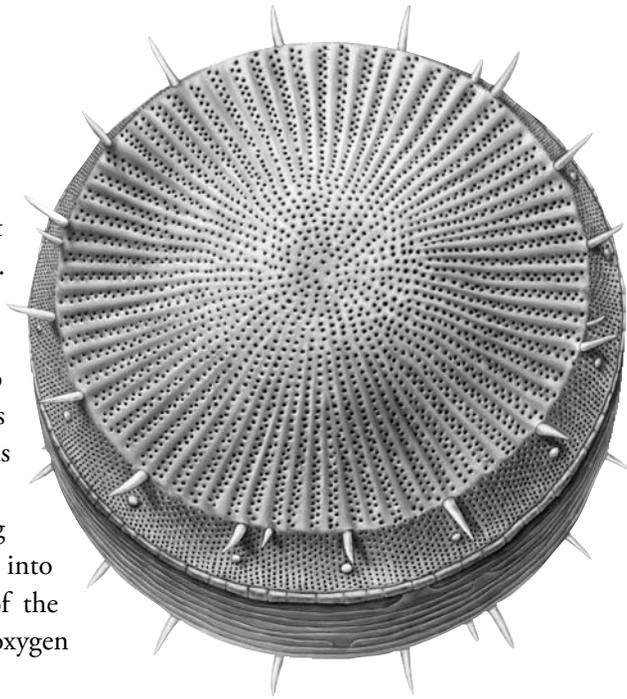


## DIATOMS: One-Celled Wonders

Diatoms (DIE-a-toms) are one of the most important things you never knew about. They are everywhere there is water. A drop of lake water is packed with them. You probably swallow millions every time you go swimming. These tiny, one-celled life forms populate the world's ponds, rivers, and oceans (and anywhere else that's the least bit wet). They spend their invisible lives quietly using sunlight to turn carbon dioxide and water into food and oxygen. Diatoms are the basis of the food chain, and they produce much of the oxygen you breathe.



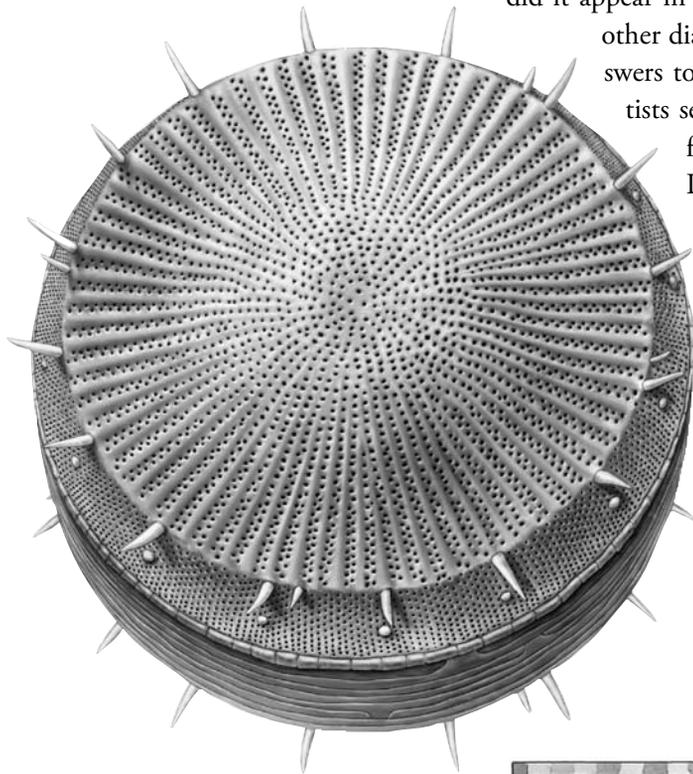
Dead or alive, diatoms are important. Their skeletons are made from a substance called silica, which is the main ingredient in glass. When diatoms die, their dead bodies pile up by the trillions on the floor of oceans and lakes, forming a chalky mud. This plentiful mud is used as a water filter, an insecticide, and even as an ingredient in some toothpaste.

More important still, dead diatoms fossilize (become preserved) over time. The fossil record can tell us many things about Earth's past, and diatoms are especially good record keepers. First, their fossils are plentiful. A dollop of mud the size of an ice cube may contain as many as 50 million well-preserved diatoms. Second, there are many different kinds of diatoms. No one knows the exact number, but scientists estimate a quarter of a million species, each one preserving a unique record of the past. And third, diatoms are so sensitive to changes in temperature and moisture that the presence or absence of a particular species can tell us a great many things about the environment. From the rise and fall of different diatom populations, we can learn

about changes in past climates, which in turn can give us more clues about the world that plants and animals occupied in the past.

