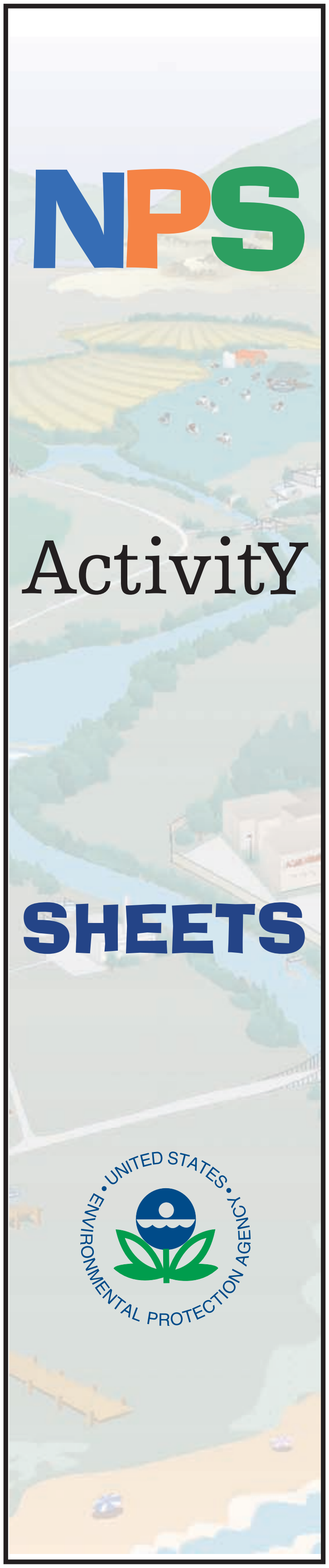


Activities to Accompany

Hysteria Over Pfiesteria

For Grades 6–8

Objectives:

Students will be guided through an investigation of the *Pfiesteria* outbreaks through a variety of approaches employing writing, math, drawing, summarizing and deductive skills. As students assimilate details of the *Pfiesteria* problem, they will begin to develop a multifaceted understanding of the issue and its potential links to nonpoint source pollution. In Exercise II, they study the spatial and temporal distribution of *Pfiesteria* outbreaks in an effort to explore reasons for the connection between nonpoint source nutrient pollution and the occurrence of *Pfiesteria* outbreaks. This will lead them into an exercise investigating their own households as sources of nonpoint source nutrient pollution. Finally students look at real-time data collection efforts to make the connection between the science they read about and actual data interpretation from science labs studying *Pfiesteria* in North Carolina's rivers.

Exercises:

Exercise I. Draw Your Own Pfiesteria
Exercise II. Locating Pfiesteria
Exercise III File Your Own Pfiesteria Kill Column
Exercise IV Nutrients in the Water

Time Required:

Individual exercises are designed to be approximately ½ hour to 45 minutes long. The time to complete an exercise can be longer if the optional links to related Web sites are explored for a deeper examination of the subject. All exercises are well-suited for in-class lessons. Exercise IV has two steps, each of which can stand alone.

Curricular Standards and Skills:

Math:
measurement
scientific method
biological terminology,
life form classification

Thinking Skills:
deductive reasoning

Language Arts:
reading comprehension
essay writing

Social Sciences:
spatial understanding– regions, waterbodies, hydrology

Vocabulary:

Nutrients: Substances that all living organisms need for growth and reproduction. Two major nutrients, nitrogen and phosphorus, occur naturally in water, soil, and air. Nutrients are present in animal and human waste and chemical fertilizers. All organic material such as leaves and grass clippings contains nutrients.

Nutrient Loading: adding nutrients to a system. In particular, nitrates and phosphates added to aquatic systems can often cause microorganisms such as algae to undergo a population explosion.

Algae: aquatic photosynthetic organisms which are not true plants, but close relatives, often microscopic. Small algal populations are normal; overpopulation (green turbid blooms) indicate nutrient pollution.

Bloom: a severe overpopulation of aquatic algae, characterized by serious green turgidity. Can lead to anoxic conditions.

Eutrophication: the result of overloading an aquatic system with nutrients (sewage, phosphate), producing an overgrowth of algae, low dissolved oxygen, and little aquatic life.

Toxic: a substance is said to be toxic if it harms or kills plants or animals by direct action.

Toxin: any poisonous product of animal or vegetable cells. The toxins produced by harmful bacteria cause the symptoms of many diseases.

Cyst: a protective outer membrane formed around an organism, such as a protozoan, during reproduction or in response to unfavorable environmental conditions.

Dinoflagellates: a unicellular biflagellate, typically marine, algae that is an important component of plankton; usually photosynthetic.

Flagella: long whip-like moveable structure or tail extending from the cell and used in locomotion.

Pfiesteria: a microscopic, single-cell organism that has the ability to behave like an animal under certain conditions. It belongs to a group of phytoplankton known as dinoflagellates.

