

Instructor Notes

Kildare, USA: An Environmental Health Simulation

This activity is an environmental simulation set in the following scenario. A mysterious illness infects more than a dozen people during a summer in Kildare, USA, and the possibility of an epidemic is sending fear throughout the town. To take part in the simulation, the activity participants will play the parts of environmental health investigators to find what is causing the illness, how it is being spread, and what should be done in order to resolve the problem. This simulation incorporates the concepts of bioaccumulation, biomagnification, genetic variability, and metabolism/transformation of a safe substance into a toxin. Participants consider economics and ethics to formulate persuasive arguments to support their actions and decisions.

Suggested Background Readings

- An Introduction to Groundwater Hydrology
- An Introduction to Toxicology
- Principles of Environmental Site Assessment

National Science Education Standards for Grades 5–12

Science as Inquiry

- Abilities Necessary to Do Scientific Inquiry

Identify questions and concepts that guide scientific investigations. Students act as environmental health investigators to find the cause of a hypothetical illness by formulating a testable hypothesis and demonstrating logical connections among the scientific concepts guiding that hypothesis.

Design and conduct scientific investigations. During their investigation, students use evidence, apply logic, and construct an argument for their proposed explanations about the cause of the illness, how the illness spreads, and how to resolve the problem. Students examine the cause-and-effect relationship between medical conditions, lifestyles, economics, and environmental health.

Formulate and revise scientific explanations using logic and evidence. Students engage in discussions based on scientific knowledge, logic, and investigational evidence to formulate persuasive arguments that defend their decisions. These discussions may result in revisions to their previous scientific explanations about the illness.

Recognize and analyze alternative explanations. Students learn to review current scientific understanding, weigh the evidence, and examine the logic while analyzing alternative explanations for the illness.

Communicate and defend a scientific argument. During the environmental health simulation, students learn to express concepts, use language appropriately, speak clearly and logically, construct a reasoned argument, and respond appropriately to critical comments.

Science in Personal and Social Perspectives

- Personal and Community Health
The severity of disease symptoms is dependent on many factors. Students learn that human resistance affects the way people experience disease symptoms.
- Natural and Human-Induced Hazards
Natural and human-induced hazards present the need for humans to assess potential dangers and risks. Students assess individual versus community risks in determining solutions to the simulated environmental health problem.
- Risks and Benefits
Risk analysis considers the type of hazard and estimates the number of people that might be exposed and the number likely to suffer consequences. Based on this evaluation, students determine options for reducing or eliminating the risk of people becoming ill in fictitious Kildare, USA.

Getting Ready

Make overheads of both maps of Kildare and the lists of options and solutions for Parts 1, 2, 3, and 4. Photocopy the sets of results for all four parts; cut apart the individual bulleted lists of results; and put each bulleted list into a separate folder or envelope with the title of the result written on the front of the folder or envelope. Results are coordinated with the overhead options by numbers and letters such as 1A, 1B, and 1C.

Procedure Notes and Outcomes

Divide the class into groups of 3–4 participants. Give each group a copy of the Activity Instructions; then have each group independently decide on an option, or “action,” from the Part 1 overhead—for example, an interview, test, or experiment. Tell the class that groups must individually account for the “expenses” from any actions taken. After presenting the group’s rationale to you (their boss) and getting approval, each group opens the results envelope (or folder) that corresponds to its chosen action. (The results envelopes provide clues to aid the investigation.) Information in each envelope is only shared within each group, not with the entire class. Allow the groups to choose as many actions as they need to identify the cause of the illness, instructing them to devise their own individual group’s methods for collecting and organizing investigation facts and for tracking expenses. Finally, tell the class that, as each group finds the solution to Part 1 (the cause of the illness), its members must collectively write a short report supporting their findings. The groups submit the report to you, the boss.

This activity must have constraints to be more than an exercise in guesswork. Put monetary and/or time constraints on the participants, or make the activity competitive to simulate the business world. The participants must be motivated to think before they act.

Once a group finds the correct cause, it proceeds to Part 2 and repeats the process until all three parts are completed. The activity works well over a period of 3–4 days, with each part taking one class period. Grade each group based on logic used and money spent in making decisions.

