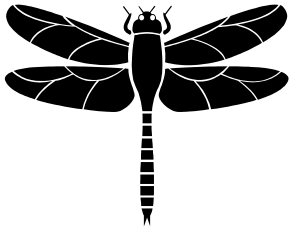
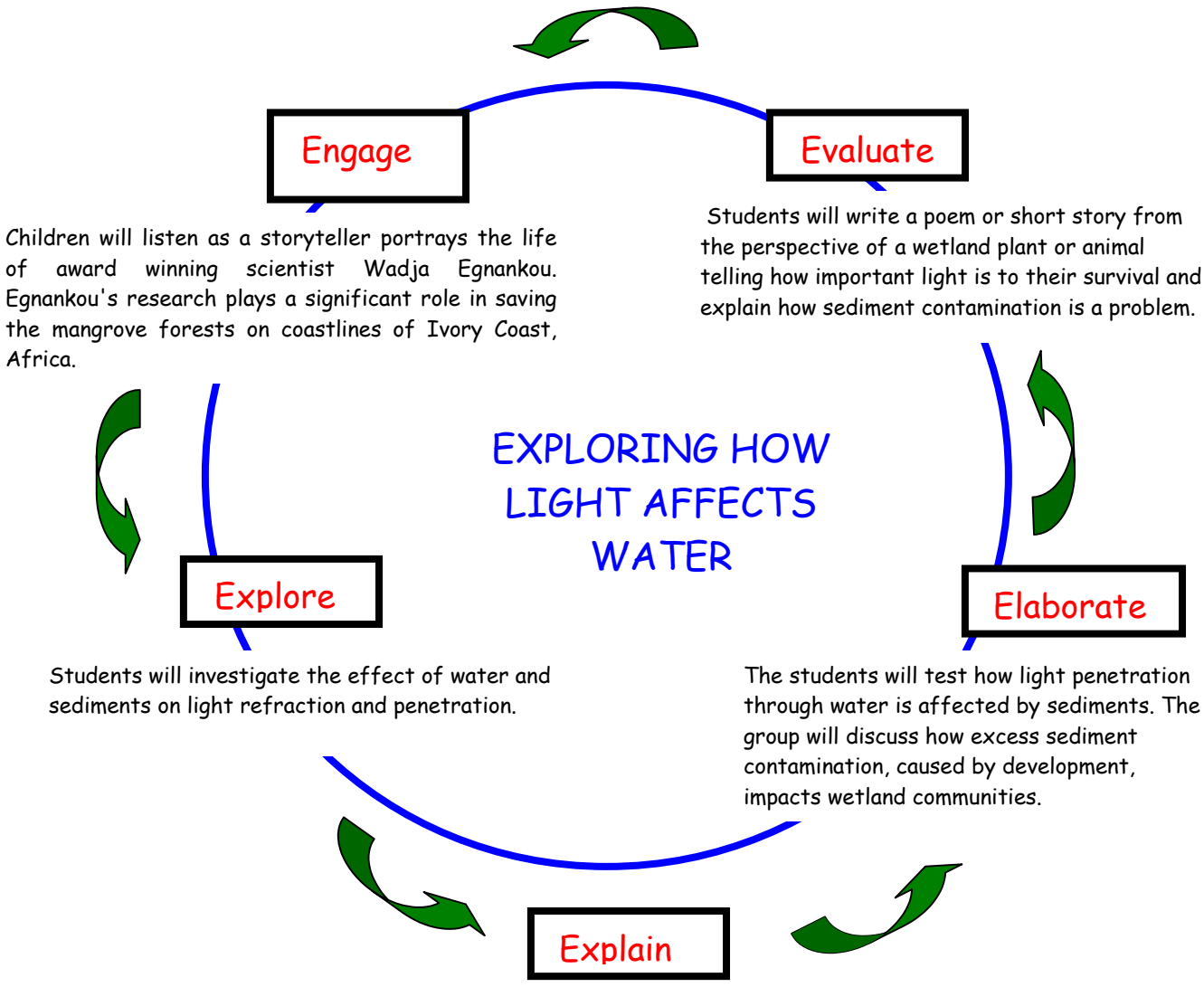
WATER EDUCATIONAL TRAINING
Science Project

at
Eastern Michigan University



WET SCIENCE LESSON #11: **Exploring How Light Affects Water**

WET LESSON #11: Exploring How Light Affects Water
5-Step Learning Cycle Outline



WET Lesson #11:How Light Affects Water

Major Scientific Concepts: modeling, cause and effect

What do we want students to discover?

