4-H SCIENCE BLAST! IN THE CLASS

Walk in a Bag

Key Concept: Basic environmental knowledge and awareness

Grade Level: 1-3 (easily adapted for grades 4 and up)

Education Subject: Science

Success Indicator:
After completing this lesson, learners will increase their awareness and knowledge of natural resources in their communities by using observation, inference, critical thinking and reasoning skills.

Materials and Methods

Preparation Time: 15 minutes

Lesson Time: 45-60 minutes

Space: Any

Materials:
- Five to 10 brown paper grocery bags
- A variety of natural items collected outdoors (such as feathers, pine cones, interesting rocks, bark, moss, leaves, branches, bones)
- Stapler
- Paper
- Pencils
- Newsprint or other large paper
- Markers

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Adapted with permission from The Walk: Taking Your Youth Outdoors for Environmental Stewardship and Learning (2000; 4H1593). MSU Extension 4-H Youth Development.

Background Information:

What do you do if it is raining, sleeting or snowing so hard that it is difficult to lead an outdoor nature walk? Bring the walk indoors! There are many indoors ways to spark learners' interest for the outdoors. Items found in a single natural area can tell a lot about the life and the ecosystem of that area. Just collect a variety of leaves, branches, cones, dry seed heads and other natural objects from a single natural area and bring them inside, and your students can use them to identify the trees, plants and wildlife and explore the ecosystem of that area.

Instructions:

Preparation Time:

1. Collect five to 10 items from a nearby natural area. The items should have varied textures or represent specific themes, such as interesting rocks, bones, seeds, branches and leaves. Be sure not to disturb habitats or remove things that are protected or scarce.

2. Place each item in its own grocery bag and staple the bag shut, leaving an opening with only enough space to reach one hand into the bag to feel the item.

3. Set the bags on tables or in various areas in the room (depending on how much room you have) and place a large piece of paper and a marker, pen or pencil next to each bag. Write the following three sentences across the top of the paper, so there is room underneath for learners to complete the following three statements
   - "It feels . . ."
   - "It could be . . ."
   - "I wonder . . ."

Lesson Time:

1. Tell the learners they're going to take a walk along a "walk-in-a-bag trail," examining by touch alone the objects in each bag and writing their reactions to those objects on the large paper next to each bag. Tell them they'll have about 30 minutes to complete their walk.

2. After 30 minutes or so, or when they all seem to have finished the walk, ask for volunteers to take turns reading what the learners wrote about each of the objects. Lead a discussion of the learners' reactions.

Vocabulary:

Environment – The surroundings or conditions in which a person, animal or plant lives or operates.

Natural resources – Components in nature, such as trees, water, wildlife, mineral deposits, etc., that are necessary and useful to humans.

Stewardship – The careful and responsible management of something entrusted to one's care. Stewards are caretakers.

Nature – The physical world and everything in it (such as plants, animals, mountains, oceans, stars, etc.) that is not manufactured by people.

Habitat – The place where an animal finds the food, water, shelter and space necessary to sustain a population; the environment where a plant or animal naturally or normally lives and grows.

Life cycle – A series of stages through which something passes during its lifetime; for example, the insect — egg, larva, pupa and adult.

Ecosystem – A community of living and non-living things that all work together and make a balanced system. Ecosystems have no particular size; they can be as large as a forest or as small as some decomposing leaves on the ground.

3. Finally, reveal what was in each bag and discuss the items with the students. Talk about where each item might have come from, what plant or animal it belonged to, what sort of habitat it was part of and how the learners could have figured those things out.

Check for Understanding:

When the discussion has died down, explain that the items in the bags represent the natural environment of your local area. Ask the group the following questions:

- If you were in another part of Michigan, what kinds of things might you find in a "walk in a bag"?
- What might you find if you were in a natural area in Alaska? Arizona? Florida?
- What kinds of natural things might you find in New York City?
- Have you ever been surprised to see or hear a plant or animal in a city setting? What was it?

Learn More:

This activity can branch out in many ways. It can be the starting point for exploring our natural resources:

- Landscapes: geology, soils.
- Plants: grasslands, forests and trees, wildflowers.
- Water: rivers, streams and lakes; wetlands; groundwater.
- Animals: fish, birds, mammals, reptiles, amphibians, insects.
- Energy: renewable resources, energy fundamenta

Ways to Extend:

- Use the following activities from The Walk: Taking Your Youth Outdoors for Environmental Stewardship and Learning (online at *http://4h.msue.msu.edu/4h/resources/the_walk*) to extend this lesson into the outdoors.
  • Discovery Walk: For Seeing the Land and Watershed.
  • Woods – N – Water Walk: An Investigation Walk for Knowing the Land.
- Lead your group in an outdoor scavenger hunt or a nature bingo hike.

Michigan Grade Level Content Expectations:

Grades 1-3: Make purposeful observation of the natural world using the appropriate senses (S.IP.01.11, S.IP.02.11, S.IP.03.11); share ideas about science through purposeful conversation (S.IA.01.12, S.IA.02.12, S.IA.03.12); communicate and present findings of observations (S.IA.01.13, S.IA.02.13, S.IA.03.13).
Grade 2: Describe objects and substances according to their properties (P.PM.02.12).
Grade 3: Classify plants on the basis of observable physical characteristics (L.OL.03.41); relate characteristics and functions of observable parts in a variety of plants that allow them to live in their environment (L.EV.03.11).

Go Fish

Key Concepts: Habitat, life requirements
Grade Level: 1-6
Subjects: Science, math, social studies
Success Indicator:
After completing this lesson, learners will be able to:
- Identify and describe food, water and shelter as three essential components of habitat.
- Describe the importance of good habitat for fish.
- Define the term "limiting factors" and give examples.
- Recognize that fluctuations in fish populations occur because ecological systems undergo many changes.
- Describe how fishing is a positive tool for fisheries management.

Preparation Time: 10 minutes

Lesson Time: 30 minutes

Space:
Large area outside (20- by 30-foot area for running) or a gym or large hallway

Materials:
- Newsprint pad (flip chart) and markers, or chalkboard and chalk
- Sticky notes (medium to large)

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Adapted with permission from the Project FISH curriculum, developed by Mark Stephens, educational program coordinator, MSU Department of Community, Agriculture, Recreation and Resource Studies. Adapted from the aquatic project WILD - Aquatic Education Activity Guide (Project FISH information can be found at: *www.projectfish.org*.)

Background Information:

This lesson focuses on habitat, which determines whether an animal (such as a fish or aquatic insect) will survive in an area. This activity is a fun and educational way to demonstrate major impacts of habitat changes on fish populations.

Instructions:

1. Divide the participants into groups of five or six and hand out about 10 sticky notes to each group. Tell the participants that as a group they will discuss two items: things that are important in a fish's life and things that may affect a fish's life. These things can be very specific (for example, insects, pollution, rocks, oxygen). They must decide which are most important to the fish and list each thing individually on its own sticky note in large letters. Give them 10 to 15 minutes to accomplish this.

2. Have each group present its conclusions by bringing the sticky notes to the front of the room and placing them on a blackboard, wall or window so everyone can see them. There will be a number of duplicate answers.

3. Next, have the participants look over the notes, and ask for volunteers to come up and lump similar notes into as few categories as possible. At this point, see if the group can narrow down the groupings even further. Learners should be able to see that the notes can fit into one of four categories: food, water/water quality, shelter and space/competition.

4. Tell them that these four categories are all needed for any animal's habitat. Now they will play a game about habitat.

The Activity

1. Tell your group that this activity introduces them to how fish survive in their habitats – areas that provide the basic needs that animals have for surviving and reproducing. Ask your group: What do fish and aquatic animals such as insects need to survive? (Food, shelter, water and space.) Tell them that this game will show them more about fishes' needs for food, shelter and water.

2. Arrange the group in a large circle. Tell the learners that they are managing a pond for fishing, and it will be necessary to stock (add fish) to get the game started. The center of the circle is the playing

Tips for Success

Safety first! Clear the playing area of stones or other debris before playing. Remind players to be careful while running.

It is helpful to have adult or teen observers help with the game. Have any participants who can't run play the role of the fish biologists and record data.

Play various versions of the game. Introduce predators and other mortality factors. Have players create their own adaptations. Devise a way to introduce into the game the concept of carrying capacity (the maximum and/or average number of a given organism that an area can maintain at a particular season of the year).

Ways to Extend:

- Follow up the activity by contacting your local Michigan Department of Natural Resources office to learn about local fish population trends. Invite a biologist to speak at your next class or club meeting.

Community Service Learning:

- Older participants can teach the concepts in this lesson to younger groups. For example, teens could volunteer to lead this game at an elementary or middle school, scout meeting or youth camp.
- Work with a local biologist to improve the quality of the aquatic habitat in local lakes, rivers or streams.

Exhibits/Sharing

- Create a display about how fish populations change over time as habitat changes. Explain to community members the reasons to be good stewards of our water ecosystems.

area and the fourth component of habitat, space. Choose two to four participants to become the stocked fish and send them to one side of the circle. The other members of the group are habitat and go together to the other side of the circle. Mark two parallel lines on the ground about 20 feet apart. Have the fish line up behind one line and the rest (habitat) behind the other line.

