover, invasive species, and many more. Paleolimnology considers many **indicators** of environmental change, including chemical and geological indicators. Biological indicators include pollen, ambrosia, charcoal, diatoms, soft algae pigments, fish fossils, zooplankton fossils, chironomid (insect larvae) fossils, fossilized wood, and several others.

Diatoms make good paleolimnological indicators. They live in almost every aquatic habitat. Species are easy to identify because of their intricate patterns. Their silica cell walls preserve well in sediment so they are abundant to look at and count. Diatoms reproduce quickly so they respond quickly to rapid environmental changes. One of the most common ways that diatoms change is their **relative abundance**, that is, how many of one species are present in relation to other species. Depending on changes in relative abundance, scientists can track changes in the lake ecosystem and its watershed. Scientists know the optimal growing conditions for several diatom species and functional groups, so when they are seen in a higher relative abundance, it is known that the lake environment at the time had what they needed to grow a lot; if a species decreases, it is known that the lake environment at the time was not healthy for them.

In paleolimnology, scientists sample a core of sediment from the deepest point in a lake. They then cut the sediment into slices (intervals), and each interval represents a point in time. The bottom of the core is older than the top of the core. The sediment is dated using radioactive isotopes 210-Pb (lead) and 137-Cs (cesium from nuclear warhead testing in 1967 and the Chernobyl explosion in 1986). Diatoms are isolated from the sediments and are identified and counted using a microscope. Scientists then use statistics to compare the relative abundance of diatoms to events we know happened during the years the core represents. This shows them how diatoms, and hence the lake ecosystem, responded to natural and human events in the lake's history.

The goal of paleolimnology is not just to observe the past, but to help predict the future. If we know diatoms changed a certain way after a specific event, we can make informed decisions for the management of a watershed and regulations for a lake. For example, if scientists find that agriculture caused eutrophication in a lake because we were adding too much phosphorus, then we can make decisions to use less phosphorus and different agricultural practices.

Diatom and Paleolimnology Vocabulary Words

Algae – a general term that describes a group of organisms based on similar characteristics of how they function. Algae general live in aquatic environments, contain plastids, and can usually perform photosynthesis. They are very diverse and range from cyanobacteria to giant kelp.

Diatom - a kind of algae, specifically in the functional group photosynthetic stramenopiles or heterokonts. Characterized by a silica cell wall and golden-brown chloroplasts which they use to photosynthesize.

Frustule – the cell wall of a diatom that is made of silica (basically, glass).

Valve – one half of a frustule.

Girdle bands – bands that hold the two valves of a frustule together, kind of like rubber bands.

Ubiquitous/Cosmopolitan – a species that is found all over the world.

Indigenous/Endogenic – a species that is found only in a certain place.

Centric – a round valve shape in diatoms (for example, Cyclotella or Stephanodiscus).

Pennate – a valve shape in diatoms that is not round. It is usually symmetrical on two sides (like a heart; for example, Navicula or Cymbella).

Planktonic – organisms that float in the water column.

Benthic – organisms that do not float in water but instead live attached to or moving on solid surfaces.

Raphe – slit in one or both valves of a diatom through which they exude part of their cytoplasm to move along a substrate in a motion that resembles a conveyor belt or tank wheel.

Morphology – the shape and other characteristics of an organism's body that helps distinguish it.

Ecology – how an organism behaves and functions in relation to other species and its environment.

Paleolimnology – the study of environmental change in lakes (also streams and wetlands).

Eutrophication – an addition of excessive nutrients to a water body that decreases water quality and light for photosynthesis, causes algal blooms, and can cause the death of fish and underwater plants and human sickness.

Indicator – a geological or chemical characteristic or biological organism that responds in a known way to environmental changes and hence can be used to assess how a lake responds to changes.

Relative abundance – a statistical way to compare the number of species present in a sample in a ratio to each other.

Procedure

I. WATER STUDY

Studying microscopic organisms in water samples with your class is a great year-round activity for all ages. There are many resources and lesson plans available. On the MinnAqua Leader's Guide *Fishing: Get in the Habitat!* CD the lesson "From Frozen to Fascinating" offers comprehensive background material and activity instructions, particularly if you are studying water in the winter. Visit www.dnr.state.mn.us/minnaqua/leadersguide/index.html to learn more about the MinnAqua program and curriculum referenced here.