- Water refracts (bends) light
- Objects are in a different place than they appear under water
- Water magnifies objects
- Impurities in water affect light penetration
- Animals living in a wetland ecosystem have to adapt to refraction and penetration of light in water
- Impurities in water or excess sediments may hinder aquatic organisms from performing essential functions like photosynthesis (for plants) and finding food or shelter (for animals)

Michigan Curriculum Framework Content Standards:

- (Standard II.1.2., elementary) Reflecting on Scientific Knowledge: Understanding science concepts through creative expression.
- (Standard III.5.5., elementary) Ecosystems: Effects of humans on the environment.
- (Standard IV.2., elementary) Using Scientific Knowledge from the Physical Sciences in Real-World Contexts: Changes in matter.

Materials (for 25 students; 5 groups of 5):

- 5 pennies
- 5 White styrofoam bowls
- 5 small containers with enough water to pour into bowl until just over half full
- 1 roll paper towels
- 5 two-liter bottles with top cut off filled 2/3 with water
- 5 straws
- 5 strips of paper with large typing on it (see Appendix)
- 5 small cups with cold **skim** milk (1 qt. should be enough)
- 5 flashlights
- 1 sedimentator tube (WARDs Catelog #80-0009)
- enough paper for each student to write and draw responses

Engage (10 min.):

Students will hear a story from the storyteller to get them thinking about the relationships between urban and economic development and a wetland ecosystem. Children will listen as a storyteller portrays the life of award winning scientist Wadja Egnankou. Egnankou's research plays a significant role in saving the mangrove forests on coastlines of Ivory Coast, Africa.

Explore (15 min.):

1. Have the students put a penny in the center of the bowl and position themselves low enough around it so they can just barely see the edge of the penny over the edge of the bowl.
2. Have one student gently pour the water from the small container on top of the penny until it is visible by all the students around the bowl.
3. Ask students why they can now see the penny through the water when they couldn't see it through the air? Answer: Light is bent or refracted when it travels from air to water or from water to air and so makes objects appear closer to the surface than they really are.
4. Show the overhead transparency of a drawing of light rays traveling from one's eye to the apparent fish (straight – since we perceive light to travel in straight lines) and to the actual fish (bent or refracted), and from the fish to the bug. Cover the definition of refraction at the bottom. (refer to the figure in the Appendix)
5. Have the students draw a straw on a piece of paper (straight), and then have them put the straw in the water in the two-liter bottle and observe it from different angles. What does the straw look like now? Draw this straw. Possible responses: Straw looks broken; straw looks bent; straw appears shorter underwater; straw looks magnified under water (short and fat).
6. Next have students observe the strip of paper with the type on it through the water, held behind the bottle (refer to Appendix for copy of typed paper "Titled Water Science is Fun". How has the type changed? (bigger, squashed, blurry)

    - **Science process skills: observing, describing, communicating, comparing**

Explain (15 min.):

1. Introduce "**refraction**" – the bending of light caused by light slowing down as it travels from air to water (or speeding up as it travels from water to air). At this point, unveil this definition of refraction from the bottom of the transparency with the fish, bird, and bug on it.

2. When light is refracted it can magnify, like a lens in a magnifying glass or a pair of glasses or a telescope.

Elaborate (15 min.):

Have the students shine a flashlight through the two-liter bottle of water onto a white paper background. What does it look like? (white, bright) Observe how the quality of light changes as some skim milk is slowly poured into the water. (The milk makes the water look bluish, while the light shining through the increasingly milky water onto the paper turns yellow, orange, then red, and finally will not pass through the milky water at all.)

Introduce the idea that white light is made of all colors combined. The blue part of the light is reflected by the surface of the milk (so it looks a bit blue). Only the orange and red parts of the light get through the milky water until there is too much milk and the water becomes completely opaque (where no light can get through at all). At this point, to connect this idea with an ecosystem, show the clear sediment tube and shake it SLIGHTLY to demonstrate how easily impurities in the water block out the light and affect its penetration into the water.