Tributary: a branch (smaller stream) bringing water into a stream, river, etc.

Phytoplankton: minute, floating aquatic plants; algae

Hydrology: a science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

Worksheets:

1. Know Your Nitrogen exercise (Source: the Chesapeake Bay Foundation / State of Pennsylvania DEP.) Download from: http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Subjects/NonpointSourcePollution/know%20your%20nitrogen.pdf or http://www.dep.state.pa.us/dep/deputate/watermgt/watermgt.htm (listed under 'Related Information' on the DEP Web Site)

2. Draw your own *Pfiesteria* worksheet.

3. Trigger Test adapted from Envirohealth Link Summer Institute Publication at http://www.mpt.org/learningworks/teachers/ehl/

Internet sites referenced:

Web site 1:: "Background Information on *Pfiesteria*" www.*Pfiesteria*.org/*Pfiesteria*/*Pfiesteria*.html

Web site 2: "Life Cycles of *Pfiesteria pescicida*" www.*Pfiesteria*.org/*Pfiesteria*/lifecycle.html

Web site 3: "Images of *Pfiesteria*"
www.*Pfiesteria*.org/archives/images.html

Web site 4: "Dinoflagellates, Protists and *Pfiesteria*" http://www.mdsg.umd.edu/MarineNotes/Jul-Aug97/side1.html

Web site 5: "*Pfiesteria piscicida* and *Pfiesteria*-like Organisms"
http://www.mdsg.umd.edu/pfiesteria/cb.html

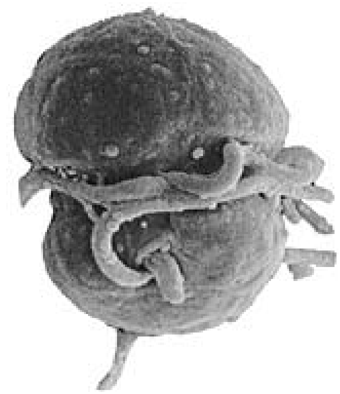
Web site 6: "*Pfiesteria piscicida*, Fact Sheet" www.epa.gov/owow/estuaries/*Pfiesteria*/fact.html

Web site 7:
"Alien in Our Midst? Phantom Algae Suspected in Bay"
http://www.mdsg.umd.edu/MarineNotes/Mar93/index.html

Web site 8: "Neuse Estuary Monitoring Project" http://www.pfiesteria.org/nrdp/index.html

Web site 9: "Water Quality Parameters"
http://imc.lisd.k12.mi.us/tests.html

Exercise I.
Draw Your Own Pfiesteria!



Step 1. How big is *Pfiesteria*?

The size of *Pfiesteria* is 5-450 Um (micrometers).
Compare that with your ruler: 1 millimeter is 1000 micrometers.
If the smallest *Pfiesteria* were lined up on your ruler, 200 of them would fit in 1 mm!

Step 2. What does *Pfiesteria* look like and what does it do?

Go to Web site 3: http://www.pfiesteria.org/imagearchives/index.html. This Web site contains a photographic perspective of the organism, as seen through microscopes.

As you can see there are many different versions of Pfiesteria? This is because they can take on different forms depending on their particular life-cycle stage. They are in the **flagellated**, **amoeboid**, or **encysted** forms or stages.

> Click on web site 2: www.Pfiesteria.org/Pfiesteria/lifecycle.html, for details on how *Pfiesteria* actually kill fish.

Step 3. Make your own *Pfiesteria*.

Use the empty box on the Draw Your Own Pfiesteria worksheet below to draw a picture of Pfiesteria in one of its stages. Make sure you identify the stage. In your drawing, identify the features that correspond to the descriptive name of the lifestage, and label key features such as the flagella.

> For ideas on how to translate a photograph into a drawing, click on web site 2: www.Pfiesteria.org/Pfiesteria/lifecycle.html and enlarge the drawing.

Step 4. Figure out the scale of your drawing.

Measure the diameter of the *Pfiesteria* in your drawing using a ruler. Now compute the scale of your drawing with respect to a 'real' *Pfiesteria*.
(Hint: If the diameter of your *Pfiesteria* is 1 mm, then the scale would be 1:200)

Worksheet: Draw Your Own *Pfiesteria*

Name: ________________________ **Date:** _______________

Name of Stage: ________________________

Scale of Drawing: ______________________

Additional Resources and activities (as time permits):

Women in Science:
Investigate how *Pfiesteria* got its name. The story of Dr. Lois Pfiester is at http://www.susqu.edu/satsci/97-08-30/essay%20revised.html.

Investigate the investigators:
Read the news story below about how Pfiesteria disabled and affected the scientists researching it.