This is where four scientists, a famous lake, and a mysterious diatom enter our story. Brian Shero, a professor at a small New York college, was studying diatoms in Yellowstone Lake when he found a diatom he had never seen before. He sent it to a diatom expert, Edward Theriot, to identify. Ed's life goal has been to learn everything he can about diatoms. He was surprised and excited to discover a diatom he didn't know. It was a species that was brand new to science, and more amazing still, there was no record of it living anywhere else on Earth. In honor of its hometown lake, the new diatom was named *Stephanodiscus yellowstonensis* (Steff-ah-no-DISK-us yellowstone-EN-sis), which means crowned disk of Yellowstone.

Ed was curious about the origins of the mysterious diatom. How and when did it appear in Yellowstone Lake? Did it arise from some other diatom species already there? To find out answers to these questions, Ed and a team of scientists searched for fossil diatoms in mud samples from the bottom of the lake. Yellowstone Lake was formed after the last Ice Age, around 14,000 years ago. Ever since then diatoms have lived and died in the lake. Their sinking skeletons have built up fossil deposits dozens of feet thick, creating a unique time line for scientists to study.

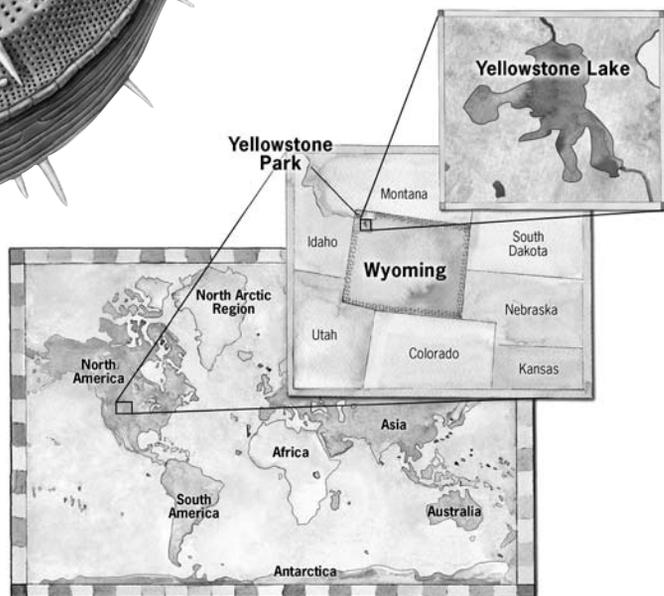


The name of the diatom *Stephanodiscus yellowstonensis* means “crown disk of Yellowstone.”

UNSM Angie Fox illustration

Yellowstone Lake is located in Yellowstone Park.

SMM Lonnie Broden illustration





Yellowstone Lake in Yellowstone National Park contains a species of diatom that is found nowhere else.

Photo courtesy Joe Sawyer

Scientists take a core sample from beneath Yellowstone Lake.

Photo courtesy Edward Theriot

To actually see the fossil deposits is difficult work. The scientists drove a tube a few inches wide and as long as a telephone pole down through hundreds of feet of water and lake-bottom sediments. Sediments in a lake settle gently year by year, forming undisturbed layers often as distinct as the layers of a birthday cake. When the long tube was pulled up, it revealed layers of mud in clear stripes. Each stripe represented a year of diatoms. “We can look in there and find the sediment from 11,298 years ago, in the summer,” Ed says. The core sample covered the entire geological history of the lake, from its birth 14,000 years ago to the present.

What Ed found in the core sample blew him away. By identifying and counting diatoms sample by sample, he could see evolution in action. When Yellowstone Lake first formed, a diatom lived there called *Stephanodiscus niagarae* (Ny-ah-gary), the Niagara diatom. There was no sign yet of *S. yellowstonensis*, the Yellowstone diatom. Over the next 4,000 years, some Niagara diatoms began to change, resembling *S. yellowstonensis* more and more. “We can watch, literally watch, as these diatoms go from one species to another,” Ed exclaimed. In the core sample, the scientists were able to find



The diatom *Stephanodiscus yellowstonensis* (right) has about five ribs between each spine. Counting the ratio of spines to ribs is the way diatom experts tell this species from similar ones.

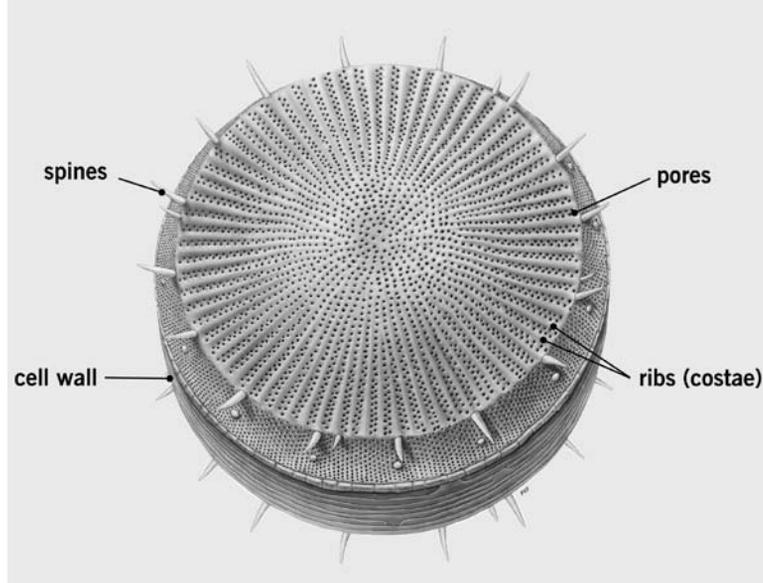
UNSM Angie Fox illustration

Edward Theriot (below) is a diatom scientist at the University of Texas at Austin.