Bring up cause and effect at this point. Water bends light, and sediment changes light penetration. See if students can figure out what effect these phenomena have on fish and birds living in a wetland ecosystem. Have them discuss this in their groups, and take some shares. Possible answers:

> They have to account for the difference in position to hunt – either for a bird diving for a fish, or a fish jumping for an insect. Use the transparency with a bird eyeing a fish, and the fish looking the other way at a bug. (refer to the figure in the Appendix.) Impurities in the water, such as sediments (and even temperature differences) affect the abilities of animals to detect their prey.

- **Science process skills: observing, questioning, comparing, contrasting, describing, inferring, communicating, summarizing**

Evaluate (20 min.):

Show impenetrable sediment tube (or point out opaque milk). Have students brainstorm and write answers to two questions:

- If you were a bird, how would you catch a fish in there?
- How can man prevent excess sediments and other pollutants from getting into the water?

See Appendix for additional Elaboration/Evaluation writing instructions.

References:

Conceptual Physics by Paul G. Hewitt, 7th edition, HarperCollins; p. 485 and p. 499. Also www.conceptualphysics.com

Website Resources

- Environmental Organizations
- Michigan DNR
- Water in the City
- Wadja Egnankou

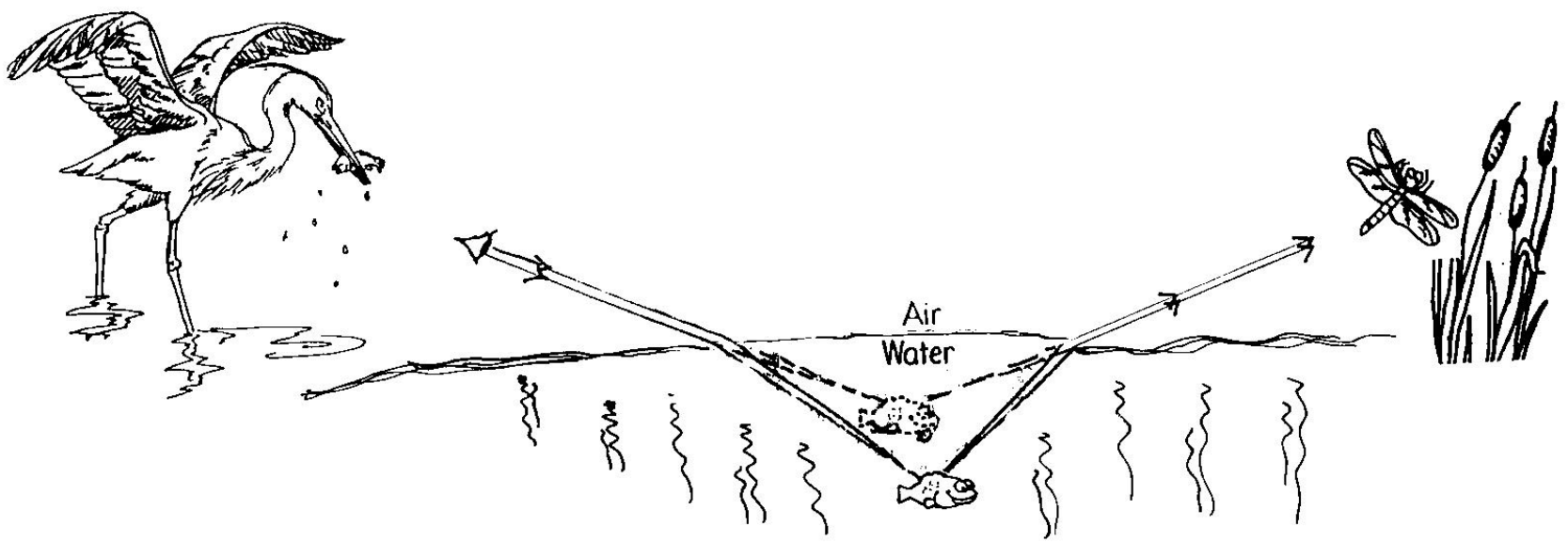
Appendix

A. Overhead Figure: Refraction, page 7.

B. Biography summary of Wadja Egnankou, pages 8-11.

C. Writing Instructions for the Elaboration/Evaluation portion of the lesson, pages 12-16 .

D. "WATER IS FUN" –sheet for making strips, page 17.



Refraction: the bending of light when it travels from water to air (or from air to water)*

* or any other clear materials

Wadja Egnankou

Taken from "Taking the Heat-Wadja Egnankou Ivory Coast" in Eco-Heroes. Twelve Tales of Environmental Victory A Wallace (1991) San Francisco: Mercury House

President Houphouet-Boigny has ruled the Ivory Coast since 1960, when the nation declared its independence from France. He has been known to do whatever he thinks necessary including violence and breaking the law to stay in power. Houphouet-Boigny wants his country to have the appearance of material wealthy and urban development. In comparison to other African countries, people who live in the Ivory Coast do earn better livings.