Sunday, September 1, 1996

Scientists track the 'phantom'

By TONY BARTELME
Of The Post and Courier staff

What happened to Howard? The questions circled through JoAnn Burkholder's mind, like the sweep hand of a clock. During long walks in the woods, during the nights she couldn't fall asleep. *Was he careless?* Not Howard. He was one of the best scientists she had ever worked with. *What did I miss?*
What is happening to my husband? Aileen Glasgow was asking her own questions. Howard was a whiz at math but now he couldn't add two plus two. *Is it stress?* One night he got lost driving home from work.

And those rages?

They were getting worse. And they were over trivial things. One time he burst into the bedroom at 2 a.m. screaming about how the vacuum cleaner cord wasn't coiled. The next morning he didn't even remember his outburst.

Could it have something to do with his work?

For the past few years, Glasgow had been consumed by his research. He and a handful of scientists at N.C. State University in Raleigh were studying a newly discovered microbe called **Pfiesteria** piscicida, nicknamed "the phantom."

Usually found in shallow estuaries, **pfiesteria** has the ability to change into at least 24 different forms, from an amoeba with Gumby-like appendages, to a stealthy round cyst that hides in sediment, to a ferocious two-tailed killer that drugs schools of fish and sucks off their skin, sometimes leaving behind millions of carcasses with blood-red sores and holes the size of half dollars.

This strange critter was responsible for about half the fish kills in North Carolina in the early 1990s, including one on the Neuse River that wiped out more than a billion fish.

It has been found near Charleston, close to an aquaculture operation. While it hasn't caused any major fish kills here, scientists are keeping an eye out for it. It has been found as far south as the Gulf of Mexico and as far north as Delaware. It is perhaps the world's most flamboyant and stealthy algae. And a source of real concern.

Scientists like Burkholder say that in the past two decades, there has been an alarming increase in the growth of toxic algae like **pfiesteria**. These organisms pose a danger not only to fish but also to people. Many scientists fear the increase of these nearly invisible creatures is yet another signal that pollution and development have thrown the earth's environment out of whack.

Like a horror film

In 1993, the year Howard Glasgow "went down," as his colleagues say, he and Burkholder knew as much as anyone about **pfiesteria** (pronounced fee-steer-ee-uh).

In fact, several years before, it was Burkholder and researchers at N.C. State's veterinary school who discovered it. Ed Noga, a fish pathologist, and a grad student, Steve Smith, walked into their lab one morning and found the fish belly up. Noga put more fish in, but they died too.

The only clue was a single-celled organism with two tails that appeared when the fish were dying and then seemed to vanish. Noga asked Burkholder to look into the matter.

Burkholder, a self-described workaholic with curly brown hair and a quick laugh, was an aquatic ecologist in the school's Department of Botany. As she examined the aquariums in Noga's lab, she found what looked like harmless ball-shaped cysts in the sediment.

Hour after hour, she and other researchers watched these cysts under the microscope. Eventually, they learned that in the presence of fish, these cysts would change form, Burkholder says, "like Dr. Jekyll and Mr. Hyde."

The cysts transform into a microbe with sperm-like tails. The new organism discharges a poison that drugs the fish and causes their skin to slough off.

While the fish gasp for air, swim upside down or in circles, the **pfiesteria** swim toward the peeling fish and feed on them, sucking up bits through a straw-like arm. The **pfiesteria** reproduce while they're eating. When they're sated, they turn into harmless, colorless amoebas or into cysts that sink back to the sediment, safe and secure.

Burkholder learned that Noga had gotten water for his tanks from the Pamlico-Albemarle Sound in North Carolina. And it was there, on May 23, 1991, she was able to confirm her discovery in the field. During a massive fish kill, a state chemist noticed a coffee-colored slime among the carcasses. He immediately shipped samples to Burkholder. They contained the same creature found in Noga's aquariums. "Something like this for a scientist comes only once in a lifetime," Glasgow said. "We discovered something fascinating and mysterious."

"It's really a triumph of evolution, so versatile," Burkholder added. In one of its forms, **pfiesteria** steals the green coloration from algae, allowing it to ambush fish while masquerading as a microscopic plant. And, "the first time we saw this thing transform in three minutes and gain a 20-fold increase in size, we had to pick our jaws up. We were elbowing each other out of the way from the microscope."

Sometimes, because of the phantom microbe's bizarre behavior, it was tempting to give it human characteristics. "When an amoeba was in the petri dishes and we jiggled it inadvertently, it looked like it would hold on with one arm and wave with the other," Burkholder recalls with a smile.

But there is something sinister about this organism. For instance, it loves human blood.
One day Glasgow pricked his finger to see what the **pfiesteria** would do. He mixed a few drops of blood and **pfiesteria** and put the sample under a microscope. The microbe went into a feeding frenzy, sucking the blood cells dry, turning red in the process.

And like Jason in those Friday the 13th movies, **pfiesteria** was really tough to kill. Douse it with sulfuric acid. Pour bleach onto it. Dry it out. It would still come back.