For Part 1

Instruct the participants to carefully read the information on Kildare (provided with the Activity Instructions). When complete, discuss the information thoroughly to ensure that everyone understands the situation. Challenge the groups to determine the cause of the illness before the end of the class period. Show the Part 1 Overhead. Tell the class that time is critical, but their actions should be based on logical and educated reasoning. In addition, the agency they work for has limited dollars to work with, so proceed accordingly.

Inform the groups that when they choose an action, they must have it approved by you, their boss. You, as the boss, should insist that the participants have good rationale for every action. For example, it would not be logical to do genetic testing on all the patients before reviewing their medical records, but it would be logical after determining that all the afflicted have a similar ethnic origin. Groups need to write a sentence or two each time they choose an option, explaining why their choice is the appropriate action and including the cost of the action along with a running total of money spent. Once an action is approved by the boss, groups go to the results section of the room and open the envelope containing the results of their action. Each group must record the results and return to their workstation. Once a group feels they have found the cause, they submit their answer along with the documentation explaining their reasoning.

By the end of the class period, all groups should discover that all the afflicted people have a genetic predisposition to this condition.

For Part 2

Discuss the Part 1 results and thought processes that led to the groups' conclusions. Discuss ways to improve the activity. Discuss conclusions and unsolved problems. Before beginning Part 2, all groups should know that genetic predisposition is the cause of the illness, but now they need to determine the source of the toxin so preventative actions can be taken. Use the same procedure for Part 2 as was used in Part 1.

By the end of the class period, each group should determine that the cause of this illness is the chemical I-Swing coming from the Enterprise Plastics Corporation (EPC). I-Swing is probably metabolized to the chemical U-Shake by those individuals with the appropriate

enzymes. However, this will have to be verified. People who are eating fish from Lake Rainbow are ingesting I-Swing.

For Part 3

Discuss conclusions, problems, and unfinished business from Part 2. The participants should now all know that I-Swing is the responsible chemical, but they need to figure out why I-Swing is showing up in such high concentrations in fish and why it is only harmful to those individuals possessing the enzyme I-Roll.

Using the same procedures as are used in Parts 1 and 2, the groups will eventually come to the conclusion that I-Swing is absorbed by small protozoa. These protozoa are then eaten by insect larvae and small fish. Both of these organisms are eaten by game fish. I-Swing cannot be metabolized or excreted by these organisms, so it accumulates in the muscle tissues of the fish. I-Swing is excreted very readily by most individuals. However, those homozygous recessive individuals who produce the enzyme I-Roll metabolize I-Swing into the very toxic chemical U-Shake. U-Shake is the ultimate cause of the mysterious symptoms.

For Part 4

Discuss the results from the previous parts. Use Part 4 to tie in the topic of risk assessment. Show the overhead for Part 4 and assign a solution to each group. Allow 20 minutes for the groups to prepare a list of reasons why their solution is correct and then present their list to the class.

As an alternative to showing the overhead, use a class discussion to generate a list of solutions. Assign a solution to each group and ask them to generate a list of reasons why this is the best solution. Once all the lists have been presented, hold a class discussion to come up with the downside of each solution and to discuss other possible solutions.

For homework, tell participants to choose one of the discussed solutions and write a persuasive paper supporting it.

Reference

Seiple, R. Sycamore High School, Cincinnati, OH. "A Ticking Time Bomb," unpublished work.

Part 1 Results

1A—Interviews with Doctors Involved in Diagnosis of the Disease

Of the 15 individuals with the mysterious illness:

- The first three patients have developed seizures and partial paralysis.
- Fifteen have aches in the joints.
- Twelve have developed a rash.
- Seven have complained of severe headaches.
- None have developed fevers.
- Ten live south of the lake.
- Four live north of the lake.
- One is from out of town but is visiting his father for the summer who lives on the lake next to Wegreen State Park.
- One family of four has all developed symptoms.
- Nine are the only members of their family to develop symptoms.
- The parents of one set of affected siblings have remained symptom free.