About half the people of the Ivory Coast still live in the countryside, where they wear native dress and follow ancient traditions and customs, including magical arts. In forest villages just a short drive from the superhighway that the president has
built, magicians of the forest are believed to have fantastic powers.

The president has big plans for his development program. These plans have been based on continued economic growth of his country. The president also has a very big ego, and he takes most of the credit for everything done. One example is the development of his ancestral village of Yamoussoukro where fancy large buildings, hotels and swimming pools have been built, but are still almost empty. They looked impressive when they were first built but now are decaying due to lack of repair and from the country's high humidity. The president has been encouraging the citizens of the Ivory Coast to learn how to play golf, and has built beautiful golf courses.

The 1970s were a bad time for the nation's economy. This was because world prices dropped for coffee and cocoa, the nation's major crops. Timber sales also dropped, because so much of the forests continued to be cleared for farmland. At the same time, the things that the people of the Ivory Coast imported rose in cost. Despite the lack of money, the president kept on borrowing money for his building. Eventually, the nation was heavily in debt. Despite this foolishness, the president jailed those who complained.

While all this was going on, Wadja Egnankou, a humble college professor at the country's only university has been studying the country's mangrove forests. He has been a lone voice in the struggle to protect them and to help local communities. Wadja is short and intelligent-looking with a beautiful and constant smile.

The coastline of the Ivory Coast consists of sandbars and low, sandy islands built up by heavy surf and ocean currents. Behind these barrier islands, lagoons form natural inland waterways. Mangrove forests thrive in the waterways of coastal
creeks and where the river meets the ocean. This is because where the fresh water of the river meets the salt water of the ocean is rich soil. The trees may reach 75 feet, but most are usually between 25 and 40 feet tall. They form dense, bushy stands with tangles of stilt-like roots exposed at low tide.

For a long time, coastal mangrove forests were considered "wastelands" by those who wished to develop the land. This is because the forests looked like hot, mucky, mosquito-ridden messes. They were valueless, according to the developers who thought that they should be drained, cleared and built on to make money.

But, today we know that the mangroves are profoundly useful ecosystems. They are nature's solution for defending the tropical rainforests that grow down to the shore. This is because mangroves control soil erosion (or washing away), which
one of Africa's worst ecological problems.

Throughout the world, mangroves ecosystems are thought to contain only about 80 species of trees and shrubs. But they provide habitat (living area) for more than 2000 species of fish and reptiles. In the Ivory Coast, the mangrove forest is home to manatees, sea turtles, crocodiles, and many reptile and bird species including parrots and touracos. In addition, the mangroves play a critical role in the food chain, serving as a nursery for many kinds of fish, a main source of protein for people who live in the Ivory Coast.

The mangroves are a food factory, which starts with falling leaves. Three tons of leaves fall per acre every year. As the leaves rot, they are eaten by tiny larval crabs, shrimp and mollusks (animals that live in shells). These are then eaten by larger shrimp, clams , and lobsters, which are eaten by larger fish, which become food for people.

In addition, to being a food factory, mangroves are beautiful places. Wadja Egnankou says, "When you go into a mangrove forest, it's like walking into an air-conditioned house. In the water, you can see the fish right there at your feet. You see birds, all sorts of animals-it's like a paradise. When I travel through the mangroves, I feel very happy".

Wadja believes that one hope for the future of the mangroves is in eco-tourism, a new industry that is bringing in a lot of money in several tropical countries. Wadja tells villagers, "You are living in paradise here; you're destroying it and wasting it. There are people-tourists-who would come and pay a lot of money for you to be a guide for a day". Wadja thinks tourists coming to stay in tropical coastal houses made of clay and palms, with sand floors, where they would live like the villagers: swimming in the lagoons, fishing, relaxing by day, then making music and dancing at night.

Wadja's dream for his country and that of the presidents contrasts sharply. For example the current government has plans for an elaborate seaside resort that would destroy ten thousand acres of coastal lagoons to the east of Abidjan. A city for 120,000 inhabitants would be built, along with hotels, a convention center, amusement park and an animal reserve. So far, no building has begun.