Photo courtesy Marsha Miller

Sheri Fritz (bottom) studies how climate change influences the evolution of diatoms.

Photo courtesy Tom Simons University of Nebraska-Lincoln.



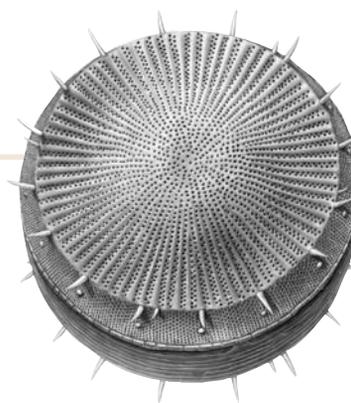
a diatom that had some parts that looked like the Yellowstone diatom and some parts that looked like the Niagara diatom. When a form shares features with two different species, it is sometimes called a “transitional form.” Not only did the core sample show that a new species had evolved, but it also proved to be the fastest evolution so fully demonstrated in the fossil record.

But how did it happen? Ed wondered what else was changing while the diatom was developing new features. He teamed up with Sherilyn Fritz, a geologist who studies how lakes change through time. Sheri looked at the amount of volcanic ash in the layers and at other fossils. She sent mud to her colleague Cathy Whitlock to look for pollen, the tiny grains that flowering plants produce. Like diatoms, pollen grains fossilize, and they are helpful in tracking changes in plant life, temperature, and rainfall.

Ed and Sheri then analyzed the data and came up with an interesting theory about the mysterious appearance of the Yellowstone diatom. In this activity you will have a chance to explore the world of diatoms, meet the new diatom, *S. yellowstonensis*, learn how to make a core sample, check out Ed and Sheri’s data, and see if there is a connection between diatoms and climate change.

## PART ONE

# Meet the diatoms



Diatoms are dazzlingly beautiful little organisms that live in oceans, lakes, rivers, and puddles. . . just about everywhere you find water. Explore the tiny world of diatoms with a deck of diatom cards.

## Work in small groups or with a partner

Each team will need:

- Diatom Fact Cards 1–3 (cut, fold, and tape 12 diatom cards)
- sheet of paper
- tape
- scissors

### 1 Sizing Up Diatoms

Look at the diatom pictures on the cards. Diatoms come in many sizes. So if diatoms are everywhere, why haven't you ever seen one? Because they are small. How small?

Look at this circle: o. Guess how many diatoms it would take to fill in the circle. (The answer is on the last page of this activity).

### 2 Discovering Diatom Shapes

Explore how beautiful diatoms are to behold.

- a Sort the diatom cards into groups or families in a way that makes sense to you. As you sort the cards, don't forget to read the general diatom facts on the back of the cards.
- b What feature or features did your group use to sort?
- c Share your sorting with the other groups. Did every group sort the same?

**Diatom Fact Cards 1**

Cut on dashed lines, fold on solid line.

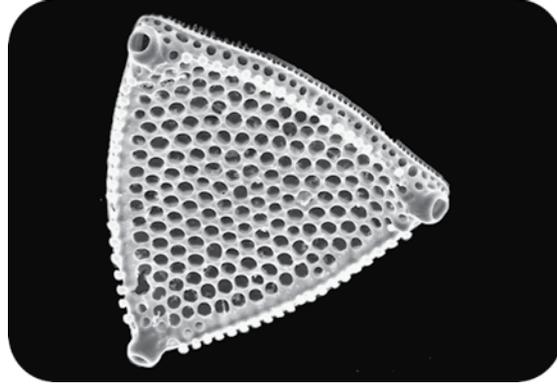
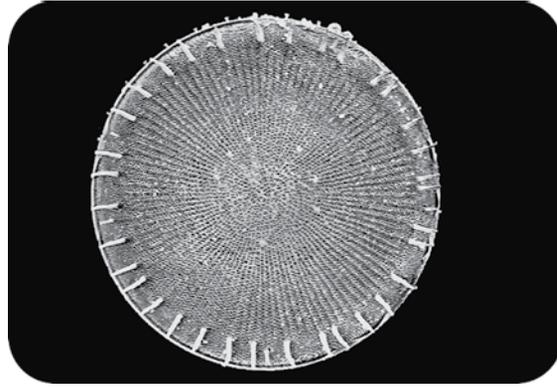
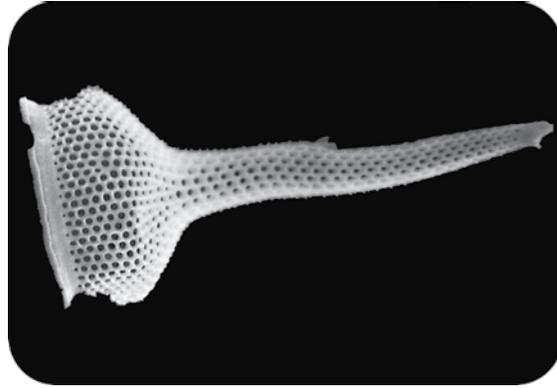
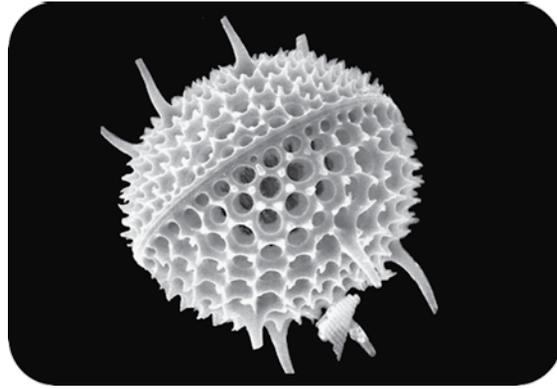