1B—Interviews with Area Business Owners

- Five businesses in town have only paper and plastic wastes.
- There is a pizza restaurant that buys all of its ingredients from its national chain's distributor. No cases similar to this illness have appeared in any of the towns where this pizza chain serves its products.
- There is a popular restaurant called Fresh Catch overlooking the lake. Fresh Catch is famous for its homemade wines and fresh fish. The fish are caught daily in Lake Rainbow.
- Both restaurants serve roughly 100 people a day.

1C—Interview with Patients

- One patient is retired and is an avid recreational enthusiast. He loves to boat, fish, and garden. He is 61 years old. He never eats out and has not traveled out of town recently. He lives north of town.
- The family whose members all became ill is made up of two teenage daughters, a mother who is a homemaker, and a father who is an employee of Sume. They traveled to Disney World roughly a week before becoming ill. They all became ill within two days of each other. The teenage girls became ill first, followed by the mother, and finally the father. They ate at the Fresh Catch restaurant the day they returned from vacation. Dad has worked at Sume for 20 years.
- Two female patients, unrelated, work at U-Glo nuclear plant. They each have one child. They do not remember doing anything special or going anywhere. However, they both were among the first to develop symptoms, and it has been several months since the diagnosis.

Of the other eight patients:

- four swam in Lake Rainbow within the last 2 months,
- seven ate at Fresh Catch and five ate at the pizza restaurant,
- one works at EPC,
- two work at the pizza restaurant,
- one works at Fresh Catch,
- one is unemployed,
- three work at retail stores,
- two have recently returned from vacation, and
- one developed symptoms while on vacation.

1D—Screening for Pathogens and Toxins in Lake Rainbow

- There are a variety of pathogens and toxins present in Lake Rainbow, but none are even close to dangerous levels.
- The pathogens are principally bacteria called coliforms, but they pose no immediate threat.
- The toxins range from fossil fuels and fossil fuel by-products to waste products from EPC, U-Glo, and Sume, all present in the Industrial Park. However, these chemicals are present within acceptable levels and are not known to cause any harmful effects.

1E—Genetic Screening of Patients

- Curiously, all patients have enzymes called I-Roll that are produced only by individuals who are homozygous recessive. This genetic condition is not well documented, but it is thought to be extremely rare. Upon further research, all patients are found to be of the same European origin.

1F—Interviews with Businesses in the Industrial Park

- These interviews showed very safe working conditions. All waste disposal methods, though not ideal, are legal. Each business disposes of numerous chemicals into the lake, but once again, at legal levels.

1G—Air Emissions Study from the Industrial Park

- The quality of air is reduced, but well within the acceptable limits. The prevailing winds are from west to east. No measurable fallout is present.

1H—Past Literature

- In 1919, European doctors described a rash that developed in three family members who had no peculiar habits. All developed arthritis before more severe neurological problems eventually resulted in the death of the father and two children. No other cases have been reported.

1I—Conduct Blood Serum Work on Patients

- The blood serum revealed that all patients are free of pathogens. All common “poisons” were screened for and came up negative.

1J—Conduct Tests on Patients’ Home Environments

- Though all homes are located on old farmland, no hazards are found. Homes vary from average economic value to luxurious.

Part 2 Results

2A—Household Water Study

- The household water study shows no presence of toxins.

2B—Local Food Study

- No retail or restaurant food showed signs of toxins, except the fish served at Fresh Catch, which contained large amounts of the chemical I-Swing.
- The fish contain levels 10 times the safe limit for I-Swing. Fresh Catch is adamant that they are not the cause of the illnesses since hundreds of customers have eaten their fish selection and not developed symptoms.

2C—Local Stream Study

- Small amounts of the chemical I-Swing are found next to and downstream from the industrial park.

2D—Air Quality Study

- No dangerous levels of toxins are found.

2E—Blood Serum Study on Patients

- Extremely high concentrations of the chemical U-Shake are found in the blood serum of patients. Some of the chemical I-Swing is present in patients who have only recently developed symptoms, but not in those with more advanced symptoms.

2F— Local Soil Study

- No toxins are detected.