Wadja runs his campaign to save mangroves on next to nothing. His program has four stages. First is to tell the people who live in or near the mangrove forests of their importance. The second is count and study all the plants and animals that live in the mangroves. The third is to map the mangrove forests, and the fourth is starting fish farms in the mangrove forest.

In the first stage, he teaches the people about the mangrove forest and how it works, how to keep it nurturing the fish. “I go to the village and get everyone together-the old people, the young people-and show them slides and explain," Wadja says. The people live because the fish live; the fish live because the mangrove lives. This concept is supported by local religions that emphasize proper relationships with all is a key to harmony.

In the fourth stage, Wadja encourages a traditional method of fishing called "acadja": "The natives build a trap surrounded by mangrove sticks. The mangrove sticks start rotting and become natural bait. Little fish come to nibble the nutrients, go inside, and can't get out. The people wait three or four months, until the fish are big enough to harvest. But if the mangroves disappear, this fishing method will disappear".

Wadja was born in 1961, the fourth in a family of six boys. His father died when he was too young to even know him. Wadja was a bright student and he was encouraged by his uncle who was a primary teacher in his hometown. He skipped two grades and won scholarships.

He first saw the mangroves when he was a boy or five or six years old, but it was not until he was studying in France at the University of Toulouse, where he majored in botany (the study of plants), that he learned of their importance. Wadja now has a Ph. D. from this university and since 1985, he has been a professor of botany and tropical ecology at the National University in Abidjan. Bom at the same time as his country's independence, he believes that by sharing his education with others will empower them also. In the Ivory Coast, 43% of the population is fifteen years of age or younger and most are uneducated. Single-handedly, he risks all he has gained to work for the betterment of his country and its natural resources.

In 1989, the Ivory Coast government applied for a loan from the African Development Bank to finance the construction of a coastal road that would cross the country's last largely intact mangroves and rainforest. Wadja was asked to join an international team of scientists to study the environmental impact of the highway. Eventually, the road was rerouted away from the mangrove and rainforest area. Wadja believes that environmental and social issues are closely connected.

The Ivory Coast has had one of the world's highest rates of deforestation since the mid-1970s. Tropical rainforests have been reduced from an estimated 30 million acres in the early 1960s to fewer than four million acres today. In the African rainforest, which covers 8% of the land, many important trees grow: balsa, rubber, mahogany and ebony grow close together. But most of these forests have been cleared for timber exports and to grow coca and coffee.

The result has been that there is now less land to grow food; so more forest cutting has occurred to produce more farmland. When the trees are cut down and their roots die, the soil is washed away when it rains. The severe decrease of Ivory Coast's forests has led to increasing drought conditions.

In 1992, Wadja Egnankou was awarded the Goldman Environmental Prize for his work. The prize includes $60,000 and tremendous international publicity and prestige. This has already given him some political power. For example, President Houphouet-Boigny has honored him with a luncheon reception at the president's palace. While there, Wadja was given the opportunity to make a speech about his work. Many believe that Eadja will become a major leader in the environmental and political movements of the country, as well as in other western and central African Countries.

Contact: Wadja Egnankou at: Faculte des Sciences et Techniques, Department de Botamque, 22 B.P. 582, Abidjan 22, Ivory Coast.

INSTRUCTIONS FOR CREATIVE STORIES ON THE EFFECTS OF POLLUTION IN THE WETLAND HABITAT

ELABORATION/EVALUATION

The previous exploration, explanation, and elaboration activities are part of the prewriting stage for this activity. Students will use drawings, labels, and lists of ideas in their journals to show how water affects light penetration and how impurities in water affect the wetland habitat. The drawings, labels, and lists will help them create a story about the wetland habitat where pollution has occurred and the effects of impurities in water upon plant and animal life in the wetlands.

ELABORATION

1. Using an overhead or large chart paper, show students how to draw and record their observations on the affects of light penetration in water. First, draw and record their observations on the pennies when water is added to the container. Then, draw and record their observations of the straw in the water from different angles. Next, draw and record their observations of the strip of paper with the type on it; "Water Science Is Fun, Light Bends". Finally, draw and record their observations of the water and its changes as skim milk is poured into container.

2. Be sure to model and explain the process, using drawings, labels, arrows, and running comments on the overhead or chart paper.