Diatoms are so sensitive to chemical changes in water that scientists use them as markers to track pollution.

Diatoms reproduce by splitting their top and bottom halves apart and growing another half shell.

Diatoms live in both fresh and salt water, rivers, lakes, and ponds. They can be found almost everywhere on Earth that is wet.

Diatoms grow hard, translucent shells of silica that are very much like glass.



Photos courtesy David Harwood and Vladimir Nikolaev.



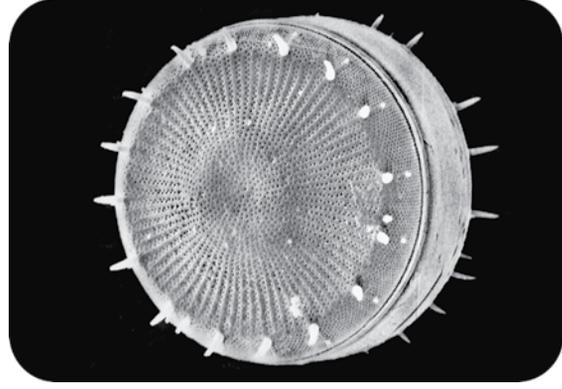
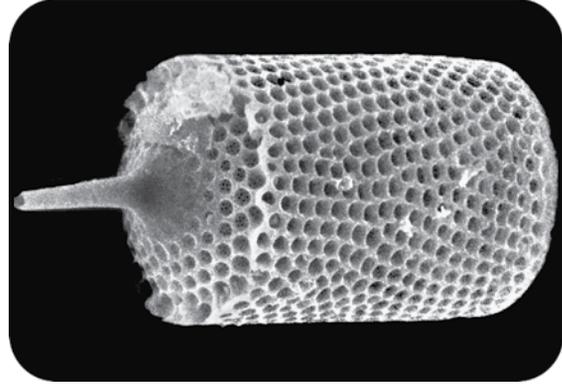
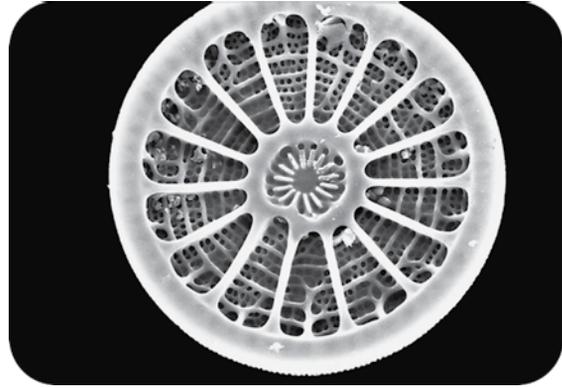
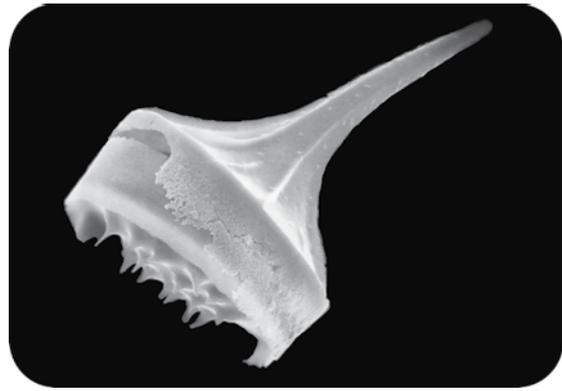
## Diatom Fact Cards 2

Like land plants, diatoms use sunlight to turn carbon dioxide and water into food and oxygen.

Diatoms have no equipment for moving effectively on their own. They drift about in water or slide on ooze at the bottom of lakes.

Diatomaceous earth (diatom powder) is used in pool filters. The tiny holes in diatom shells make them an excellent filter material.