2G—Industrial Park Waste Analysis

- The chemical I-Swing is found in the waste discharged from the Kildare Industrial Park, but in legal and safe concentrations.

2H—Study of Fish in Lake Rainbow

- The chemical I-Swing is found in high concentrations in trout and other game fish.

2I—City Water Supply Study

- No toxins are found in Kildare's water supply.

2J—Waste Analysis of Individual Businesses

- Safe and legal amounts of the chemical I-Swing are by-products of plastic manufacturing at EPC and are emptied into Lake Rainbow.
- No I-Swing is found in the waste from U-Glo or Sume.

Part 3 Results

3A—Food Chain of Lake Rainbow

- The chemical I-Swing does not seem to be harmful to any of the lake fauna. However, I-Swing does not metabolize and therefore accumulates in organisms that ingest it. This is referred to as bioaccumulation.
- I-Swing is readily absorbed by the small protozoa, and concentrations rise as one moves up the food chain. This is referred to as biomagnification. Game fish are at the top of this lake's food chain.

3B—Metabolic Activity of I-Roll

- The enzyme I-Roll catalyzes the breakdown of the chemical I-Swing to the chemical U-Shake. U-Shake is harmful in large quantities, but not in small amounts.

3C—Blood of People Who Are Well, But Have Eaten the Fish

- No presence of the chemical I-Swing is found in the blood of people who are well, except in those who have recently eaten Lake Rainbow fish.