3. After students see your model, have them complete their own drawings in their journals. Encourage them to use labels, arrows, and running comments to show the behavior of the hot and cold water.

4. Once students have completed their drawings, have them discuss how impurities in the water may affect plant and animal life in the wetlands. Be sure to insert additional information to help them understand how impurities in the water change plant and animal behavior.

EVALUATION

1. Explain that students will be creating a story about an animal or creature of the wetland after the pond water became polluted with sediments from nearby road construction or housing developments. Read an example of a story they might create about an animal/plant from the wetland habitat (You may use your own example or enclosed example).

CREATIVE STORIES ON THE EFFECTS OF POLLUTION IN THE WETLAND HABITAT

EVALUATION (continued)

2. Using the overhead of the Pond Web or large chart paper, show students how they can create their own story by making a web about the pond and its plant and animal life.

3. Be sure to explain that they can use the Wetland Poster to add information to their webs.

4. After modeling the process on your overhead or chart paper, have students work individually to complete their own webs. First, encourage them to brainstorm ideas for possible wetland plants and animals for their story as a group. Next have them choose the wetland plants and animals for their diary entries and place them next to the center shape of their web. Students can then begin to place information about the plant's, or animal's activities in the contaminated water, using their journals and the Wetland Poster, on the web sheet. Be sure to emphasize that they do not need to worry about spelling and to use temporary spelling throughout. Be sure to also circulate as they work on the webs, giving praise for their ideas or asking questions as needed.

5. After students have worked on their webs about 4-6 minutes, have 2 to 3 individuals share their ideas with their small group. Be sure to give specific praise to individuals for their use of descriptive adjectives or verbs to describe the plant's or animal's activities.

6. Students should be encouraged to simultaneously add more information to their own charts while they listen to their peers (Be sure to praise individuals who do this). Then give them 4-5 minutes to add more details to their webs.

7. After they have added more details to their webs, have several students share 2 to 3 ideas from their webs. Once again encourage students to add information to their webs as they listen.

8. Next, read the example of a story once again so that they might create their own stories about the wetland plant and animal life after the contamination of the pond from the chemicals (You may use your own example or enclosed examples).

9. Students may create poems about the plants or animals in the contaminated pond water if they prefer.

EXAMPLE OF A CREATIVE STORY

The still, crystal clear water of Mill Creek Pond suddenly changed one spring, just two years ago. The still, crystal clear water became blackish. The pond water had become polluted with sediments from the nearby road construction and the new homes being built around the pond. The pond's food chains and webs altered abruptly that fateful day.

The deep red throat and chest of the male stickleback were no longer visible to other males. They could no longer warn other males to keep out of their territory where the underwater nests lay. Now the nests of eggs, which they fiercely defend from other male sticklebacks, birds, or other fish, were in danger. Now there was no way to make them selves look fierce in this dark, murky water. What's more they couldn't see their enemies, the perch and pike, if they approached the nests.

The only way Red, a long-time inhabitant of Mill Creek Pond, could protect himself was to raise his sharp spines, just in case an enemy was nearby. He would also have to be more sensitive to any movement of the water. This would be his only clue that an enemy was close by. He could not depend on his bright, blue eyes to spot approaching danger in the black, scummy water.

Even though there was plenty of food to eat yesterday, Red couldn't see the water boatmen, larvae, tadpoles, or small fish scurrying through the water. The shallow, clean water had become a deep, dark blackish color due to the sediments swirling about. The only possibility might be to jump out of the river to catch a caddis fly or dragonfly hovering over the pond. But a kingfish or herons might be nearby. With their long bills, they would be able to spear and snap up Red. His location would be known. Nevertheless, Red took a chance. He leaped up, and sucked down a dragonfly. Willing to take a second chance, he jumped up again, gobbling up a caddisfly.

Two herons, wading in the shallow water, spotted Red. They stood very still, staring into the water. But the water was dark and murky. They couldn't see where to plunge their bills into the water to catch Red. Red knew he was lucky, but decided to move near the elodea and pondweeds to hide for a while.