Small diatoms measure 15-20 micrometers (twice the size of a red blood cell, too small to see). The biggest diatoms measure up to 2 millimeters (as wide as a pencil line).



Photos courtesy David Harwood and Vladimir Nikolaev.

## Diatom Fact Cards 3

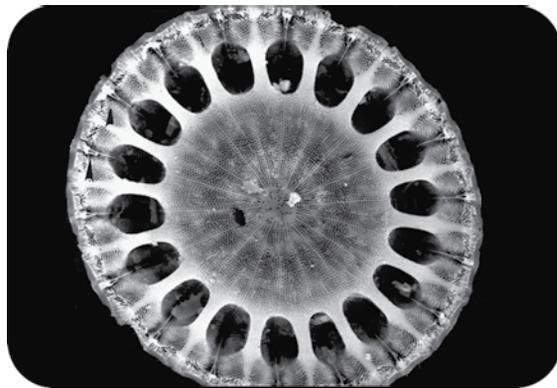
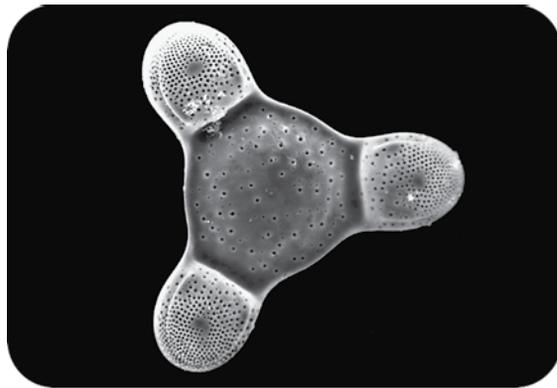
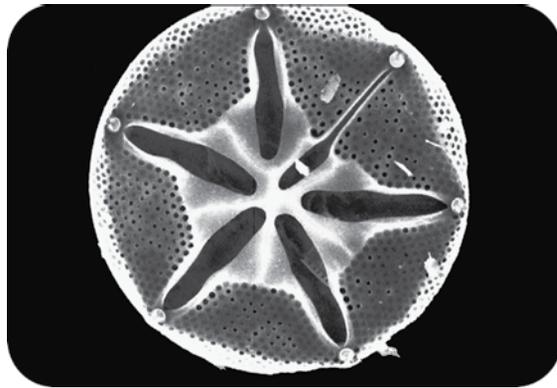
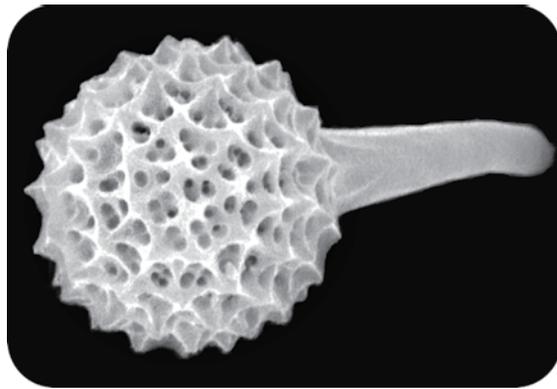
✂ Cut on dashed lines, fold on solid line.

Probably the most important life form on Earth, diatoms are constantly at work turning sunlight into food. They are a basic food for many other animals from tiny shrimp to giant whales.

Pond scum is another name for diatoms. The brown slime on stones at the water's edge is very likely a huge population of tiny diatoms.

Diatoms are single-celled organisms. There are more than 250,000 species of diatoms. Each one has a unique shape.

Police sometimes use diatoms to help solve crimes. The unique mix of diatoms in a lake or river can pinpoint a water source. This has proved handy in identifying where a victim with lungs full of water originally died.



Photos courtesy David Harwood and Vladimir Nikolaev.

### 3 Fascinating Facts

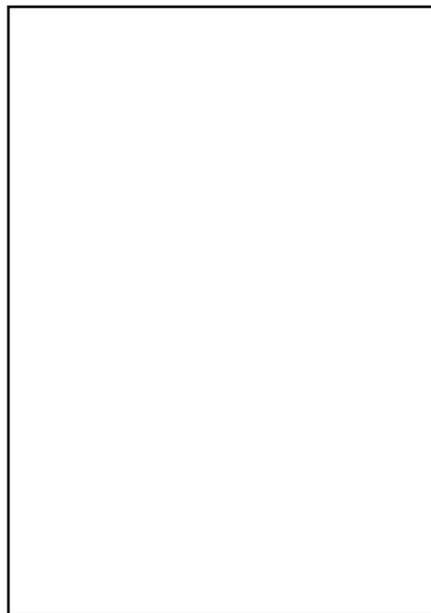
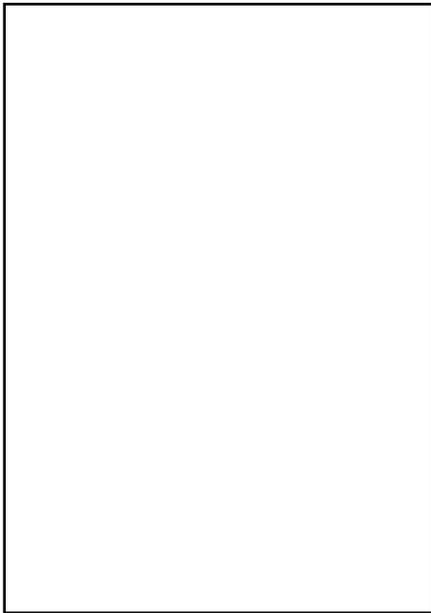
Recall your favorite diatom fact. Write it in the form of a question. Use your question to quiz the rest of the group.