3. The fish need to find food, water and shelter. When a fish is looking for food, it should clamp its hands over its stomach. When looking for water, it moves its hands to its cheeks to imitate water moving through gills. When looking for shelter, it holds its hands together over its head. A fish can choose to look for any one of its needs during each round of the activity.

4. Those playing the role of habitat also need to choose which component of habitat they will be: food, water or shelter. The habitat participants then make the sign showing which component of habitat they have chosen to be.

5. The game starts with all players lined up on their respective line with their backs turned toward those on the other line.

6. The group leader begins the first round by asking all the players to choose what they will be . Players on the habitat side of the game choose what habitat element they represent (food, water or shelter). Players on the fish side of the game choose what habitat element they need at that particular time (food water or shelter), and then make that sign.

7. Tell the players that a fish cannot change what it is looking for once it has seen what is available. Remind the players to keep doing their signs until they have found a match. When you see that the players are ready, count "One... two... three... go fish." At that point, the players turn to face one another while they continue to show off their hand signs.

8. When the fish see the habitat component they need, they are to move to it and tag it. Each fish must hold the sign until getting to the habitat person with the same sign. Each fish that reaches its necessary habitat component takes that component back to the fish side. When two or more fish reach a habitat component, the fish who gets the habitat item first survives.

   Any fish that fails to find its food, water or shelter dies and becomes part of the habitat in the next round. The fish that has died is now a habitat component and so is available as food, water or shelter to the fish that are still alive.

   Habitat components stay in place on their line until a fish tags them. If no fish needs a particular habitat component during a round, the habitat component just stays where it is in the habitat line. The habitat person can change which component he/she is from round to round but not after seeing what the fish signs are. Many kids would rather be fish, so this rule is important!

Point out to the players that, as habitat declines, competition to gain the needed things for survival will increase. Remind the group that pushing and shoving will not be tolerated.

9. The group leader or helper (playing the role of a fisheries biologist) keeps track of how many fish there are at the beginning of the game (that is, year one) and at the beginning of each round (years two, three, four and so on).

Participants eventually will use these numbers to create a graph with number of years on the X axis (horizontal) and number of fish on the Y axis (vertical).

10. At the end of at least five rounds, gather the players together to discuss the activity and the graph. (This can be done indoors, individually or as a group.) Encourage them to talk about what they saw. For example, ask them to describe how the numbers of fish changed over time.

Ideally, the players will recognize that they saw a small population of fish finding more than enough resources to meet habitat needs. Then the population of fish expanded during the next two to three rounds (years) of the game until the habitat was depleted and there wasn't enough food, water and shelter for all the members of the population of fish. At that point, some fish died from starvation, didn't have good water or lacked shelter. These are called limiting factors -- the condition or amount of something that limits the number or distribution of a particular organism. When the fish died, they returned nutrients to the habitat.

11. Now add an angler to the game. Have the angler stand at the side, between the fish and the habitat. Allow the angler to catch a specified number of fish by touching them before they get to the habitat (for example, the pond owner sets a fishing limit of two fish, as a rule). This version of the game will introduce the concept of fisheries management involving fishing.

After the round, the angler can choose to keep and eat the fish (returning them to habitat) or release them back to be fish again. Ask the players: What would have happened if no fishing limit (regulation) was imposed? What would happen if the habitat completely lacked one component of habitat (such as food)? (The population would "crash.") End by explaining to the players that fish populations depend greatly on their habitats, and that, to take the best care of our resources, we and biologists need to understand not only the fish but all of the things in the habitat that fish need to survive and reproduce.

Michigan Grade Level Content Expectations:

Grades 1 – 2: Share ideas about science through purposeful conversation (S.IA.01.12, S.IA.02.12); communicate and present findings of observations (S.IA.01.13, S.IA.02.13); demonstrate scientific concepts through various illustrations, performances, models, exhibits and activities (S.RS.01.11, S.RS.02.11).

Grade 1: Identify the needs of animals (L.OL.01.13).

Grade 4: Determine that animals require air, water, and a source of energy and building material for growth and repair (L.OL.04.16).

Grade 6: Describe common patterns of relationships between and among populations (competition, parasitism, symbiosis, predator/prey) (L.EC.06.21); predict how changes in one population might affect other populations based upon their relationships in the food web (L.EC.06.23); identify the factors in an ecosystem that influence changes in population size (L.EC.06.32); describe how human beings are part of the ecosystem of the Earth and that human activity can purposefully, or accidentally, alter the balance in ecosystems (L.EC.06.41); Predict possible consequences of overpopulation of organisms, including humans, (for example: species extinction, resource depletion, climate change, pollution) (L.EC.06.42).

4-H SCIENCE BLAST! IN THE CLASS

Biofuel Blast

Key Concept:
How biofuels are made through the process of fermentation

Grade Level: 1-7

Education Subject: Science

Success Indicator:
After participating in this activity, learners will be able to:

- Explain that sugar in corn and other cellulose (plant materials) can be converted into biofuels through fermentation.
- Conduct a science experiment.
- Demonstrate how to compare and contrast treatment results from an experiment.

National 4-H Curriculum:
2009 National 4-H Science Experiment Biofuel Blast, 4-H National Youth Science Day

Materials and Methods

Preparation Time:
10-20 minutes

Lesson Time:
45-60 minutes; 10 minutes (or longer) to observe bottle

Space: Any

Materials:

- Clean, empty 20-ounce plastic water bottles with caps (one per learner and two additional bottles to be used as controls; fewer if learners will be working in groups)
- White granulated sugar (3 tablespoons per learner or group if learners will be working in groups)
- Warm tap water (enough to half fill each plastic bottle)
- One packet (equal to 1 tablespoon if using a jar or bulk package) of active dry yeast or dry quick-rise yeast per learner or group
- 9-inch latex balloons (one per learner; use nonlatex balloons if you or any learners are allergic to latex)
- Scissors (one per group)
- String or yarn to measure diameter of balloon
- Measuring tape or ruler (one per group)
- Small plastic or paper funnels (one per learner)

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Developed jointly by the University of Wisconsin-Madison Extension Service, Wisconsin 4-H, the Great Lakes Bioenergy Research Center, the National 4-H Council, the National 4-H Headquarters at U.S. Department of Agriculture, and the National 4-H Science, Engineering and Technology Leadership Team, as part of the 4-H National Youth Science Day initiative.

Instructions:

Preparation time:

Read through the activity and gather the supplies from the materials list.

Lesson time:

1. Tell the learners they're going to learn about biofuels in this activity. Read aloud or paraphrase the following:

   Yeast breaks down sugars to get energy, the same way that eating sugars gives your body energy. In the process, the yeast releases two waste products: carbon dioxide (the same gas that you exhale) and ethanol (a liquid that can be used as a biofuel). Ethanol is mixed with water in the experiment and is invisible.

   *Ethanol is a type of **biofuel** energy obtained from recently harvested plant materials. (**Fossil fuels** such as coal or oil are sources of energy from plants and animals that died a very long time – millions of years – ago.). The sugars inside of corn kernels can be broken down by yeast to make carbon dioxide and ethanol. In a chemical plant, the ethanol is removed from the mixture to make a fuel that is mixed with gasoline and sold at some gas stations.* You may have

Vocabulary:

Biofuel – A fuel (a material that can be burned as a source of energy) that comes from recently harvested material such as corn kernels, as opposed to fossil fuels such as oil and gas, which come from material that died a long, long time ago.

Carbon dioxide – A gas that is released when you exhale; is a product of fermentation of sugars by yeast in this experiment; and is implicated in global warming when present in high levels in our atmosphere.

Cellulose – A major component of plant material; it is not digestible by humans and is part of dietary fiber. It is the most common organic compound on earth.

Circumference – A measure of the distance around a sphere.

Control – A part of a scientific experiment that acts as a standard and does not include the variable being tested.

Ethanol – A liquid produced by the fermentation of sugars by yeast; it can be mixed in a refinery with gasoline and used as a fuel in car engines.

Fermentation – Generally, the process by which organisms such as yeast break down substances for energy without using oxygen. In this experiment, the fermentation of sugars by yeast produces energy for the yeast and releases carbon dioxide and ethanol as waste products.

Fossil fuels – Sources of energy such as coal and oil, which come from plants and animals that died a very long time ago.

Renewable energy – Energy from sources such as the sun or wind that can be replenished.

Variable – Something that can vary, or differ, in a scientific experiment.

Yeast – A type of fungus that is made up of only one cell per organism (as opposed to a mushroom, for example, which is a fungus that is made up of lots of cells per organism).

noticed this at the gas pump, where signs may read "E10," which means the fuel mixture is 10 percent ethanol and 90 percent gasoline.

In the United States, most ethanol is made from corn. In this experiment, we're going to observe how yeast can break down processed sugars (such as granulated sugar and sugars found in corn syrup) through fermentation. We'll also see if yeast can use other plant products to make biofuels.

