Bioaccumulation

Topic

Harmful toxins can *bioaccumulate* in the marine food chain.

Introduction

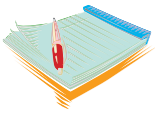
Harmful algal blooms (HABs) occur when toxin-producing members of the phytoplankton undergo population explosions. Only a few species of phytoplankton produce toxins. On those occasions when the populations of toxin producers are high, some animals within the food chain may be damaged or killed.

Toxins released by harmful algae cause problems for a variety of organisms because they move through the marine food chain. Each phytoplankton cell produces only minute quantities of the toxin. However, the toxin can bioaccumulate in organisms. Bioaccumulation is a process in which materials build up in the tissues of organisms faster than they can be broken down.

In this experiment, you will carry out a simulation that shows how toxins bioaccumulate in a marine food web.

Time Required

50 minutes



Materials

- animal identification card
- small, plastic sandwich bag
- masking tape
- science notebook

- two 1-pound bags of M&Ms™ candy (for the entire class)
- watch with a second hand or stopwatch
- dry erase board or flip chart

Safety Note **Please review and follow the safety guidelines. Do not eat the M&Ms™ candies in this experiment.**

Procedure

1. Tape an animal identification card to your shirt. In this experiment, you will play the role of the animal named on your card.
2. Go to the area that is designated for this experiment. The experiment must be conducted within the boundaries of this area. Your teacher has scattered M&Ms™ that represent phytoplankton throughout the area. There have been HABs in this area, and some of the phytoplankton (M&Ms™) are toxic.
3. On the teacher's signal, students who are wearing cards labeled "krill" have 30 seconds (sec) to move around the area and graze. Grazing is simulated by picking up phytoplankton and putting them in a bag. The bag represents the krill's stomach.
4. After 30 sec, students who are wearing a card labeled "small fish" have 10 sec to move around the area and eat as many krill as possible. To eat a krill, a student wearing a "small fish" card takes the krill's bag of food. The "eaten" krill must sit down on the ground and remain there through the exercise. Living krill can continue to graze on M&Ms.™
5. After small fish have been eating for 10 sec, the penguins can enter the area. Penguins have 10 sec to move around the area and eat small fish. To eat a small fish, a student wearing a "penguin" card takes the small fish's bag(s) of food. The "eaten" small fish must sit down on the ground and remain there through the exercise. Living small fish can continue to feed on krill, and living krill can continue to graze on phytoplankton.

6. After penguins have been eating for 10 sec, the seal has 10 sec to move around the area and eat penguins. To eat a penguin, a student wearing the "seal" card takes a penguin's bag(s) of food. The "eaten" penguin sits down on the ground. Living penguins can continue to eat small fish, fish can continue to eat krill, and krill can continue to eat phytoplankton. At the end of 10 sec, the experiment ends and everyone stops moving.
7. Students who represent dead organisms should move to one side of the area and sit as a group.
8. Students who represent living organisms should move to the other side of the area and sit as a group. Living organisms should examine the contents of their bags to find out how much toxin each animal consumed. To do this, each living organism should:
   a. Pour the candies from all of the bags in their possession onto a sheet of notebook paper. Count all of the M&Ms,™ and write the total number of candies on the data table on the dry erase copy board to share with the class. Each student should copy these numbers and the data table in his or her science notebook.
   b. Count the red and orange candies and write the total number of these colors on the data table on the dry erase board. Each student should record in his or her science notebook these numbers on the data table. Red and orange candies represent toxins produced in the HABs.
9. Toxic algae accumulate in the bodies of animals that eat them. If as much as 25 percent of the food an animal eats is toxic, that animal will die. Each student should calculate the percentage of toxic food consumed by living animals with this formula:

$$\text{Percentage of toxic food} = \frac{\text{number of red and orange candies}}{\text{total number of candies}} \times 100$$

Percentages can be recorded on the data table in each student's science notebook.

10. Krill that have 25 percent or more toxic food should sit with the dead krill. Krill with less than 25 percent toxic food should remain in an area designated for living animals.
11. Small fish with 25 percent or more toxic food in their bags should sit with the dead krill. Surviving small fish should remain with the surviving krill.
12. Penguins with 25 percent or more toxic food in their bags should sit with the dead krill and small fish. Surviving penguins should join the surviving krill and small fish.
13. If the seal has more than 25 percent or more toxic food in its bags, it should sit with the dead krill, fish, and penguins. If not, the seal can sit with the living krill, fish, and penguins.