### 4 Who's Closely Related?

Choose two diatoms that you think are most closely related. Tape them in the boxes below. Why do you think they are closely related?

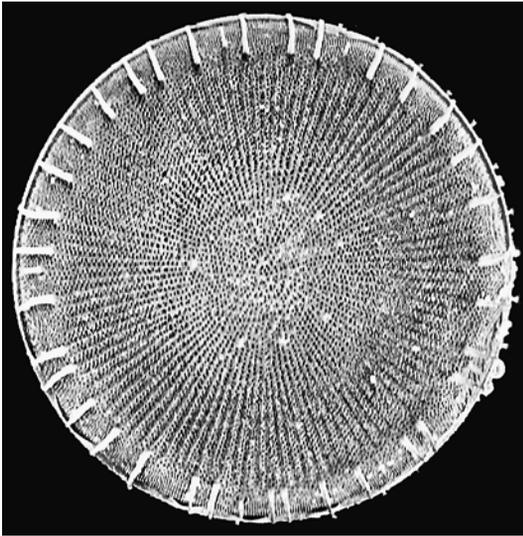
## Discovering Diatom Shapes

Tape your card choices here

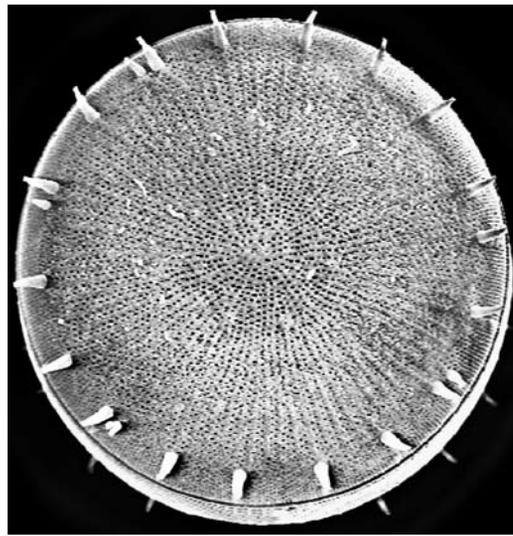


### 5 Diatom I.D.

The new diatom that Ed and Sheri studied was named *Stephanodiscus yellowstonensis* after the lake it was found in. It is very similar to another species, *Stephanodiscus niagarae*, which is found in neighboring lakes, but not in Yellowstone Lake. Both diatoms can be identified on these scanning electron microscope (SEM) images by their round shape like a bicycle wheel with many thin ridges or “ribs” radiating out from the center.



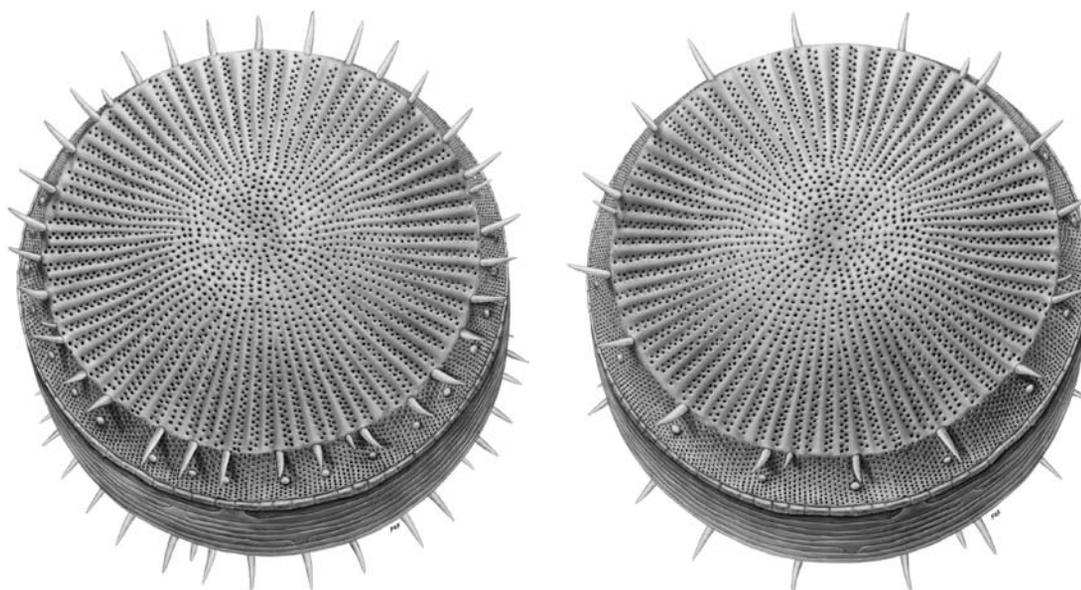
*S. niagarae*. Photo courtesy Edward Theriot.