2. (**Note:** Depending on your space, time and equipment constraints, you may want to have the learners work in small groups. For simplicity, these instructions are written as if the learners will be working individually.) Have the learners collect the supplies they'll need for the experiment.

3. Tell them to use a funnel to add 1 tablespoon of yeast and 3 tablespoons of sugar to their empty bottles, then fill each bottle half full with warm tap water. (The water should be very warm to the touch but not so hot that it is painful or scalding.) Tell them to replace the cap on the bottle tightly, then shake it to mix the yeast and sugar in the water.

   Prepare your two controls: use a funnel to add 1 tablespoon of yeast to each of the two additional bottles and fill each bottle half full with warm tap water. Do not add any sugar.

4. After the contents are thoroughly mixed, have the learners remove the bottle caps again and place a balloon over the open top of each bottle, then observe what happens. Do the same with the two bottles used as controls. It will take a few minutes for the yeast to start eating the sugar, but soon learners will see their balloons starting to inflate, but they will see no change in the two control bottles. Explain that carbon dioxide gas is filling the balloons. Carbon dioxide is the same gas that humans and other animals exhale when breathing. As the yeast organisms eat the sugar in the bottle, they release waste products, one of which is carbon dioxide. However in the two controls there is no sugar available for the yeast to eat and the yeast can not release any carbon dioxide, which would make the balloon inflate.

5. When the balloons seem to have reached a stable state, have the learners measure their balloons to find out which one contains the most carbon dioxide. Show them how to cut a long piece of string, wrap it around the largest part of the balloon and mark where the string begins and ends while it is wrapped around the balloon. Then have them measure the length of the string from mark to mark with a measuring tape. This is called measuring the circumference. Have them compare the circumferences of the balloons by placing all of the measurements side by side or hanging them on the wall.

Check for Understanding:

After the learners have compared the circumferences of all the balloons, return their attention to the group and ask them the following questions:

- What happened during the activity — what did you observe?
- How large was the circumference of your balloon after 10 minutes (in inches)?
- How large was it after one hour?
- What changes did you observe in the two controls?
- Can you convert that size between inches and centimeters? Why do most scientists use metric measurements?
- For older students: Can you calculate the approximate volume of the carbon dioxide inside the balloon and share it with everyone? (**Note:** You may have to remind them of the formula for figuring the volume of a sphere.)
- Were there any differences in the sizes of the balloons? Why do you think this might be?
- Do you think the yeast might eat other types of food to make carbon dioxide?
- When you make bread, you add yeast to make the bread rise. Now that you have seen what happens when yeast eats sugar, how do you think the yeast makes the bread rise?
- What do you think would happen if you added very hot water to the yeast? (Note: Do not attempt this without adult supervision. Hot water may cause injury.)

Ways to Extend:

In small-group experiments, see how yeast can break down processed corn sugars (such as those found in corn syrup) and other plant products (such as dried ground-up leaves or wheat bran from the grocery store) to make biofuels. Have learners experiment with other variables (water temperature, amount of sugar, yeast, cellulose source, etc.). Your possibilities are limitless!

Find more information at the archived 2009 4-H Biofuel Blast site at: *https://site.4-h.org/nysd/archive.php*.

- The youth work sheets are at *https://site.4-h.org/nysd/misc/pdfs/experiment_guides/4-H_NYSD_Youth_Worksheets.pdf*.
- The facilitator guide is at *https://site.4-h.org/nysd/misc/pdfs/experiment_guides/4-H_NYSD_Facilitator_Guide.pdf*.

Michigan Grade Level Content Expectations:

Grades 1-4: Manipulate simple tools (S.IP.01.14, S.IP.02.14, S.IP.03.14, S.IP.04.14); demonstrate scientific concepts through various activities (S.RS.01.11, S.RS.02.11, S.RS.03.11, S.RS.04.11); generate questions based on observations (S.IP.01.12, S.IP.02.12, S.IP.03.12, S.IP.04.12); plan and conduct simple investigations (S.IP.01.13, S.IP.02.13, S.IP.03.13, S.IP.04.13); share ideas about science through purposeful conversation (S.IA.01.12, S.IA.02.12, S.IA.03.12, S.IA.04.12); communicate and present findings of observations (S.IA.01.13, S.IA.02.13, S.IA.03.13, S.IA.04.13);

Grades 5-7: Design and conduct scientific investigations (S.IP.05.12, S.IP.06.12, S.IP.07.12); use tools and equipment appropriate to scientific investigation (S.IP.05.13, S.IP.06.13, S.IP.07.13); investigate/evaluate data, claims and personal knowledge through collaborative scientific discourse (S.IA.05.12, S.IA.06.12, S.IA.07.12); communicate and defend findings of observations and investigations using evidence (S.IA.05.13, S.IA.06.13, S.IA.07.13).

Grades 3-4: Make accurate measurements with appropriate units (S.IP.03.15, S.IP.04.15).

Grade 3: Describe ways humans are protecting, extending and restoring resources (E.ES.03.43); describe helpful or harmful effects of humans on the environment (E.ES.03.52); describe how materials taken from the earth can be used as fuels for heating and transportation (E.SE.03.32).

Grade 4: Identify current problems that may be solved through the use of technology (S.RS.04.17); compare and contrast the states of matter (P.PM.04.23).

Grade 6: Identify kinetic or potential energy in everyday situations (P.EN.06.11).

Grade 7: Identify evidence of chemical change through color, gas formation, solid formation and temperature change (P.CM.07.21).

Fashion a Michigan Fish

Key Concept: Adaptations

Grade Level: 1–7

Education Subject: Science

Success Indicator:
After participating in this activity, learners will be able to:
- Classify fish according to body shape and coloration.
- Describe adaptations of fish to their environments.
- Describe how adaptations can help fish survive in their habitat.
- Interpret the importance of adaptations in animals.
- Learn to be better anglers by using lures, baits and other gear designed for various adaptations of fish.

Materials and Methods

Preparation Time: 30 minutes
Lesson Time: 30 minutes
Space: Any
Materials:
- Adaptation cards (one from each of the five categories for each group) (Note: Body shape and coloration are the only cards needed for younger participants.)
- Colored markers (four or five sets of a variety of colors)
- Newsprint or other large paper
- Photos or drawings of a variety of Michigan fish (available online from Project F.I.S.H. at *projectfish.org* or from the Michigan Department of Natural Resources at *http://www.michigan.gov/dnr/0,1607,7-153-10364_18958---,00.html*)

Background Information:

The major purpose of this activity is for learners to investigate the concept of adaptation in fish. An adaptation is a feature that increases the animal's likelihood of surviving and reproducing in its habitat. Aquatic animals are the products of countless adaptations over long periods of time.

When a habitat changes, either slowly or catastrophically, the species of animals with adaptations that allow them many options are the ones most likely to survive. Some species have adapted to such a narrow range of habitat conditions that they are extremely vulnerable to change. They are overspecialized and are usually more susceptible than other animals to death or extinction.

In this activity, the learners will design a fish and draw pictures of the adaptations their fish will have. As these adaptations become part of the fish's design, the fish becomes better suited to the habitat in which it lives. Because of the variety of conditions within each habitat, many types of fishes can live together and flourish. This is important to anglers. As they learn about the particular adaptations of the fish they pursue and about the habitat where these adaptations occur, they can adjust their fishing methods or techniques. Some fish adaptations are listed in the table at the end of this activity.

Instructions:

(**Note:** The first three steps are optional for younger participants. The remaining steps need to include only the adaptation cards for body shape and coloration. The reproduction and mouth and fin type cards are optional for younger learners.)

1. Ask the learners to draw a kind of animal that has a special adaptation; for example, long necks on giraffes for reaching high vegetation to eat, large eyes set into feathered cones in the heads of owls to gather light for night hunting.
2. Conduct a group discussion on the value of various kinds of adaptations in animals.
3. Pool all of the drawings of adaptations. Categorize them into the following groups:
   - Protective coloration and camouflage.
   - Body shape or form.

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Adapted with permission from the Project FISH curriculum, developed by Mark Stephens, educational program coordinator, MSU Department of Community, Agriculture, Recreation and Resource Studies. Adapted from the aquatic project WILD - Aquatic Education Activity Guide (Project FISH information can be found at: *www.projectfish.org*.).

Tips for Success

Make sure all of the learners in a group are providing input to the group's drawing. Visit each of the groups to see if they need more information or help, especially for younger learners.

Adaptation

- Have each group create a three-dimensional fish with the particular adaptations out of scrap materials you make available. These can then be made into a display about adaptations. Visit a recycling center in your community to pick up reusable materials.
- Pick one card from a set and have participants find photos of fish with that particular adaptation.