Basic water study:

1. Obtain a water sample from a stream, lake or river. Any clean container with a lid will do.

2. Introduce the concept of the food pyramid. Mirco-organisms are very important in creating a solid base. There needs to be significantly more individuals at lower trophic levels to support organisms further up.

3. Have students use microscopes, or half a petri dish on an overhead projector to magnify the water.

4. As a class or individuals have the students work to identify the organisms with the water sample using the plankton identification sheets from MinnAqua. Have students draw what they observe.

II. DECODING DIATOMS

Using samples of diatoms from lake sediment can help researchers understand changes in lake health throughout history. Each species has optimal conditions for growth. Some thrive on nutrient rich water, and some require clear water.

The core sample you will use today is modeled after a case study of Lake George, located near the east end of Lake Superior. The model with layers is our replica of a core sample. The paper diatoms in each layer represent the distribution of species actually found in one cm of sediment as reported in the case study. Students will try to identify the diatoms present in their layer and figure out which series of years the layer represents.

Divide class into five small groups. Give each group a layer of the core, and each group or student a copy of the *Diatoms Decoded* worksheet. Using the species cards have students sort and identify the diatoms in their layer.

The *Diatoms Decoded* worksheet can be used as a guide to help students identify the most prevalent diatoms and what their ideal growth conditions are.

a. Students will record the type of diatoms, their habitat and growth conditions on the chart

b. Using the photographs on the identification cards, students will draw where in the lake the diatoms would have been present. This activity will help to clarify benthic (bottom dwelling) and planktonic (free floating) varieties. If there is an overabundance of planktonic diatoms, they limit the amount of sunlight that can reach the benthic species.

c. Students will use graphical representation to record the number of each diatom found within their layer.

d. Finally, given the Lake George Paliolimnology timeline chart students will use the clues of diatom species, and abundance to match a time period.

i. What clues helped you to reach this conclusion?
ii. How does studying micro-organisms from hundreds of years ago help us to understand environmental changes of a lake?

Diatom core key:

Core color: Dark Blue	1700-1850	Low Aulacoseira Many Raphids Benthic dominant (Staurosira)	• Before human settlement • Natural conditions of clear water, lots of benthic habitat of macrophytes and sand
Teal	1850-1900	Increase Staurosira Increase raphids	• Deforestation, 1898 dam built – more sand (more habitat) • Increased macrophytes (nutrients)
Green	1904 – 1973	Increase Aulacoseira, Cyclotella Low raphids	• 1945 peak planktonic • Tannery (metal contaminants)
Yellow	1973 – 1993	Aulacoseira No raphids Fragilaria crotonensis dominates	• More nutrients • Eutrophication
Beige	1993-2011	Cyclotella increases Raphids increase	• Improved water quality – clearer water, less nutrients • More benthic habitat, light • Response to less nutrients inputs because of Clean Water Act in 1972 – important to realize that pollution in water takes a long, long time to clean up

Ideas for Younger Students

After investigating a pond/lake water sample, the core can still be used with a few modifications. The layers of the core can be used for sorting and graphing projects.

1. In small groups, have students sort the different diatoms by matching shapes.
2. As a class, graph the quantity of each diatom, using pictures as labels.

3. Introduce the concepts of biodiversity, that there are many different kinds of organisms, and that if one kind has many individuals, another kind might not have enough resources (light, nutrients and space) to grow, and become crowed out.

III. BUILD YOUR OWN CORE

After using the cores to identify the layers from the Lake George model, your class can create their own environmental explanations for a core model.

Give students a layer of the core model, along with the species identification cards. Have groups identify and count the number of diatoms present for each species.

Ask groups to brainstorm possible environmental influences that could contribute to this diatom combination.

a. If there are many diatoms that thrive in clear water, what can that tell us about the health of the body of water?
b. If there are diatoms that thrive on nutrients, such as those that come from run-off or eutrophication, what might be a possible explanation – farms, factory, etc.

Each group should choose a scenario that fits their collection of diatoms. As a whole class, work to construct a model that tells the story of a fictional lake using each small group's explanation. They may choose to show a model habitat improvement, or a model of habitat destruction.