*S. yellowstonensis*. Photo courtesy Edward Theriot.

## 6 Consider This

Look at the drawings of the two species of diatom shown below.



How do you know they are different species?

Hint: The experts count the number of “ribs” between the pointy “spines” jutting out from the ends. How many ribs are there for every spine in the Niagara diatom? How many ribs to spines are there in the Yellowstone diatom?

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## PART TWO

# Sampling the past

To solve the mystery of where the Yellowstone diatom came from, two scientists teamed up to share their knowledge. Sheri Fritz, a geologist, took core samples (samples of mud collected in a tube) from the bottom of the lake. Ed Theriot, a diatom expert, helped identify ancient diatoms in the core samples. In sorting out the evidence, Sheri and Ed discovered that the Yellowstone diatom had a unique history. They believe this diatom provides the most complete fossil record of the evolution of a new species in the fossil record.

Check out Sheri and Ed's core sample findings. Then make your own muddy history with layers of "mud," and take a core sample. Then use a scientist's methods to reconstruct your own series of past muddy events.

### Work with a partner

Each team of two will need:

- Your Pollen Chart
- Your Diatom Chart
- Read the Core Sample
- one small cup (5 oz, clear is better)
- one clear plastic straw
- brown sugar (9 teaspoons)
- three different bright colors of sugar (1/2 teaspoon each)
- paper plates (3)
- plastic spoon
- cm ruler
- newspapers (to cover work tables)

### 1 Tracking Diatoms

To begin their core sample, the scientists dug down through the mud at the lake bottom until they reached a layer that dated from 14,000 years ago. They removed the core sample and took it back to the lab. There they took tiny scoops of mud from the core every few centimeters. By carefully washing and sorting the contents, they were able to learn which diatoms lived in a specific layer.

- a Read the Diatom Chart. When did the Yellowstone diatom first show up?

### Diatom Chart

Date of core sample	<i>Stephanodiscus</i> DIATOM VARIETY
Now	<i>S. yellowstonensis</i>
2,000 years ago	<i>S. yellowstonensis</i>
4,000 years ago	<i>S. yellowstonensis</i>
6,000 years ago	<i>S. yellowstonensis</i>
8,000 years ago	<i>S. yellowstonensis</i>
10,000 years ago	<i>S. yellowstonensis</i>
12,000 years ago	<i>S.</i> (transitional)
14,000 years ago	<i>S. niagarae</i> -like ancestor

- b** A form that shares features with two different species is sometimes called a “transitional form.” When does the transitional form between the Yellowstone diatom and the Niagara diatom show up in the core sample?
  
- c** Look back at the previous activity section to see what differences you might expect to find between the Niagara diatom and the Yellowstone diatom. List them here.

## 2 Tracking Plant Pollen

If you have ever stuck your face in a flower and come away with a dusty nose, you know about pollen. Plants produce huge numbers of pollen grains to fertilize their seeds. These tiny grains settle everywhere, including in the mud at the bottom of lakes. Under magnification the tiny grains have a distinct shape unique to each species of plant. Pollen trapped in ancient mud tells what plants were alive when that mud layer was formed. Because different plants thrive in different climates, knowing the kind of plants alive at each time provides good clues to past climate conditions.

Here's how to make some sample "muds." Then drill your own core sample, and use your pollen finds to make sense of the past climate.

- a** Make different muds that contain pollen. The whole group should decide on which color sugars will represent which kind of pollen (e.g. green for sage and grass pollen, red for lodgepole pine pollen). Everyone should follow the same rules. Put 3 teaspoons brown sugar on a plate. Add 1/2 teaspoon of one color of the sugar that will represent sage and grass pollen. Stir and label this plate "sage and grass pollen." Lumps are fine.
- b** On another plate, put 3 teaspoons brown sugar and add 1/2 teaspoon of the color of sugar that represents lodgepole pine pollen. Label its plate.
- c** Put 3 teaspoons of brown sugar on a third plate. The brown sugar represents mud of the glacial period. The frozen climate permitted little plant growth and few pollen grains.
- d** Write the pollen (sugar) colors on Your Pollen Chart to help you identify your pollen types.

**Your Pollen Chart**

POLLEN COLOR (SUGAR COLOR)	TYPE OF POLLEN	HABITAT	CLIMATE
	Sage, grass 	Meadows, grasslands	Wet, cool
	Lodgepole pine 	Thick forest	Dry, warm
	None	Icy glaciers	Frozen, cold

- e** Diatoms are represented by the third color of sugar. Decide what kind of climate conditions your diatoms require. Check one type.