The more they learned about the phantom organism, the more concerned they became about its effect on the environment. Burkholder's experiments showed that **pfiesteria** thrived in sewage and waters polluted by agricultural runoff, especially runoff from the state's massive hog farms.

"I think **pfiesteria** has always been here, but we've been adding tons of nutrients to our estuaries, and we've slowly tipped things in favor of it. **Pfiesteria** is a sign of an estuary that's out of balance."

When she told North Carolina officials of her concerns in 1993, a top health official said he didn't believe **pfiesteria** killed fish.

"We just can't go on such a small amount of data. You've only got two years worth of data," he told her. Burkholder couldn't believe what she was hearing.

"We just had major fish kills. We're talking a billion fish. The fish had to be bulldozed from the beach. I had two years of fish kill data and 400 confirming bioassays." She recalls the official saying that she was irresponsible to suggest that hog farms might be causing problems.

"I'll never forget the wording of what he said next. He said, `Come back in 10 years. When you have 10 years of data, we will be willing to consider that **pfiesteria** might be killing fish."

Microbe's bizarre effects

Burkholder was furious, in part because she suspected **pfiesteria** was not only dangerous to fish, but also to humans. She knew this from experience.

In January 1993, she poured samples into beakers the size of an egg shell. It was a tricky operation. "I was pouring it right up against my face. I was doing that for about four hours. I can tell you that I was very lucid when I walked in the lab, but I don't remember much for about eight days afterward."

The fragments of memory she has left of that period are incomplete, like a puzzle with its pieces thrown about. "I would have lucid moments and then fade back out. I would stare at a computer screen and I could recognize words but I could not write a sentence.

"It was a frightening feeling. I had to hide. I didn't talk to anyone. I couldn't have a telephone conversation because I literally couldn't remember what the person said at the beginning of their sentence when they got to the end."

After eight days, she felt better and went back to work determined to upgrade her laboratory.
"The trouble was that there were no federal regulations or guidelines on working with toxic phytoplankton," Burkholder said.

"So we called industries and asked them what they did around neuro-toxic substances. I talked with a culturist at the FDA who told me he kept his stuff in big open vats. `Don't worry about it. Wear a lab coat and gloves,' he told me."

But by the summer of 1993 and after $40,000 in renovations and safety equipment, she had her own small building on a hill away from campus.

The building had three main rooms. Near the entrance was a small alcove and office area - the "cold room." Next door were two other rooms where the **pfiesteria** were kept in small tanks. These were the "hot rooms." Respirators were required as well as gloves and special booties. No one could work in the hot rooms for more than two hours. A ventilation system changed the room's air once every five minutes.
"It was supposed to be a great facility," Burkholder said.

A scientist's collapse

That summer Howard Glasgow's mind began to scramble. He had been working 80 to 100 hours a week, much of it in the trailer's safe "cold room," planning experiments, writing reports.
But as the weeks went by, he missed appointments, complained about headaches, had trouble sleeping and remembering phone numbers.

His wife, Aileen, who worked in a doctor's office, became more and more concerned. "I saw him change from a fun-loving, easygoing person - very laid back - to someone who was irritable and forgetful."
At first, she chalked it up to stress. After all, Howard was about to make an important presentation in France about **pfiesteria**. "He had the hardest time putting that speech together," she said. Glasgow gave an excellent presentation, however, although afterward he couldn't remember questions people asked him.
When he got back to Raleigh, he continued to unravel. "He would get mad over very insignificant things, like if I asked him to go pick up some coffee," Aileen said.

At work, he was sullen and sarcastic. "Here was someone who respected you and now seems like he doesn't want to work with you," Burkholder said. "We didn't know what to think." Burkholder also thought it might be stress, or maybe some problems at home.

"I did a little test. I asked him something about the lab and he told me about it. A few minutes later I asked him about it and he couldn't remember. The hair on my arm stood up."

One day he stomped into Burkholder's office. "He said he was sick and tired of me saying I hadn't told him things, and he stormed out, tossing out lots of profanity. If he had been anyone else, I would have fired him, but all we wanted was our old Howard back."

A few days after Thanksgiving, Glasgow was putting water into an aquarium when he splashed water on his arm. Within 30 minutes, he had a big lesion with red streaks. A day or two later, he got lost driving home.

"He came home absolutely distraught," Aileen said. "I said, `you probably were thinking of something else.' He said, `No, I really got lost.'" He had tried to call home but couldn't remember the phone number.
Enough was enough. Fearing he might have a brain tumor or some other disease, Aileen said they were going to the hospital. He insisted on driving. Even though the hospital was just a few miles from their home, he drove to a strip mall instead.

Appointments with specialists were made, but his condition worsened through the week. Glasgow has degrees in biology and chemistry, but his reading level plunged to the level of his 6th-grade daughter. He couldn't add or subtract. All the while, he never suspected anything was wrong.

"If someone thought I had a problem, I'd say, `It's your problem. Not mine.' My peers and colleagues said I would go into rages but I have no memory of that."