Data Table

Organism name	Total number of M&Ms™ in all of this animal's bags	Total number of red and orange M&Ms™ in all of this animal's bags	Percentage of toxic food consumed

Analysis

1. Did the seal survive the HABs? Why or why not?
2. What percentage of the entire food chain died as a result of HABs?
3. Why did some animals survive the HABs?
4. In your own words, define "bioaccumulate."
5. Oysters are animals that filter food particles like plankton from the water. How could dining on oysters during a HAB affect a person's health? Explain your answer.

What's Going On?

HABs produce toxins that accumulate in the food chain. In marine food chains (Figure 1), the production of toxins is most deadly for the top-level carnivores, like penguins and seals. Grazers such as krill and animals that feed on them may not take in enough toxins to cause their death, but they act as vectors of the toxin, passing it along the food chain.

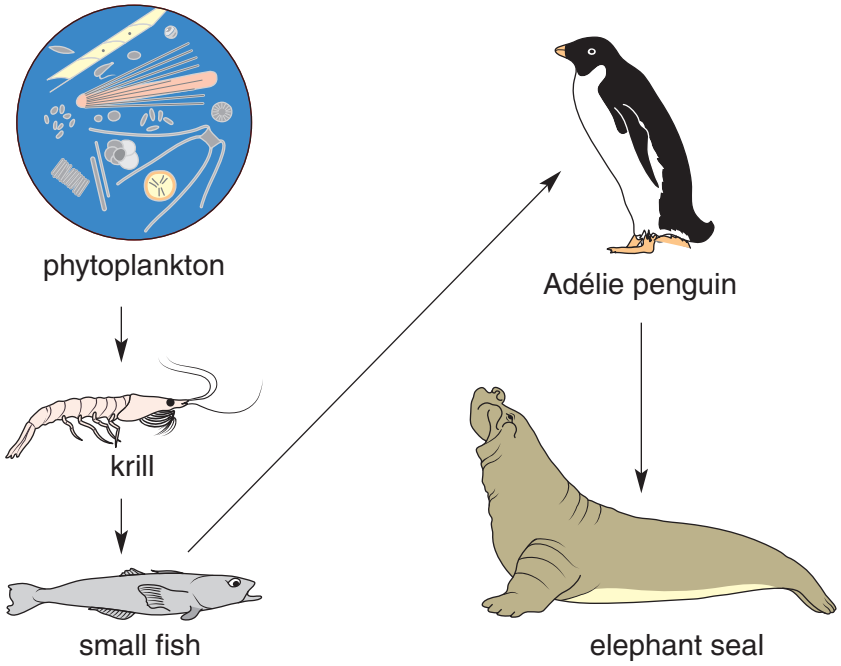


Figure 1

In some marine food chains, humans are the top predators. Outbreaks of HABs can affect humans who eat fish or shellfish that have fed on the toxic algae. Ciguatera fish poisoning (CFP) occurs in Florida and Hawaii, and humans have been affected by eating contaminated fish such as barracuda, snapper, and amberjack. The symptoms of CFP include vomiting, cramps, diarrhea, and headaches. Diarrhetic shellfish poisoning sometimes occurs on the West Coast. People who dine on mussels, scallops, and oysters that have fed on toxic algae may experience nausea, vomiting, abdominal pain, and diarrhea. Neurotoxic shellfish poisoning, most often seen along the Gulf of Mexico and the southeastern Atlantic coast, can affect humans as well as dolphins, manatees, and birds. Symptoms include vomiting and dizziness. Two types of poisoning that can occur anywhere along the coasts of the United States are paralytic shellfish poisoning and amnesic shellfish poisoning. Humans most often contract these conditions by eating contaminated shellfish.

Want to Know More?

See Our Findings.

OUR FINDINGS

BIOACCUMULATION

Notes to teacher: Make an "animal identification" card for each student. Cards will assign each student a role during this exercise. If your class contains 28 students, make one index card labeled "seal," three index cards labeled "large fish," nine index cards labeled "small fish," and 15 index cards labeled "krill." If you have more than 28 students, give the others a card labeled "krill."