Wet cool,       Dry, warm       Frozen, cold

Add 1/2 teaspoon of the diatoms (third color of sugar) to that colored climate layer. Fill in the chart below.

**Your Diatom Chart**

YOUR DIATOM'S COLOR (SUGAR COLOR)	CLIMATE YOUR DIATOM REQUIRES

### 3 Make History

- a** Gather your materials with your partner. Put the cup on a newspaper. Choose a mud and put it in the cup. Make a layer at least one centimeter thick (more is fine).
- b** Add a second layer of different mud.
- c** Continue adding layers (up to 5 more) and record the order below.

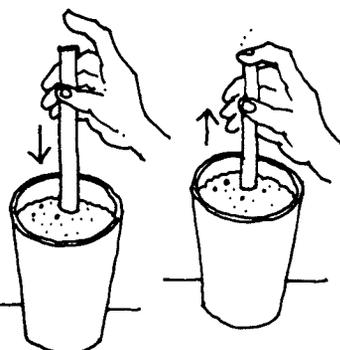


Layer	_____
Layer	_____
Layer 5	_____
Layer 4	_____
Layer 3	_____
Layer 2	_____
Layer 1	_____

### 4 Take a Core Sample. Read the Layers

Your team will take a core sample of another team's cup. Your challenge is to map the pollen types in the layers to make a climate history and determine where the diatoms appear.

- a** Swap cups with another team. Take a core sample by pushing a straw straight down through the layers.
- b** Put your finger on the open end of the straw and remove the core by pulling up. (Keep your finger on the straw to keep the material inside.)
- c** Dust off the outside of the straw so you can see the layers. Read your core's history by recording each layer. Fill in the information for each layer starting from the bottom up, using both words and a drawing on the chart below.



- d** What was the weather like in the oldest period in your core sample?

**Read the Core Sample**

DRAW CORE SAMPLE HERE	LAYER # Counted from the bottom up	TYPE OF POLLEN IN LAYER	CLIMATE TYPE	CHECK IF DIATOMS ARE PRESENT
	Layer 5			
	Layer 4			
	Layer 3			
	Layer 2			
	Layer 1			

**5 Consider This**

How did the climate change from the oldest layer (#1) to the most recent?

---

## PART THREE

# Mystery in Yellowstone Lake

Sampling pollen in ancient mud is a great tool for figuring out weather conditions of the past. Sheri's friend, Cathy Whitlock, analyzed the pollen found in the core samples from the mud at the bottom of Yellowstone Lake. The pollen gave clues about the climate conditions thousands of years ago. Now is your chance to analyze the scientists' data.

### Work with a partner

Each team of two will need:

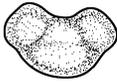
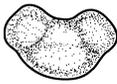
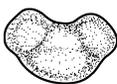
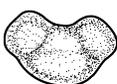
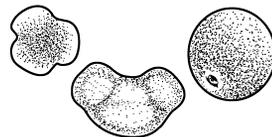
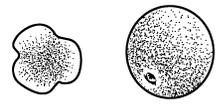
- Core Sample Chart
- Pollen Chart (from Part Two)

### 1 Climate Clues

Use the pollen data to create a 14,000-year weather report of Yellowstone Lake.

- a** Fill in the Core Sample Chart. Use the Pollen Chart as the key to identify the plant pollen found in the core sample. Be sure to fill in both pollen type and the climate conditions.
- b** Write a weather report for Yellowstone Lake for the past 14,000 years. Summarize the trends.
- c** When did the transitional form of the Yellowstone diatom begin to appear in the core sample? According to the pollen record, what else happened about this time?

**Core Sample Chart**

DATE OF CORE SAMPLE	DIATOM VARIETY	POLLEN TYPE	CLIMATE
Now	<i>S. yellowstonensis</i>	 name:	
2,000 years ago	<i>S. yellowstonensis</i>	 name:	
4,000 years ago	<i>S. yellowstonensis</i>	 name:	
6,000 years ago	<i>S. yellowstonensis</i>	 name:	
8,000 years ago	<i>S. yellowstonensis</i>	 name:	
10,000 years ago	<i>S. yellowstonensis</i>	 name:	
12,000 years ago	<i>S. (transitional)</i>	 names:	
14,000 years ago	<i>S. niagarae</i> -like ancestor	 names:	

Linda Allison illustration.

## 2 Consider This

No one can say what exactly caused the Yellowstone diatom to evolve. We do know that diatoms are extremely sensitive to environmental conditions like available light, nutrients, and temperature changes. What changes do you think might have affected the evolution of this new diatom?

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## PART FOUR

# Be a science reporter

Write a short news story about diatoms. Tell your readers about a new species of diatom that is found only in Yellowstone Lake. From core samples taken beneath the lake, scientists can tell that the Yellowstone diatom first appeared thousands of years ago, at a time when the climate was dramatically changing. Based on what you have learned, explain how you think this new diatom came to exist in the lake.

**P.S.** Don't forget the headline.

*Answer:* You could fit about 1,000 diatoms into the circle.