Michigan Grade Level Content Expectations:

Grades 1 through 7: Generate questions based on observations (S.IP.01.12, S.IP.02.12, S.IP.03.12, S.IP.04.12, S.IP.05.11, S.IP.06.11, S.IP.07.11); communicate and present findings of observations and investigations (S.IA.01.1, S.IA.02.13, S.IA.03.13, S.IA.04.13, S.IA.05.13, S.IA.06.13, S.IA.07.13).
Grade 1: Identify the needs of animals (L.OL.01.13); identify characteristics that are passed on from parents to young (L.HE.01.11).
Grade 3: Identify and compare structures in animals used for controlling body temperature, support, movement, food getting and protection (L.OL.03.32); relate characteristics and functions of observable body parts to the ability of animals to live in their environment (L.EV.03.12).
Grade 4: Identify individual differences in organisms of the same kind (L.EV.04.21); identify how variations in physical characteristics of individual organisms give them an advantage for survival and reproduction (L.EV.04.22).
Grade 5: Explain how behavioral characteristics (adaptation, instinct, learning, habit) of animals help them to survive in their environment (L.EV.05.11); describe the physical characteristics (traits) of organisms that help them survive in their environment (L.EV.05.12).

- Mouth type and feeding behavior.
- Reproductive behavior.
- Other (one or more categories the learners create in addition to the four groups listed above which they'll need for the rest of the activity).

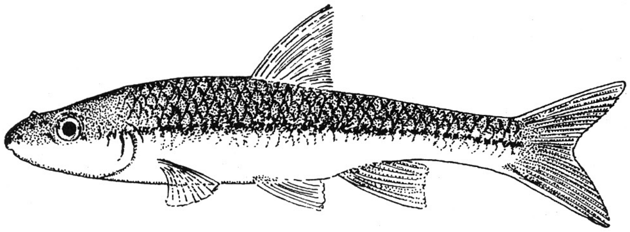
4. Divide the adaptation cards into five groups of five cards each, one each of coloration, mouth type, fin type, body shape and reproduction.
5. Distribute one complete set of cards to each group of learners. There might be five groups with four to six learners in each group. If the group is larger than about 30 people, make additional sets of adaptation cards.
6. Ask the participants to "fashion a fish" from the characteristics of the cards in the set they receive. Each group should:
   - Create an art form that represents the group's fish.
   - Name the fish (common name and scientific name).
   - Describe and draw the habitat for the fish.
   - Design and describe what it would take to catch this fish.
7. Ask each group to report on the attributes of its fish and identify and describe its adaptations. Ask the learners to describe how this kind of fish is adapted for survival.
8. **(Optional)** Now that the learners have some knowledge of adaptations, place the fish photos or drawings (these should be the same-sized photos or drawings or be put onto cards of the same size) on the floor or table and ask the learners to categorize them according to their adaptations. See if they can get them into proper families, and have them describe how and where these fish may feed. This part of the activity is optional or may be done as a separate activity.
9. **(Optional)** Playing the game "Concentration" or "Memory" can reinforce what has been taught in this activity. Simply create a second set of photos or cut the ones you have in half (this is the reason to have the photos or drawings on the same-sized cards) and mix them upside down in columns and rows. Have the learners flip over two at a time to find a match. If no match is found, the cards are turned back over and it's the next player's turn. If a player finds a match, that player gets another turn. This will enhance the observation skills of any age group.

Learn More:

- Invite a biologist from a local college or university, a zoo or nature center, or from a state or federal agency to speak to the group.
- Contact a local charter or commercial fisherman, a biologist, or even a taxidermist to arrange a variety of fish species for your group to examine.
- Have learners create three-dimensional and poster fish for examination in a local public area. This is a great fair project for both school and 4-H club or group events.
- Get information about adult Project FISH training online at *projectfish.org*.

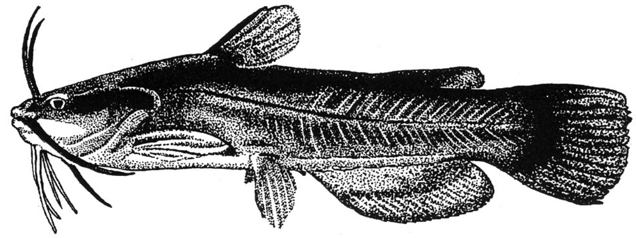
HANDOUT: FASHION A MICHIGAN FISH ADAPTATION CARDS

COLORATION



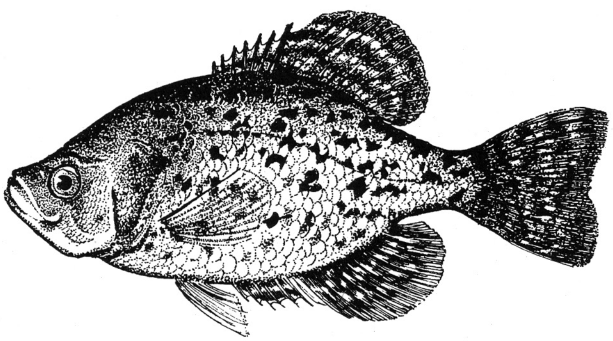
Light-Colored Belly
(Most Minnows)

COLORATION



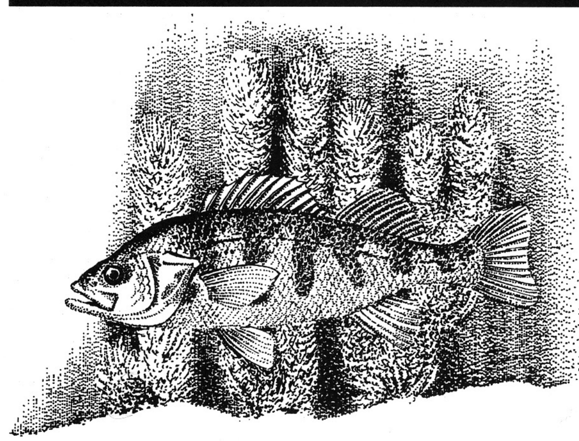
Dark Upperside
(Bullhead)

COLORATION



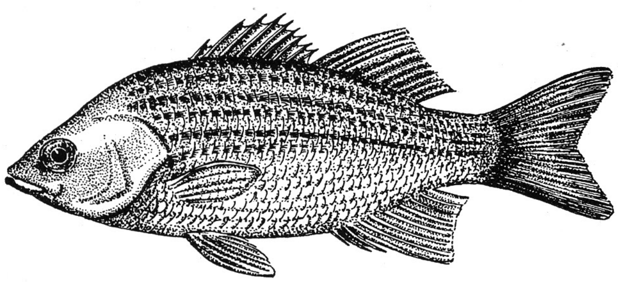
Mottled
(Crappie)

COLORATION



Vertical Stripes
(Yellow Perch)

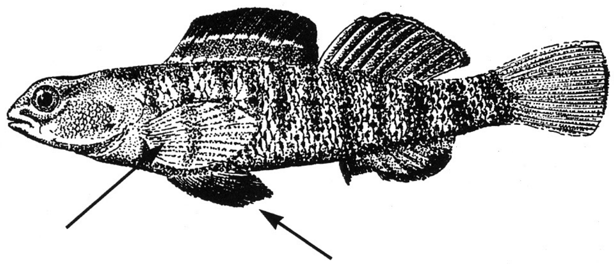
COLORATION



Horizontal Stripes
(White Bass)

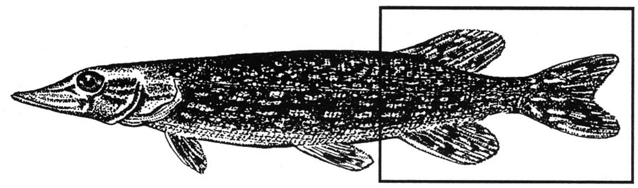
HANDOUT: FASHION A MICHIGAN FISH ADAPTATION CARDS

FIN SHAPE AND LOCATION



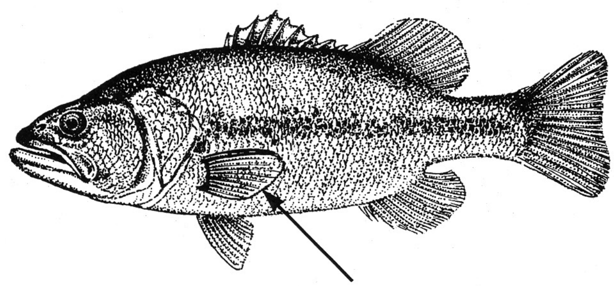
Large Pectoral or Pelvic Fins
(Rainbow Darter)

FIN SHAPE AND LOCATION



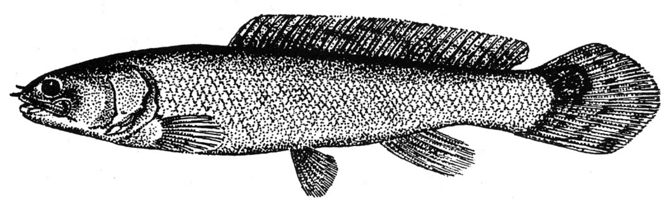
Anal and Dorsal Fins Posterior
(Northern Pike)