Eventually, Aileen said, "It got to the point where all he could do was stutter. We were frantic."
After extensive tests at Duke Medical School, doctors found bruises in his brain in the area that controls memory. They found high levels of enzymes in his liver. His blood pressure was erratic and his kidneys were secreting phosphates. All this suggested that his body was trying to detoxify itself. He was told to stay away from the lab.

Solving the mystery

While Glasgow recovered, Burkholder was obsessed with what happened. As lab director, she felt professional responsibility. As a friend, she felt tremendous guilt. "Howard was like a brother to me. Here we are, we're all excited about the research, and you know you've done some good detective work, but someone is collapsing in front of you, and you don't see it."

She began to talk to fishermen. They were nervous at first. "No one wants their waters to be known to have problems because no one will buy their fish."

But some eventually told her and other researchers stories of how they had sores. A shrimper described how he went shrimping in 1992 in the Pamlico estuary with a history of fish kills. He felt nauseated and developed sores later that day. A mental fog enveloped him - so thick he said he wasn't able to drive for two days. Commercial fishermen who worked in the Pamlico spoke of "fish poisoning" and how they routinely rinsed their hands with bleach after sorting fish.

Still, Glasgow's illness didn't make sense. He and everyone else in the lab had taken so many precautions. Howard himself had overseen much of the lab's construction. If **pfiesteria** was to blame, how had he been exposed?

"I'd dream about it, the way he looked in the office when he exploded," Burkholder said. "I had nightmares about the fact that he could hardly talk. I had visions of his face with a dull look, his muscles fixated like a person with Parkinson's. I wanted to know what happened. I had to know what happened."
Suddenly one night she woke up. She knew.

She called the university's public safety people to test the ventilation. They did a smoke test to trace where the air went. It was obvious what had happened. Because of a contractor's mistake, air was piped from the hot room into the cold room through a vent over Glasgow's desk.

As soon as she saw the smoke entering Glasgow's office, Burkholder phoned Aileen.
"I remember being so enormously relieved that we knew what happened, almost overjoyed," Aileen said. "It make perfect sense."

After several months at home, Glasgow's condition improved. Doctors say he can't go near the **pfiesteria** when it's in its toxic stage. They fear that, like someone who is hypersensitive to bee stings, Glasgow could walk in a lab with **pfiesteria** and never walk out.

Slow to respond

The summer of 1995 was a bad one on the Neuse River. Week after week, it seemed, thousands of dead fish would wash up along its shores. At first people thought it was because the river lacked dissolved oxygen, a common cause of fish kills.

But something else was at work here. There was plenty of dissolved oxygen, and the dead fish had big red sores. There was that familiar coffee-colored foam and sweet smell Burkholder was so familiar with. It was the phantom at work.

North Carolina was slow to come to grips with with the fish kills, some say.
"We had a lot of trouble trying to get the health department to respond to this thing," said Rick Dove, Neuse river keeper. Sponsored by the Neuse River Foundation, Dove monitors the river and finds ways to improve it. "I was calling them on the phone to get down here. We've got fish down here, and people are eating them. A lot of them took the fish home and cut the sores off.

During these fish kills, some people who were in the water developed health problems.
Joe Lopes put in a piling for a dock and spent hours in the water. He cut his foot. Not long after that he was hospitalized with fever and sores all over his body. Doctors thought he might have chigger bites, but then he started vomiting every 15 minutes. He collapsed in the hospital.

"His white blood count was sky high," his wife, Yvonne, said. "They still don't know what's eating his system." She learned later from Burkholder that **pfiesteria** was active in the area her husband had been working. She doesn't let her son go near the water now. And she wonders why it took the state so long to warn people about the river.

Bill Lotz and three other divers for the N.C. Department of Transportation were examining bridges during the fish kills.

"Out of my crew three were affected. Three had skin lesions. One had memory loss," he said. One time he almost walked off a 10-foot culvert. "I was almost totally unaware of the surroundings."
Last October, the state finally closed the river to fishing.

Sometimes, however, Burkholder gets the feeling North Carolina's power brokers don't want to find out how bad the **pfiesteria** problem is. After Burkholder took water samples during a 26-million gallon hog waste spill last summer, the university started getting calls from the agriculture industry. "They asked what business I had on the river and if I could be encouraged to stop."

Anonymous callers have threatened her unless she dropped her research. She has had difficulty getting funding. Research money has gone to other less experienced researchers, including one scientist who learned how to identify **pfiesteria** by reading Burkholder's articles.

"You've got a lot of moneyed interests involved and the good old boy network, and she doesn't play that game," Glasgow said. "She'll win out. She'll be stepped on, but she'll win out in the end."

'We can't give up'

Glasgow is back at work now. Gone are the headaches and memory problems, although it took months for many symptoms to disappear.