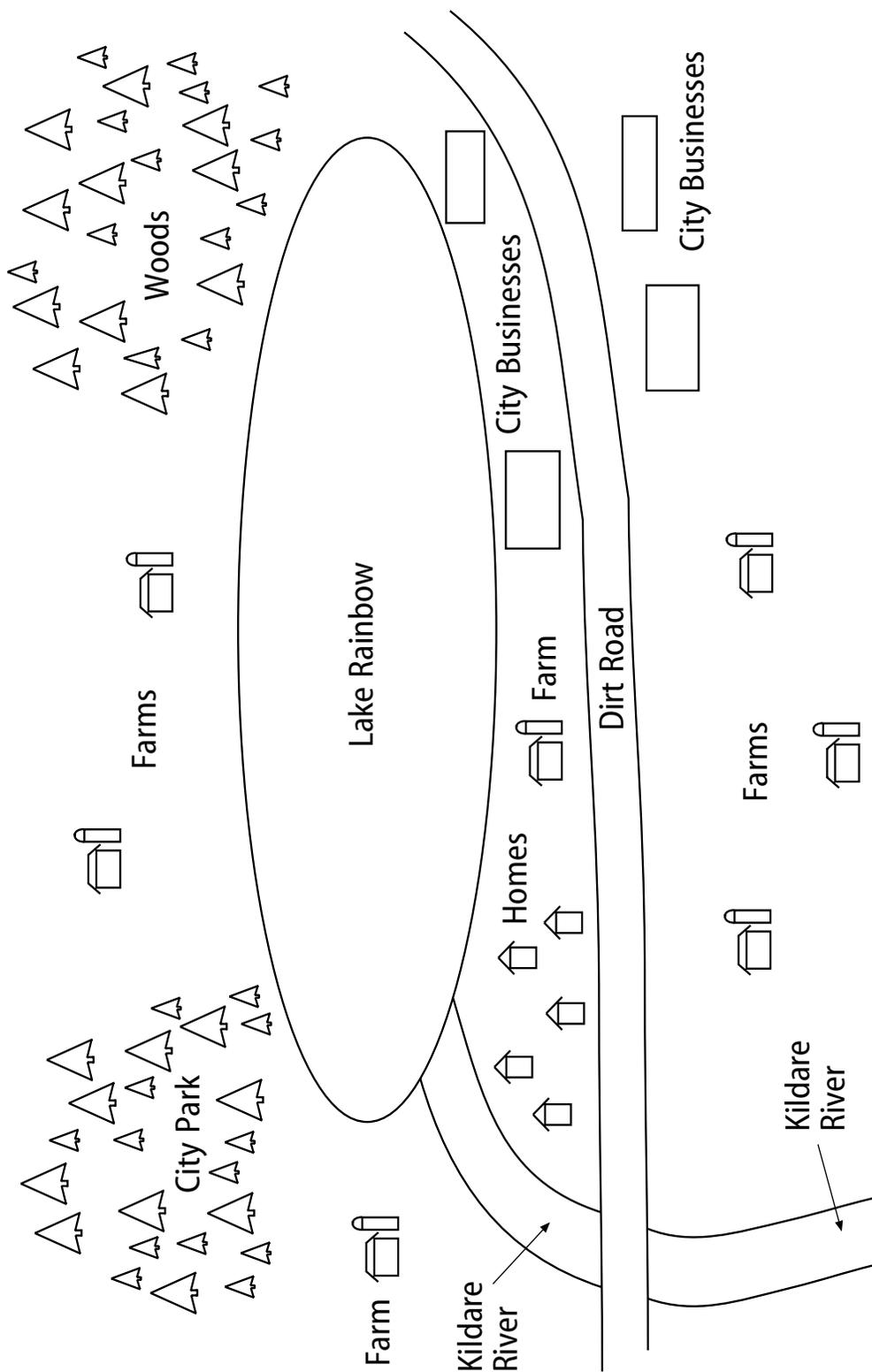
3D—U-Shake Metabolism

- The chemical U-Shake is not excreted or metabolized. It accumulates around nervous tissue, eventually disrupting neural transmission.

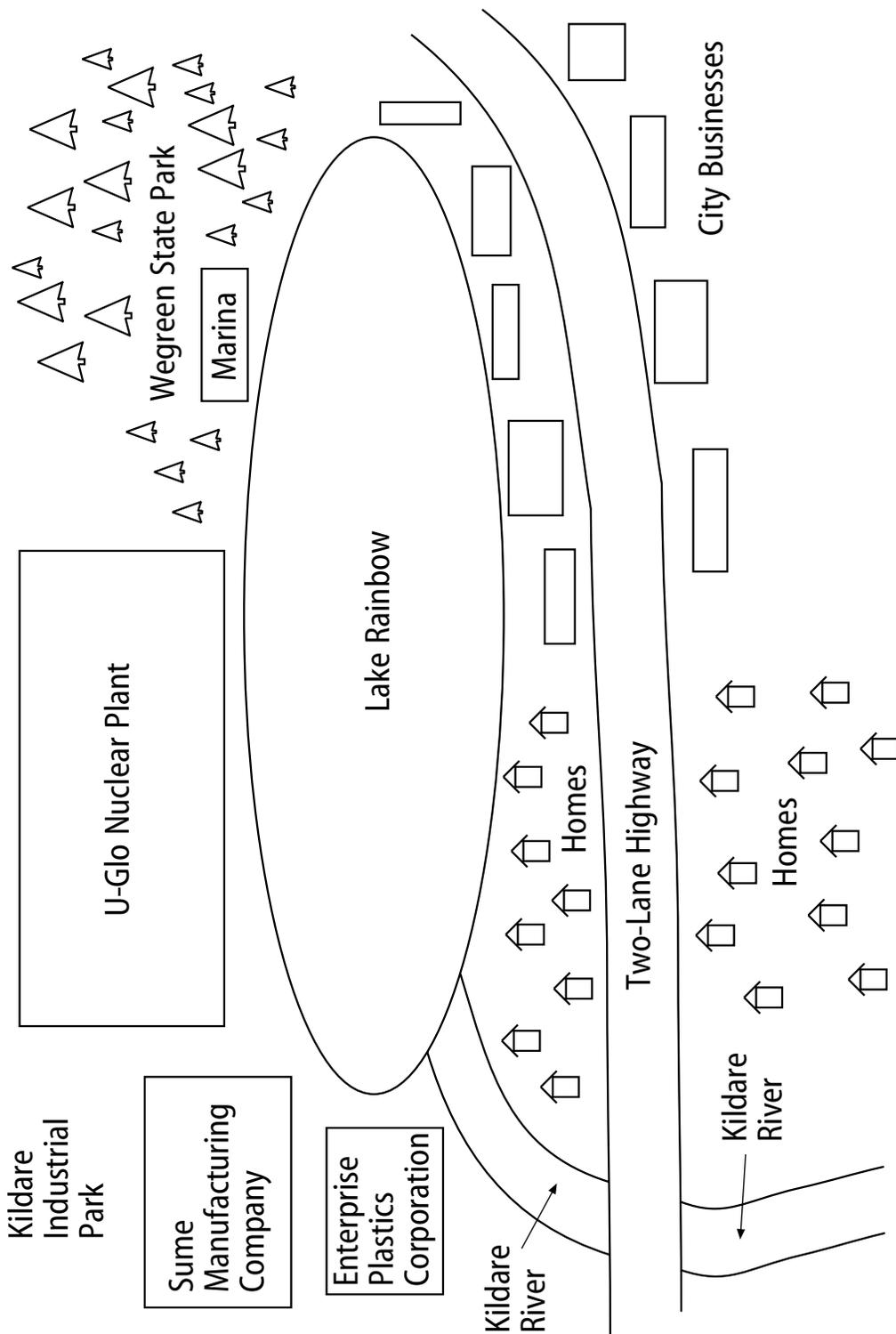
3E—U-Shake in the Lake Rainbow Food Chain