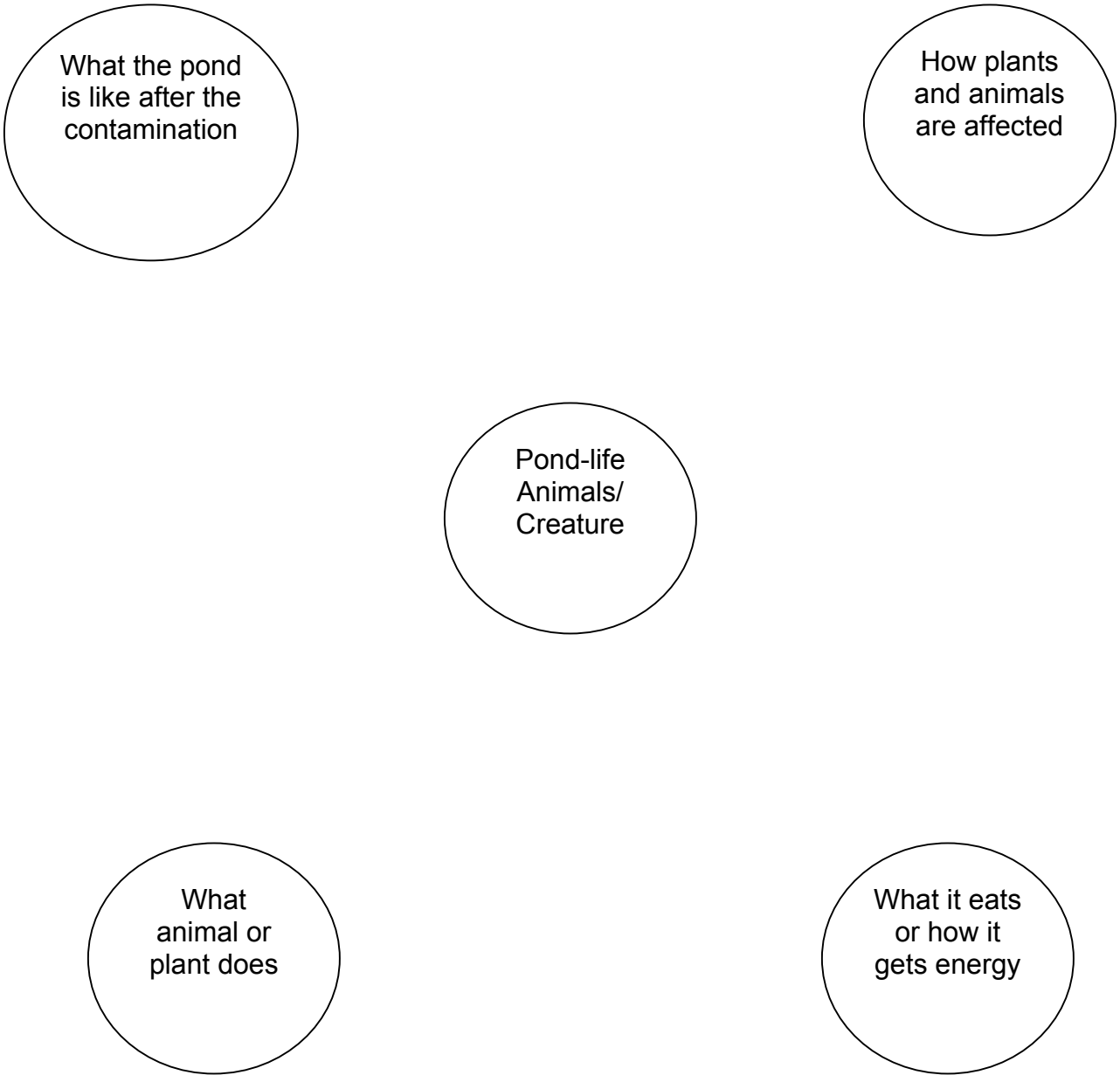
While lying very still among the rocks and pondweeds, Red wondered when the water would become clear again. He couldn't survive without food. What's more, he needed to stay close to the eggs to guard them from herons, kingfish, or bass.

EXAMPLE OF A CREATIVE POEM

A Dark, Murky Pond

Loon
Black head with a collar around the neck
Shiny black bill
Diving deep into the pond to chase the bass swimming nearby
Black, murky water with sediments moving about
Bass swimming away quickly
Escaping their enemies who can't see in the black, murky water
Wails of the loon echoing across the pond
Plenty of fish, but no way to see them
Hunger

How Light Affects Water
Overhead/Student Worksheet Web for Animal/Creature Life
In The Contaminated Pond



Water science is fun! Light bends!

Water science is fun! Light bends!

Water science is fun! Light bends!