He remembers a bizarre episode a few months after he got back. He was in Burkholder's office when the palm of his hand suddenly began to drip with sweat. The rest of his body was perfectly dry.
Burkholder continues to have health problems she believes are related to pfiesteria. Like clockwork, whenever she runs hard, she gets pneumonia. Her doctors have speculated that whenever she burns fat cells, they release the **pfiesteria** toxin. Since 1993, she's had pneumonia seven times and bronchitis once.
Burkholder and Glasgow say despite what happened, they won't stop their research. They know **pfiesteria** emits a toxin, but they haven't identified it. It's as if they had a venomous snake but not the venom. If they can identify the toxin, scientists might someday be able to control **pfiesteria** outbreaks.

They know there will be more **pfiesteria** fish kills. So far this summer, cool weather has helped keep the microbe at bay. But researchers already have noticed many fish have sores.

And worldwide, scientists say there has been an alarming increase in toxic algae and dinoflagellates, often called red tides. A red tide has destroyed reefs throughout the Florida Keys. Another toxic dinoflagellate decimated endangered manatees this year.

Dinoflagellates similar to **pfiesteria** produce among the most toxic substances known, in some cases a thousand times more potent than cyanide. A pinhead-sized quantity can easily kill a person. Several years ago, three people died and hundreds were poisoned in Canada after a toxic algae bloom. One person chewed and digested most of his lower lip before he died. Some surviving patients have permanent short-term memory loss.

"It's not a vendetta, but we have a strong vested interest in learning more about **pfiesteria**," Burkholder said. "We've lost all the time, the health problems. We have invested so much. We can't give up now."

Exercise II. Locating Pfiesteria!

A term that many scientists use for an outbreak of *Pfiesteria* is a 'harmful algal bloom' (HAB for short). *Pfiesteria* organisms have been found as far north as Delaware and as far south as the Gulf of Mexico. In recent years HABs have been occurring most often in Maryland, North Carolina, and the Chesapeake Bay.

Using a map of the United States, identify these areas. Name the states around the Chesapeake Bay.

The HAB-Nutrient connection

The two main nutrients polluting the Chesapeake Bay are nitrogen and phosphorus. Algae in the Bay use these nutrients to grow. These two nutrients are abundant in commercial fertilizer, which is spread on farmlands, lawns, and other grassed areas such as golf courses and ballfields. They are also found in waste such as cow manure from farm fields which wash off into streams that lead to the bay, or chicken manure from poultry farms in the areas adjoining the bay. (Many counties adjoining the bay have numerous large poultry farms, including the eastern shore of Maryland, Virginia and Delaware, and parts of North Carolina.)

If too many nutrients flow into an environment like the bay, algae in the water multiply and bloom more intensively. The algae can cloud the water and prevent sunlight from reaching vegetation in the water, such as submerged aquatic grasses.

Example of halodule seagrass.

When this vegetation is unable to photosynthesize, (convert sunlight and carbon dioxide into oxygen) oxygen levels in the water decrease. Organisms that feed off the grasses and breathe oxygen are stressed or die. That's why an overabundance of algae can become out of control and turn into a Harmful Algal Bloom.

The HAB- Pfiesteria Connection

Algae may also become harmful if they produce a toxin. A high abundance of algae like Pfiesteria, that produce chemicals that are toxic to humans and aquatic life can also be called a Harmful Algal Bloom. Although the term "bloom" can conjure up an image of of a dense algal population this is not always the case with HABs. Even a concentration of a few cells per liter of some microalgae can produce harmful toxic effects.

Step 1. Identify *Pfiesteria* occurrences in the Chesapeake Bay:

Go to Web site 5: http://www.mdsg.umd.edu/pfiesteria/cb.html , then click on the link that says 'map below.' Click on the years through the 1990s to see where fish kills have taken place.

Step 2. Getting information from maps

Interpret the map legend.
Name the two methods by which *Pfiesteria* in these outbreaks were identified?

____

____

Step 3. Nutrients in an estuary setting

What is an estuary?

____

____

____

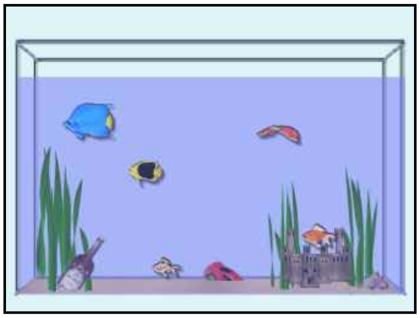
____

Think about the movement of water in an estuary setting. Does it flow rapidly or sluggishly? Compare the water environment in terms of water movement, in a home aquarium, an estuary and in a pond. What are sources of water movement in each?

Pond	Home Aquarium	Estuary
________	________	________
________	________	________
________	________	________

Oxygen gets into rivers when water crashes over rocks, when wind blows over the water, and by any other method which causes air to mix with the water. Based on this fact, fast moving rivers have more oxygen content than slow moving rivers.