- The chemical U-Shake is not found in any aquatic organisms in the lake.

Map of Kildare, U.S.A.: Pre-1970



Map of Kildare, U.S.A.: Post-1970



Part 1 Overhead: Find the Source of the Illness

- Option 1A: Interview doctors involved in the diagnosis of the disease. \$300
- Option 1B: Interview area business owners. \$300
- Option 1C: Interview those individuals who have fallen ill with the mysterious symptoms. \$300
- Option 1D: Run tests to screen for pathogens and toxins in Lake Rainbow. \$1,500
- Option 1E: Conduct genetic screening of patients. \$1,500
- Option 1F: Interview businesses where patients work. \$300
- Option 1G: Conduct air emissions study of Kildare Industrial Park. \$900
- Option 1H: Review literature written on similar symptoms of patients occurring in 1919. \$100
- Option 1I: Conduct standard blood serum work on patients. This test will identify common pathogens, poisons, and blood chemistry abnormalities. \$600
- Option 1J: Conduct tests on patients' home environments. \$600

Part 2 Overhead: Determine the Source of the Toxin

- Option 2A: Conduct household water study. \$400
- Option 2B: Conduct local food study. \$1,000
- Option 2C: Conduct local stream study. \$600
- Option 2D: Conduct local air study. \$500
- Option 2E: Conduct specific analysis of blood serum on patients for the presence of rare pollutants. \$1,000
- Option 2F: Conduct study of local soil. \$500
- Option 2G: Conduct analysis of the waste discharged from the entire Kildare Industrial Park. \$400
- Option 2H: Conduct study of game fish in Lake Rainbow. \$700
- Option 2I: Conduct study of city water supply. \$400
- Option 2J: Conduct study of the waste discharged from individual industrial park businesses. \$600

Part 3 Overhead: Determine the Final Reasoning Behind the Illness

- Option 3A: Study I-Swing in the food chain of Lake Rainbow. \$3,000
- Option 3B: Study the interaction of I-Swing and the enzyme I-Roll. \$3,500
- Option 3C: Study the blood serum in people who have eaten the fish but have not fallen ill. \$1,500
- Option 3D: Study the metabolism of U-Shake in patients. \$1,500
- Option 3E: Study U-Shake in the food chain of Lake Rainbow. \$3,000

Part 4 Overhead: Solutions

- Solution 1: Though harsh, some have argued that little can and should be done. The genetic defect is rare and will be wiped out if not treated, since all inflicted will die.
- Solution 2: Genetic screening of the town at \$250 a test. Warn homozygous recessive people for the I-Roll gene of danger in eating Lake Rainbow fish.
- Solution 3: Close down EPC until a filtering procedure can be developed to remove I-Swing. This process could take 1–5 years. Remove all fish from Lake Rainbow and restock with new fish.
- Solution 4: Fine EPC for dumping I-Swing into Lake Rainbow until I-Swing is removed from their waste. Remove all fish and restock the lake.
- Solution 5: Come up with an alternate solution.