FIN SHAPE AND LOCATION



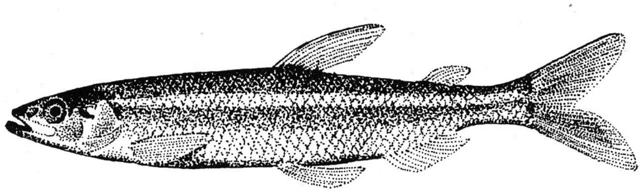
Pectoral Fins on Side
(Largemouth Bass)

FIN SHAPE AND LOCATION



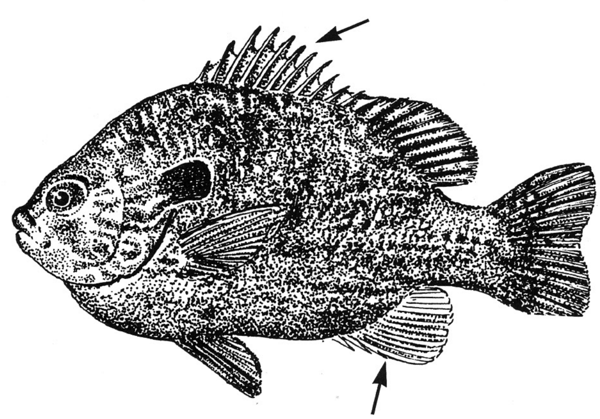
Long Dorsal Fin
(Bowfin)

FIN SHAPE AND LOCATION



V-Shaped Tail
(Rainbow Smelt)

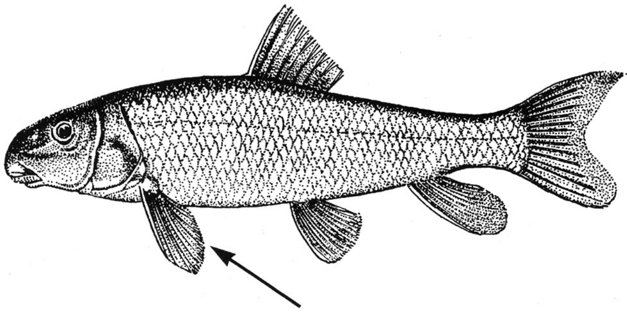
FIN SHAPE AND LOCATION



Anal and/or Dorsal Spines
(Sunfish)

HANDOUT: FASHION A MICHIGAN FISH ADAPTATION CARDS

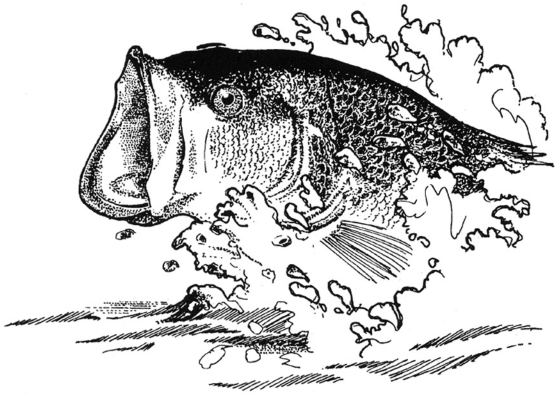
FIN SHAPE AND LOCATION



Pectoral Fins on Bottom
(Sucker)

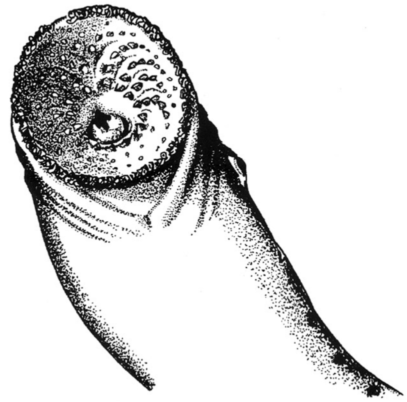
HANDOUT: FASHION A MICHIGAN FISH ADAPTATION CARDS

MOUTH/FEEDING



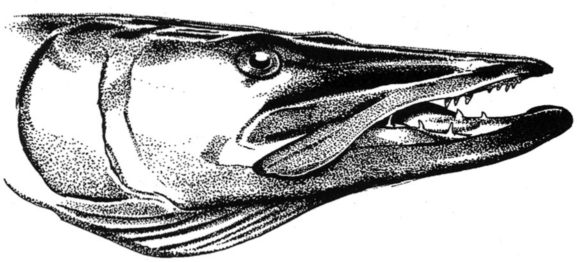
Very Large Flexible Jaw
(Largemouth Bass)

MOUTH/FEEDING



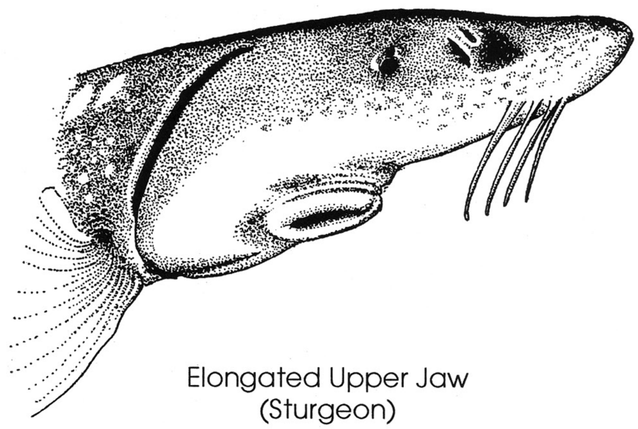
Sucking Disks
(Lamprey)

MOUTH/FEEDING



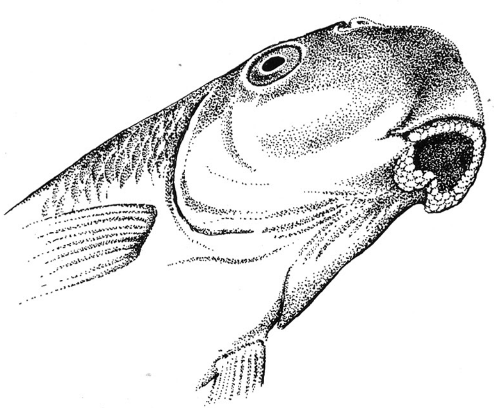
Duckbill Jaws
(Northern Pike)

MOUTH/FEEDING



Elongated Upper Jaw
(Sturgeon)

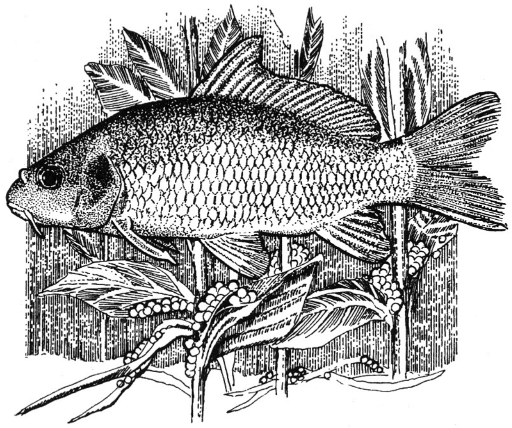
MOUTH/FEEDING



Sucker Shape
(Sucker)

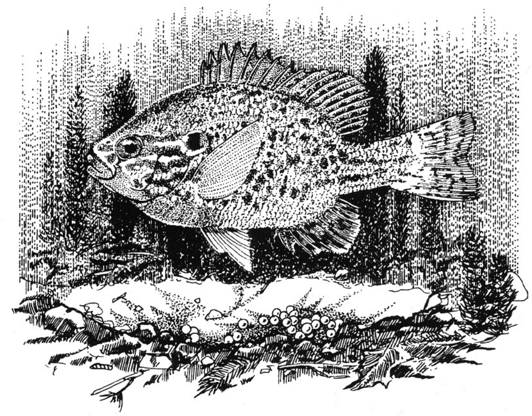
HANDOUT: FASHION A MICHIGAN FISH ADAPTATION CARDS

REPRODUCTION



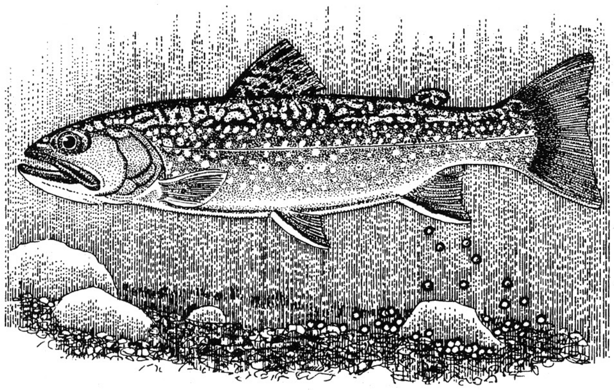
Eggs Deposited in Vegetation
(Carp)

REPRODUCTION



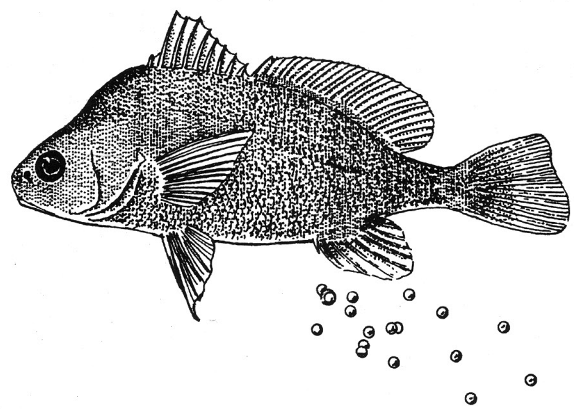
Eggs Deposited in Nest
(Pumpkinseed)