Compare rivers with a home aquarium. What are sources of oxygen in your aquarium?



Hint:

Do you bubble air through your aquarium? Do you have plants in your aquarium?

____

____

How often do you clean your aquarium? What is the purpose of cleaning it?

____

____

How do estuaries maintain healthy levels of oxygen in the water? (What are sources of oxygen in the estuary's waters?)

____

____

Fill in the blanks! Describe in each box, what happens when excess nutrients flow into an estuary environment (like the Chesapeake Bay)

	Submerged vegetation	Algae	Numbers of Pfiesteria
Excess Nutrients →	→	→	

Would you claim that *Pfiesteria* thrive in the presence of lots of nutrients? Why or why not? (Hint: what do Pfiesteria eat?)

____

____

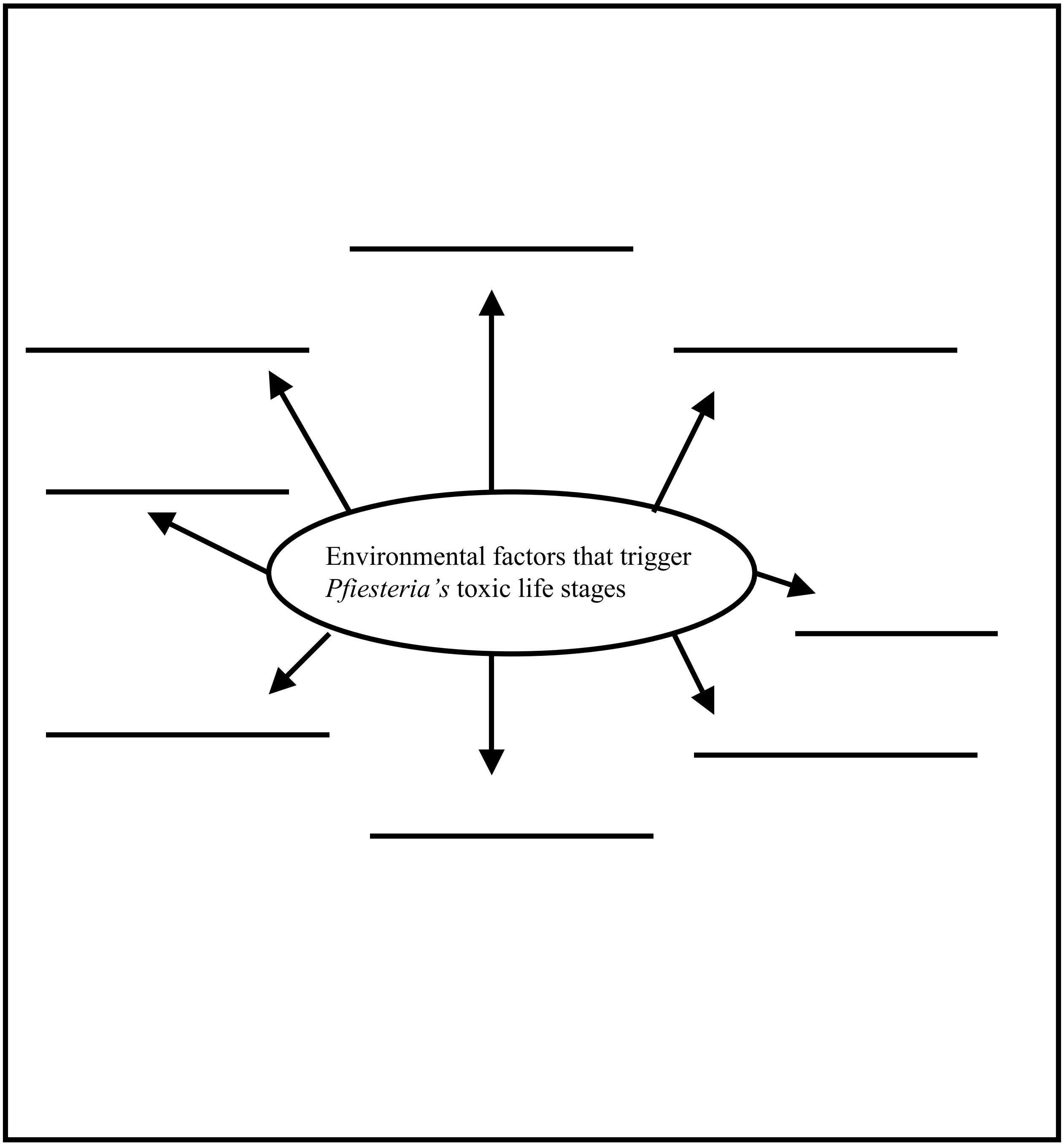
Hints:

Web site 4: http://www.mdsg.umd.edu/MarineNotes/Jul-Aug97/side1.html
Web site 6: http://www.epa.gov/owow/estuaries/*Pfiesteria*/fact.html
Check section 'What causes toxic *Pfiesteria* Outbreaks?'
Web site 1: http://www.*Pfiesteria*.org/*Pfiesteria*/*Pfiesteria*.html

Step 4. Identify Environmental Triggers.