Activity Instructions

Kildare, USA: An Environmental Health Simulation

Once an agricultural community, Kildare's present and future economic base seems to be in manufacturing and industry. The Enterprise Plastics Corporation (EPC) manufactures a variety of plastics used in larger industries. The facility employs over 500 workers, most of whom are hourly employees. The Sume Manufacturing Company, developed at the same time as EPC, manufactures automotive specialty parts and employs nearly 600 workers. U-Glo Nuclear Plant employs approximately 1,000 individuals. These three companies are located in the Kildare Industrial Park near Rainbow Lake and account for nearly half of the jobs within the community. The companies release emissions that have reduced the air quality of Kildare, but presumably within the legal guidelines.

Increased industry and residential demands have stressed the town's infrastructure considerably. Attempts have been made to modernize roads, sewers, and water lines. Upgrading the region's wells and sewage treatment facilities have caused water shortages, as efforts to meet the greater water demands challenge the need to meet quality standards.

Kildare is located in the midwestern United States and experiences weather similar to Cincinnati, OH. The population is roughly 10,000 people. The town is situated on Lake Rainbow, a large recreational lake. EPC, Sume, and U-Glo all empty some wastes into the lake, but within legal limits. Wegreen State Park is located on the other side of the lake and operates its own marina. Activity on the lake includes boating, fishing, and swimming.

Employment in Kildare	
Percent of Residents	Employment
15	EPC
15	Sume
15	U-Glo
10	small businesses in town
10	self-employed
20	employed out of town
10	public employees
5	construction

It is summer, and 15 individuals have been diagnosed with a mysterious rash and arthritic condition. Those who were diagnosed the earliest are beginning to develop some neurological complications. This development is particularly puzzling since arthritis and paralysis/seizures are not contagious. Residents are growing fearful that this will become an epidemic unless steps are taken to discover the cause and control it.

As environmental sanitarians for the county, you have been assigned to determine the origin of the illnesses and to take the appropriate actions before the situation becomes a regional, or possibly a national concern.

This is an urgent situation, so funds will be made available to address the problem. However, the more money you spend on this case, the less will be available for other situations that may arise in the future. You and your co-workers (a group of registered sanitarians, investigators, scientists, and public health employees) at the county Board of Health need to discover the source of the town's illnesses, how it is being spread, and what actions should be taken to control its spread.

Procedure

Part 1

1. Review the Part 1 Overhead that lists options for determining the cause of the illness in Kildare.
2. As a group, use logic and educated reasoning to choose an action from the option list. Remember to be mindful of the time and money involved with the various actions. Your boss/instructor will evaluate your performance as investigators based on the logic used and the money spent when you made these choices.
3. Develop a rationale for your chosen action and write a sentence or two explaining your choice.
4. Get approval from your boss (the instructor) to open the envelope containing the results of the action you chose.
5. Document the results and cost of your chosen action.
6. Repeat steps 2–5 until your group determines the source of the illness. Remember to write down your rationale for each action and keep a running total of the money spent.
7. Submit your answer along with the appropriate documentation to the instructor.

Part 2

1. After a class discussion covering the results of Part 1, review the Part 2 Overhead that lists options for determining the source of the toxin.

2. Follow steps 2–5 from Part 1 until you determine the source of the toxin. Remember to write down your rationale for each action and keep a running total of the money spent.
3. Submit your answer along with the appropriate documentation to the instructor.

Part 3

1. After a class discussion covering the results of Part 2, review the Part 3 Overhead that lists options for determining the final reasoning behind the illness.
2. Follow steps 2–5 from Part 1 until you determine your final conclusions. Remember to write down your rationale for each action and keep a running total of the money spent.
3. Submit your answer along with the appropriate documentation to the instructor.

Part 4

1. As a group, discuss the pros and cons of the solutions listed on the Part 4 Overhead.
2. Individually, decide on one solution and write a persuasive essay that supports your decision.