REPRODUCTION



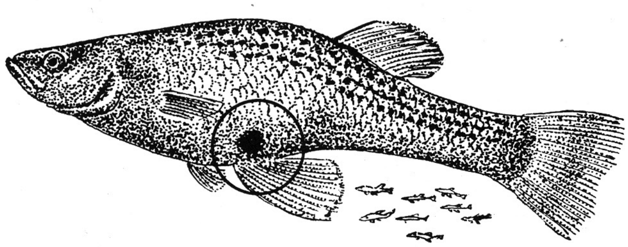
Eggs Deposited on Bottom
(Trout)

REPRODUCTION



Free-Floating Eggs
(Freshwater Drum)

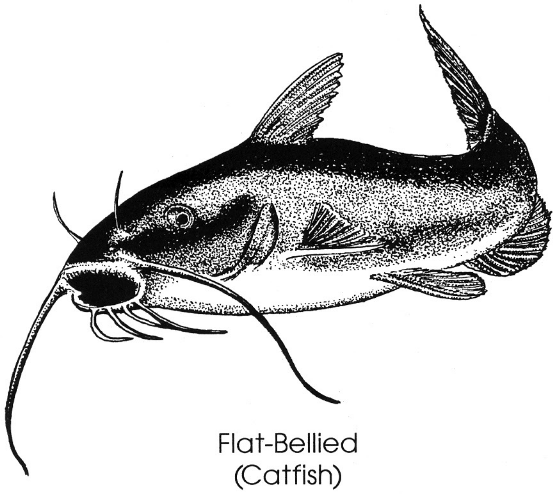
REPRODUCTION



Live Birth
(Gambusia)

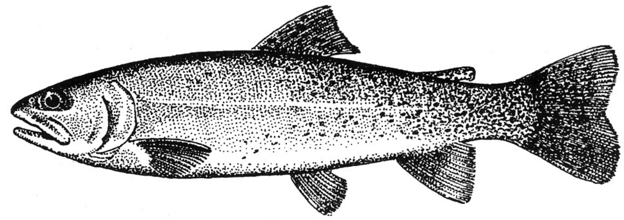
HANDOUT: FASHION A MICHIGAN FISH ADAPTATION CARDS

SHAPE



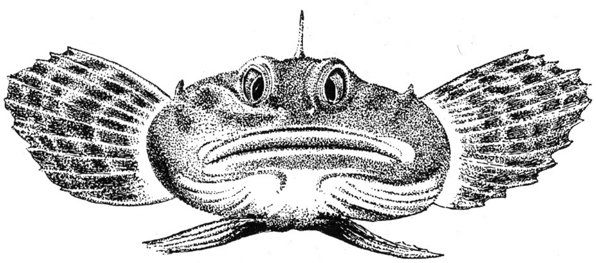
Flat-Bellied
(Catfish)

SHAPE



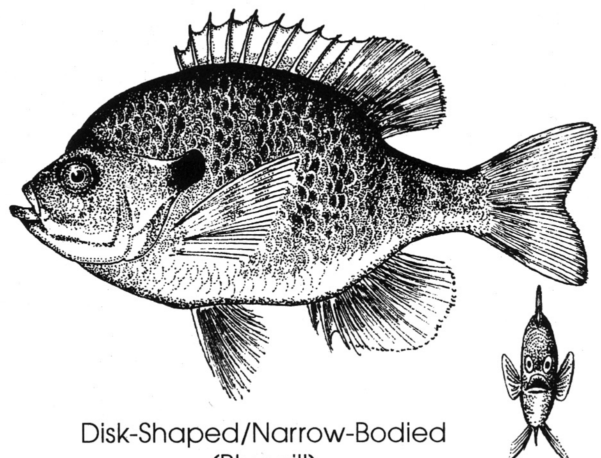
Torpedo Shape
(Trout)

SHAPE



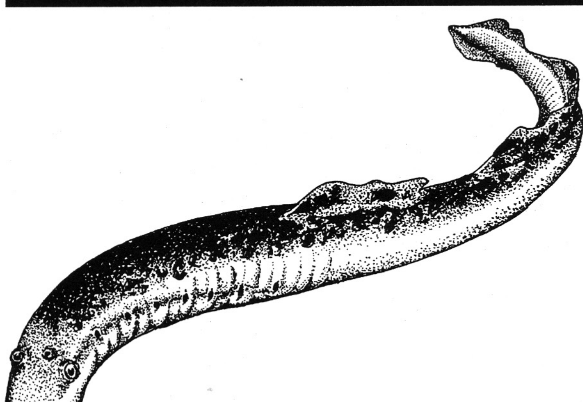
Horizontally Flattened
(Sculpin)

SHAPE



Disk-Shaped/Narrow-Bodied
(Bluegill)

SHAPE



Long and Slender
(Lamprey)

Adaptation	Advantage	Examples of fishes from Great Lakes watersheds
Mouth		
Sucker-shaped mouth	Bottom feeds on very small animals	Sucker, carp
Elongated upper jaw	Feeds off bottom	Sturgeon
Sucking disk	Attaches to prey/substrate	Sea and brook lamprey
Duckbill, elongated jaws	Grasps prey	Pike, muskellunge, gar
Extremely large, flexible jaws	Surrounds prey	Largemouth bass
Body Shape		
Torpedo	Fast moving, away from bottom	Trout, salmon
Flat-bellied	Bottom-oriented swimmer	Catfish, sucker
Vertical disk	Feeds above or below in slow water	Bluegill, pumpkinseed
Wide/horizontally flattened	Bottom dweller	Sculpin, sturgeon
Long and slender, scaleless	Attached feeder, needs low resistance	Sea lamprey
Coloration		
Light-colored belly	Predators have difficulty seeing it from below	Most minnows, perch
Dark upper side	Predators have difficulty seeing it from above	Bluegill, bullhead, catfish
Vertical stripes	Can hide in vegetation	Muskellunge, bluegill, yellow perch
Horizontal stripes	Can hide in vegetation	White bass
Mottled coloration	Can hide in rocks and in bottom	Trout, rock bass, darters
Reproduction		
Eggs deposited on bottom	Hidden from predators	Trout, salmon, minnows
Eggs deposited in nests	Protected by adult males	Bluegill, bass, stickleback
Floating eggs	Dispersed in high numbers	Freshwater drum
Eggs attached to vegetation	Stable until hatching	Perch, northern pike, carp
Live bearers (does not lay eggs)	High survival rate	Guppy, mosquito fish (no native Michigan species)
Fin Shape/Location		
Large pectoral/pelvic fins	Help stay on bottom in moving water	Johnny and rainbow darter
V-shaped tail	Continuous movement	Channel catfish, rainbow smelt
Anal and dorsal fins—posterior	Burst speed, power	Pike, muskellunge, gar
Anal and/or dorsal spines	Protection from predators	Sunfish, stickleback
Pectoral fins on side	Good for sharp turns and “rowing”	Sunfish, black bass, yellow perch
Pectoral fins on bottom	Good for stabilizing in flowing water	Trout, suckers
Long dorsal fin	Used for propelling forward or backward without body movement	Bowfin

Fins, Tails and Scales: Identifying Great Lakes Fish

Key Concepts:
Learners will identify distinguishing characteristics of fish and use a dichotomous key to identify 10 common fish families. By observing and comparing these features, learners will discover that fish, like other living organisms, can be organized and classified into meaningful groups for identification and further study.

Grade Level: 3-7

Education Subject: Science

Success Indicator:
After completing this lesson, learners will be able to:

- Describe the physical characteristics (traits) of fish that help them survive in their environment.
- Name several distinguishing characteristics of Great Lakes fish.
- Describe how these characteristics help fish survive in their environment.
- Organize Great Lakes fish cards on the basis of the similarities and differences among fish species.
- Use a dichotomous key to identify 10 Great Lakes fish families.

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This lesson is based on content from Fins, Tails and Scales: Identifying Great Lakes Fishes, a free online lesson from Fisheries Learning on the Web (FLOW), developed by Michigan Sea Grant College Program, see: www.miseagrant.umich.edu *http://www.miseagrant.umich.edu* .

Materials and Methods

Preparation Time: 30 minutes

Lesson Time: 30-60 minutes (may be spread over multiple days)

Space: Anywhere

Materials:

- Pencils or pens

Download and print the following handouts at (*http://4h.msue.msu.edu/4h/science_blast*). To access the most current materials, including assessment tools, see the FLOW website: *www.projectflow.us http://www.projectflow.us* .