On the Trigger Test worksheet, write down the environmental factors that contribute to *Pfiesteria* outbreaks.

Worksheet: Trigger Test



Exercise III.
File Your Own Pfiesteria Kill Column!

Here is one journalist's view of *Pfiesteria*. Would you agree?

One Weird Microbe!
If Pfiesteria piscicida went to a psychiatrist, it might be diagnosed with an acute multiple personality disorder. The one-celled organism sometimes behaves like a plant, sometimes like an animal. It has 24 different stages. In its smaller cyst forms, it can lie dormant for years. When fish are around, it changes into forms that emit a poison and suck off fish flesh. Other times it grows into a large non-toxic amoeba.

- Charleston *Post and Courier* reporter Tony Bartelme

A journalist has to capture the reader's attention, and she or he usually does it by focusing on the graphic details of an event, bringing the story alive.

Write a story for the school newspaper on a fictional P*fiesteria* fish kill. The editor wants you to spin the story as if it was a report on a murder. Points to be emphasized the editor says, are the following:

- The anatomy of a kill - how does *Pfiesteria* do it?
- How does it attack?
- What mechanism does it use?
- How many *Pfiesteria* are present?
- What happens to the fish?
- How long does the whole kill take?
- What is the concentration of the *Pfiesteria*?

Even though the story is fictional, try to make the circumstances believable. Make sure that the story has an identifiable location, and an appropriate date of occurrence, and get the scientific facts straight.

Hints:

Web site 2: www.*Pfiesteria*.org/*Pfiesteria*/lifecycle.html
Web site 7: http://www.mdsg.umd.edu/MarineNotes/Mar93/index.html

(Location and time might be a coastal estuary on the east coast of the United States, in the summertime.)

Exercise IV.
Nutrients in the Water

Although no scientific documentation has confirmed exactly what triggers *Pfiesteria* to become toxic, one thing that is well established by researchers: that the vast majority of *Pfiesteria* outbreaks are associated with waterways that have been heavily polluted with high levels of nutrients, such as nitrogen and phosphorus. Areas of highly concentrated animal agriculture have become the prime source of concern as a possible link between *Pfiesteria* and nutrients.

Large numbers of poultry farms are located on the coastal areas around the Chesapeake Bay. They produce manure that finds its way into the waterways. The manure is commonly used as fertilizer on farmlands, which washes off into the ditches, streams, and rivers that lead into the bay. Here, in the estuary environment, the water slows down and all the nutrients it is carrying, for example, on particles of sediment tend to settle out and concentrate.

*Do **we** contribute Nitrogen and Phosphorus loadings into our Bays and estuaries?*

Step 1: How much do you contribute?

The average homeowner can contribute to the nutrient enrichment problem in the Bay. Many everyday activities and facilities used are sources of nitrogen. Read the handout called Know Your Nitrogen. Then do the "Know Your Nitrogen" worksheet, on nitrogen generated by an average household on a yearly basis by activity. Download the Know Your Nitrogen worksheet from:
www.dep.state.pa.us/dep/deputate/watermgt/General/know_your_nitrogen.pdf

Step 2: Real time monitoring

Scientists monitoring this environmental pollution problem need more data to establish more firmly what particular conditions spawn the *Pfiesteria* outbreaks. They are particularly interested in monitoring water temperature, dissolved Oxygen and other parameters that have proved significant when *Pfiesteria* has in the recent past caused fish kills. Look at "Real Time Data" being downloaded via the web to Web site 8: http://www.pfiesteria.org/nrdp/index.html.

The Neuse River estuary in North Carolina is being monitored at various locations. Click on one of the **red** locations. Look at temperature, pH, and Dissolved Oxygen. Describe EACH.

Temperature	pH	Dissolved Oxygen
____________	____________	____________
____________	____________	____________

Look at Web site 9: http://imc.lisd.k12.mi.us/tests.html.
Read each of the descriptions under Temperature, pH and Dissolved Oxygen.
Do you think the Dissolved Oxygen conditions are alright for fish? What about pH conditions? (Back up your answers with the numbers from the real-time monitored data above)

Dissolved Oxygen	pH
____________________	____________________
____________________	____________________

Look at the real-time data over the web at the location on the Neuse River that you chose earlier. Scroll down with your mouse, and find Links to Historical Data. Click on the blue box for Hydrologic Data.

Find the span of days for which data is recorded.

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____

Find two graphs: one showing Dissolved Oxygen and one showing Temperature. What are the units of measurement for Dissolved Oxygen and for Temperature?

____

____

Describe how the dips and peaks on each graph correspond to each other.

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Can you tell if conditions are right for another *Pfiesteria* break out?

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Do you need more data on water quality? What data would you request?

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