In this experiment, one animal "eats" another by taking its bag(s) of food. Ask students who are preyed on to give up their bags of food willingly to the predators that "eat" them. If the prey make it difficult for the predators to collect their bags of food, the results may be skewed.

Select a location to carry out this experiment. You need a space about the size of a classroom. The space can be indoors or outdoors. Mark clear boundaries around the space with string or tape. Carry a dry erase board to the area to record and share results, or take students back to the classroom for calculations.

Use the traditional colors of M&M™ candies.

Analysis

1. Answers will vary. If the seal did not survive, 25 percent or more of its diet was made up of toxic phytoplankton.
2. Answers will vary.
3. Some animals survived because less than 25 percent of their diet was toxic, so they did not get a lethal dose.
4. Bioaccumulate means that a substance accumulates within the body faster than the body can break it down and eliminate it.
5. If oysters fed on toxic phytoplankton, they could accumulate the toxin in their bodies. A human who ate a meal of several oysters might take in a dangerous dose.

SAFETY PRECAUTIONS

Review Before Starting Any Experiment

Each experiment includes special safety precautions that are relevant to that particular project. These do not include all the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is necessary that you read and remain mindful of the General Safety Precautions that follow. Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly while you are performing an experiment. Materials can spill, break, or even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following the basic safety guidelines during the entire experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. For one reason, we want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical.

Read the safety precautions here and at the beginning of each experiment before performing each activity. It is difficult to remember a long set of general rules. By rereading these general precautions every time you set up an experiment, you will be reminding yourself that lab safety is critically important. In addition, use your good judgment and pay close attention when performing potentially dangerous procedures. Just because the text does not say “be careful with hot liquids” or “don’t cut yourself with a knife” does not mean that you can be careless when boiling water or punching holes in plastic bottles. Notes in the text are special precautions to which you must pay special attention.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking an unnecessary risk can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the individual experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone. When you are working off site, keep in

groups with a minimum of three students per group, and follow school rules and state legal requirements for the number of supervisors required. Ask an adult supervisor with basic training in first aid to carry a small first-aid kit. Make sure everyone knows where this person will be during the experiment.

PREPARING

- Clear all surfaces before beginning experiments.
- Read the instructions before you start.
- Know the hazards of the experiments and anticipate dangers.

PROTECTING YOURSELF

- Follow the directions step-by-step.
- Do only one experiment at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure there is adequate ventilation.
- Do not horseplay.
- Keep floor and workspace neat, clean, and dry.
- Clean up spills immediately.
- If glassware breaks, do not clean it up; ask for teacher assistance.
- Tie back long hair.
- Never eat, drink, or smoke in the laboratory or workspace.
- Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult.

USING EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives or other sharp-pointed instruments with care.
- Pull plugs, not cords, when removing electrical plugs.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.

- Clean up broken glassware immediately.
- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use alcohol-filled thermometers, not mercury-filled thermometers.

USING CHEMICALS

- Never taste or inhale chemicals
- Label all bottles and apparatus containing chemicals
- Read labels carefully.
- Avoid chemical contact with skin and eyes (wear safety glasses, lab apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING SUBSTANCES

- Wear safety glasses, apron, and gloves when boiling water.
- Keep your face away from test tubes and beakers.
- Use test tubes, beakers, and other glassware made of Pyrex™ glass.
- Never leave apparatus unattended.
- Use safety tongs and heat-resistant gloves.
- If your laboratory does not have heat-proof workbenches, put your Bunsen burner on a heat-proof mat before lighting it.
- Take care when lighting your Bunsen burner; light it with the airhole closed, and use a Bunsen burner lighter in preference to wooden matches.
- Turn off hot plates, Bunsen burners, and gas when you are done.
- Keep flammable substances away from flames and other sources of heat.
- Have a fire extinguisher on hand.

FINISHING UP

- Thoroughly clean your work area and any glassware used.
- Wash your hands.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Do not dispose of materials in the sink unless instructed to do so.
- Clean up all residues and put them in proper containers for disposal.
- Dispose of all chemicals according to all local, state, and federal laws.

BE SAFETY CONSCIOUS AT ALL TIMES!