- Great Lakes Fish Family Cards and Generic Fish Graphic
- Dichotomous Key: Great Lakes Fish Families
- Distinguishing Characteristics of Fish (one to two per group for each of two activities)

Background Information:

The Great Lakes region is home to more than 160 species of fish. A species consists of individuals that share the same gene pool.

These species belong to 28 major fish families. A family or group of different but closely related fish species can be identified using a taxonomic or classification system that helps to define fish species on the basis of common characteristics.

Learners may be most familiar with fish in the sunfish and bass family, cold-water species in the salmon and trout family, or some of the 62 species that make up the minnow family. Ancient or prehistoric fish species such as lake sturgeon and long-nose gar also inhabit waters of the Great Lakes region and possess distinctive attributes that have allowed them to survive for millions of years.

With the exception of some primitive species, most fish have common characteristics that include gills, scales, fins and bony skeletons. Some characteristics that differentiate fish include head shape and mouth orientation, fin type and location, and body shape and average adult size.

Color markings, such as vertical stripes or fin spots, may also help differentiate fish when used in combination with other factors, including geographic range.

Distinguishing characteristics can provide clues about where a species typically lives and what it eats. For example, fish in the sturgeon and sucker families have downward-oriented mouths (sometimes called

Vocabulary:

Adipose fin: Small, fleshy fin. When present, the adipose fin is located between a fish's dorsal and caudal fins.

Anal fin: Fin located on a fish's underside behind the pelvic fins.

Barbels: "Whiskers" used by bottom-feeding fish to sense food.

Caudal fin: Tail fin.

Dichotomous key: Classification tool used to sort, organize and identify a collection of objects or living organisms. (Dichotomous: divided into two parts. Key: A systematic classification of the significant characteristics of the members of a group of organisms to facilitate identification and comparison.)

Dorsal fin: Large fin or fins on a fish's back that vary in shape and size and may be connected or separate.

Family: A taxonomic category ranking below an order and above a genus.

Fry: Newly hatched young after the yolk sac has been fully absorbed and the fish shifts from the bottom to swim freely and search for food.

Genus: Major subdivision of a family or subfamily in the classification of organisms, usually consisting of more than one species.

Ichthyologist: Scientist who studies fish.

Larval fish: The stage in a fish's life cycle just after hatching from an egg. A larval fish lives off a yolk sac attached to its body.

Pectoral fins: Side fins mainly used for direction or steering.

Pelvic fins: Paired fins located on the belly of a fish or under the pectoral fins.

Snout: Front part of a fish that includes the mouth.

Spawn: To deposit eggs; to produce offspring in large numbers.

Species: A fundamental category of taxonomic classification ranking after a genus and consisting of organisms capable of interbreeding.

Superior: Directed upward.

Terminal: Directed forward.

Ventral: Directed downward.

Yolk sac: A membranous sac attached to an embryo, providing early nourishment in the form of yolk. In many fish, the yolk sac is retained for a period after hatching.

ventral) that enable them to find food along a lake or stream bottom. Other traits such as fin shape and location can provide clues about whether a fish species is maybe a more maneuverable swimmer (e.g. sunfish and bass), powerful swimmer (e.g. pike), or even long distance swimmer (e.g. trout and salmon). (See the Distinguishing Characteristics of Fish handout.)

Dichotomous Keys

To correctly identify fish and classify newly discovered species, fisheries scientists use something called a *dichotomous key*, which is a classification tool used to sort, organize and identify a collection of objects or living organisms.

A dichotomous key is made up of a series of questions with two choices. Each choice leads to another question. The key can appear in narrative form (as numbered questions), graphically (resembling a flow chart), or as a combination of graphics and narrative. By making choices and progressing logically through the key, users follow a path that ends with the correct identification of the organism.

Dichotomous keys vary in their degree of specificity. In this lesson, a simplified key has been created that distinguishes 10 Great Lakes fish families. By using their knowledge of distinguishing characteristics, Learners use illustrations of fish to work through the key and make identifications. (See Dichotomous Key)

Instructions:

1. Discuss the importance of observing distinguishing characteristics of living organisms to classify and identify them.
2. Hold up the generic fish illustration. Explain that this is not a real fish but rather a composite showing a variety of physical traits. Point out the locations and names of the various fins and other special features such as barbels (a scientific term for the "whiskers" used by bottom-feeding fish to sense food) and adipose fin (a fleshy fin located behind the dorsal fin).
3. Arrange the learners in small working groups. Provide each group with the generic fish illustration and a set of Great Lakes Fish Family Cards. Explain that the species on the 12 cards belong to 10 Great Lakes fish families.
4. Ask the groups to sort the fish cards on the basis of any set of physical characteristics they choose or about which they have some prior knowledge. (This is an important step in drawing out learners' previous knowledge and creates motivation for them to learn more.)
5. Discuss the results. Ask: How did you sort the fish? What features did you look at? Was it easy or hard? As the discussion progresses, ask: Did anyone sort by tail shape, by presence of a barbel, by mouth shape or by fin shape or location? This way, the discussion becomes informative to learners about what features scientists consider important and informative to the teacher about learners' current knowledge. Collect the cards and the generic fish illustration from each group.

6. Explain that next the students will use a dichotomous key to sort and identify fish on the basis of the characteristics that ichthyologists, or fish scientists, view as important.
7. Divide the class into new small groups. Explain the need to use classification systems to organize living organisms. Introduce the concept of a dichotomous key. Emphasize that this system uses a set of logical steps based on distinguishing characteristics and results in the correct classification or identification of an organism.
8. Pass out a set of Great Lakes Fish Family Cards and a dichotomous key to each group. (The Distinguishing Characteristics of Fish sheet may be helpful for reference.) Remind learners that the species on the 12 cards belong to 10 Great Lakes fish families. Explain that each group will use the dichotomous key to identify the correct families of the fish on the cards. (The families are trout and salmon, pike, sturgeon, lamprey, sunfish and bass, perch, sucker, goby (invasive), catfish and freshwater cod.)
9. Using the set of fish family cards, have learners begin by selecting one fish and "keying it out" by answering the questions and following the arrows as indicated on the key. They should identify the correct fish family for each fish. As they identify each illustration, have them write the name of the family on a sticky note and label each card.
10. Review the results with the learners. Hold up the enlarged fish illustrations (labeled Teacher Master) and tell about each species, pointing out distinguishing characteristics and family. Did everyone correctly identify all fish families? Was it difficult to distinguish some of the characteristics? How else might some of the characteristics be described? Remind learners that these variations, or adaptations, help fish survive in their environment.
11. Explain that one limitation of a dichotomous key is that, like humans in a family, all fish of a given family or species do not look exactly alike. There will always be individual differences. Fisheries scientists often use many additional physical characteristics, such as scale counts, fin location and body depth — in combination with factors such as geographic distribution — to correctly identify fish.

Check for Understanding:

- Were the characteristics you first noticed on the fish the ones used to categorize them?
- Did categorizing these fish help you learn about Great Lakes fish? How many could you identify and name without using a key? Why might this be important?
- How would you teach someone about using a dichotomous key?
- How would you teach someone about identifying Great Lakes fish?
- What did you learn about making decisions?
- How could the things you learned today be used to help you in other situations?
- Give an example of a challenge you had and what you did to solve it.

Learn More:

Have learners develop a dichotomous key to categorize candy, shoes or any other group of objects.

Michigan Grade Level Content Expectations:

Grades 3-7: Communicate and present/defend findings of observations and investigations (S.IA.03.13, S.IA.04.13, S.IA.05.13, S.IA.06.13, S.IA.07.13).
Grade 3: Classify animals on the basis of observable physical characteristics (L.OL.03.42).
Grade 4: Identify individual differences (for example: color, leg length, size, wing size) in organisms of the same kind (L.EV.04.21); identify how variations in physical characteristics of individual organisms give them an advantage for survival and reproduction (L.EV.04.22).
Grade 5: Explain that the traits of an individual are influenced by both the environment and the genetics of the individual (L.HE.05.11); describe the physical characteristics (traits) of organisms that help them survive in their environment (L.EV.05.12); relate degree of similarity in anatomical features to the classification of contemporary organisms L.EV.05.21).
Grade 6: List examples of populations, communities and ecosystems including the Great Lakes region (L.EC.06.11).

Water Quality Experiment

Key Concepts:
- Plant growth
- The scientific process

Grade Level: 4-7

Education Subject: Science

Success Indicator:
In completing this lesson, learners will:
- Conduct a science experiment from beginning to end and draw conclusions based on their data.
- Make accurate measurements of bean growth.
- Evaluate differences in germination and seedling growth.
- Suggest reasons for differences in germination and growth related to the watering solutions.
- Recommend and design follow-up experiments.

Materials and Methods

Preparation Time: 30 minutes

Lesson Time:
- Initial experiment set-up: 30 minutes
- Weekly for three weeks: 10 minutes
- Final measurement: 10 minutes
- Experiment wrap-up: 30 minutes

Space:
- Classroom for set-up and measuring
- Window space or greenhouse space to grow the plants, if available

Materials:
- Five 4-inch plastic plant containers
- Potting soil
- Bean seeds (three per plant container)
- Five plastic milk jugs or other water jugs with lids that can be closed (to prevent evaporation of the water and either loss or concentration of the poor quality water solutions) and labeled
- Permanent marker
- Four different watering solutions and plain tap water
- Rulers with measurements in centimeters (one per group)
- Growth chart handout (one per group plus one for the control container)
- Pencils or pens

Introduction:

Water is a precious, limited natural resource on our planet. We need to conserve water — especially fresh water — wherever we can. One common way to save water is to water plants with water that isn't clean enough for humans to drink. If we do that, will plants grow at the same rates? Will we still be able to produce food crops if we irrigate them with poor quality water?

MICHIGAN STATE UNIVERSITY | Extension

Developed by Norm Lownds, Ph.D., Curator, Michigan 4-H Children's Garden

Instructions:

Preparation time:

1. Read the lesson and gather the supplies from the materials list.
2. Label the water jugs to indicate the poor quality water they will contain. (Common poor quality waters could be pond, lake, river water, salt water, chlorine water.) Label one jug "tap water."
3. Fill all of the water jugs with the appropriate poor quality water. (Note: You may have to prepare some of the poor quality waters by adding appropriate "contaminants" to the jug. You may have to prepare new solutions of poor quality water a couple of times over the course of the three-week experiment.)
4. Leave one poor quality water for the learners to brainstorm and vote on. (Note: The final poor quality water could be anything: rain-water, vitamin water, coffee, cola, Mountain Dew, etc.. Let the kids be creative and have some fun with this.)
5. Recreate and make one photocopy per learner of the growth chart handout.

Lesson time:

Tell the learners they're going to investigate the effect of using poor quality water to irrigate crops. Read aloud or paraphrase the following:

Vocabulary:

Water quality – The physical, chemical and biological characteristics of water. It is a measure of the condition of water relative to its use for any human need or purpose. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water.

Seed germination – The process by which a plant emerges from a seed and begins growth.

Science process/scientific practice – A process or practice that includes a question, research, hypothesis, testing the hypothesis, data collection and explanation of the data collected.

Hypothesis – An educated guess.

For seeds to germinate and grow, they must be exposed to the proper conditions. Most importantly, water must get into the seed to begin all of the processes necessary for germination and seedling growth. Poor quality water (high salt content, polluted, very acidic) could prevent seed germination, and then there would be no seedling growth.

Plants (seeds) are usually watered with the same water that humans use for drinking. However, as there are more and more people, and as some water sources become poor quality – contaminated by industrial pollutants, sewage, excess fertilizer runoff and other factors – we may have to water plants with lower quality water. This raises lots of questions about how lower quality water may affect seed germination and seedling growth:

- *How salty can the water be?*
- *How acidic can the water be?*
- *How much pollution can be in the water?*
- *Can we use pond or lake water to irrigate crops without damaging the watery ecosystems?*

Ideally, we would have answers to these questions before we need them, so that if we are faced with having to grow plants with lower quality water, we know what the limits are, how to use these waters and what to expect in seed germination rates and plant growth rates.

That is the basis for this experiment. It will take a group of collaborating scientists (like you) to answer these questions so that we are prepared for problems that we may have to face in the future. Thanks in advance for your careful work on this important question.

Starting the experiment:

1. Have the learners brainstorm possible watering solutions or contaminants that they might use to water the plants. List these on the board and take a few minutes to discuss why we would or would not use some of these. (For instance, milk is often suggested, but we wouldn't use it because it will start to rot and stink up the whole room). Remove the solutions that you will not use from the list.
2. Have learners vote on the one solution to add to the experiment. Have them look over the list that you could test, select their favorite and put their heads down on their desks, and then read each option off and have those who want that one raise their hands. Record the votes to determine the top option.
3. Divide the class into four groups and have them decide on group names. Then randomly assign one group to each of the four watering solutions. Give each group one plant container and have them label it with their group name and the name of the watering solution they've been assigned, then fill the container with potting soil.
4. Explain that you're going to run the "control" for the experiment. You'll plant the same number of the same kind of seeds in a container the same size as the ones they'll use and filled with the same soil as the experimental containers. The only difference will be that you'll water the control beans with plain tap water. That way they can watch for any differences in how their plants (which they'll water with lower quality water) will grow compared with plants watered with clean drinking water.
5. Next give each group three bean seeds. Encourage the learners to examine the beans carefully and record their observations. Tell

them to plant the bean seeds by pushing them into the soil about 1/2 inch deep, then have them moisten the soil with tap water.

6. Tell the groups to carefully move their plant containers to the growing site you've arranged (such as a windowsill, a shelf under artificial lighting or a greenhouse). Be sure to set the control container with the experimental plants so they're all growing under the same conditions.
7. Discuss with the learners what effect they predict the various watering solutions will have on the plants.

Daily:

Remind the groups to water their plants lightly with the assigned watering solution every day. Remember to water the control container daily, too.

Weekly for three weeks:

Have the learners count the number of seeds that have germinated (sprouted) in their group's container and measure the height of each seedling, then record the results on their group's growth chart. Ask for a volunteer to do the same for the control container.

Final data collection/evaluation:

1. Have the groups take final plant germination and growth measurements and record their results.
2. Next create a grid on the board or on newsprint. Have the groups take turns reporting which watering solution their group used and their plant germination and growth results. Fill in the groups' (including the control container's) data on the grid. Discuss the results with the class.

Check for Understanding:

Ask the group the following questions:

- Do the data support your hypothesis about plant growth? Why?
- Which watering solution grew the fewest beans? Why do you think this happened?
- Which watering solution grew the smallest beans? Why do you think this happened?
- What other differences (besides size and number of plants) did you notice among the containers of beans?
- What water treatment would you recommend for growing bean plants?
- What new questions do you have about this water quality experiment?
- What should the next water quality experiment be?

Option:

- Enter all of the learner data into a Google docs spreadsheet and create germination and growth graphs.
- Link the spreadsheet with a Wikispaces template to present and explain the data, write up conclusions and make recommendations for future experiments. (**Note:** Contact Dr. Norm Lownds at *lownds@msu.edu* to set up this option through the Collaborating Classrooms program of the Michigan 4-H Children's Gardens at Michigan State University.)

Ways to Extend:

- Evaluate other watering solutions.
- Use different seeds for the experiment.
- Do some research on water quality in various parts of the world.
- Do some research to find crops that are being developed to grow under poor conditions, especially conditions of high soil or water salinity (saltiness)

Michigan Grade Level Content Expectations:

Grades 4-5: Demonstrate scientific concepts through various illustrations, performances, models, exhibits and activities (S.RS.04.11, S.RS.05.15).
Grades 5-7: Evaluate data, claims and personal knowledge through collaborative science discourse (S.IA.05.12, S.IA.06.12, S.IA.07.12).
Grades 4-7: Generate questions based on observations (S.IP.04.12, S.IP.05.11, S.IP.06.11, S.IP.07.11); plan/design and conduct investigations (S.IP.04.13, S.IP.05.12, S.IP.05.12, S.IP.06.12, S.IP.07.12); manipulate simple tools that aid observation and data collection/use tools and equipment appropriate to scientific investigations (S.IP.04.14, S.IP.05.13, S.IP.06.13, S.IP.07.13); communicate and present/defend findings of observations and investigations (S.IA.04.13, S.IA.05.13, S.IA.06.13, S.IA.07.13).
Grade 4: Share ideas about science through purposeful conversation (S.IA.04.12); make accurate measurements with appropriate units for the measurement tool (S.IP.04.15); determine that plants require air, water, light, and a source of energy and building material for growth and repair (L.OL.04.15).
Grade 6: Identify the factors in an ecosystem that influence changes in population size (L.EC.06.32).
Grade 7: Describe the origins of pollution in the atmosphere, geosphere and hydrosphere (car exhaust, industrial emissions, acid rain and natural sources), and how pollution impacts habitats and climatic change, and threatens or endangers species (E.ES.07.42).

HANDOUT: WATER QUALITY EXPERIMENT

Growth Chart

My name:	Planting date:
Group name:	Watering solution:

WEEK 1 DATA **Date:**	**WEEK 2 DATA** **Date:**	**WEEK 3 DATA** **Date:**	**FINAL DATA** **Date:**
Number of plants germinated: ❒ 1 ❒ 2 ❒ 3	**Number of plants germinated:** ❒ 1 ❒ 2 ❒ 3	**Number of plants germinated:** ❒ 1 ❒ 2 ❒ 3	**Number of plants germinated:** ❒ 1 ❒ 2 ❒ 3
Plant heights (in cm): Plant 1: ____________ Plant 2: ____________ Plant 3: ____________	**Plant heights (in cm):** Plant 1: ____________ Plant 2: ____________ Plant 3: ____________	**Plant heights (in cm):** Plant 1: ____________ Plant 2: ____________ Plant 3: ____________	**Plant heights (in cm):** Plant 1: ____________ Plant 2: ____________ Plant 3: ____________
Notes on our group's plants:	**Notes on our group's plants:**	**Notes on our group's plants:**	**Notes on our group's plants:**