Fins: Form and Function

Fish fins function true to form!

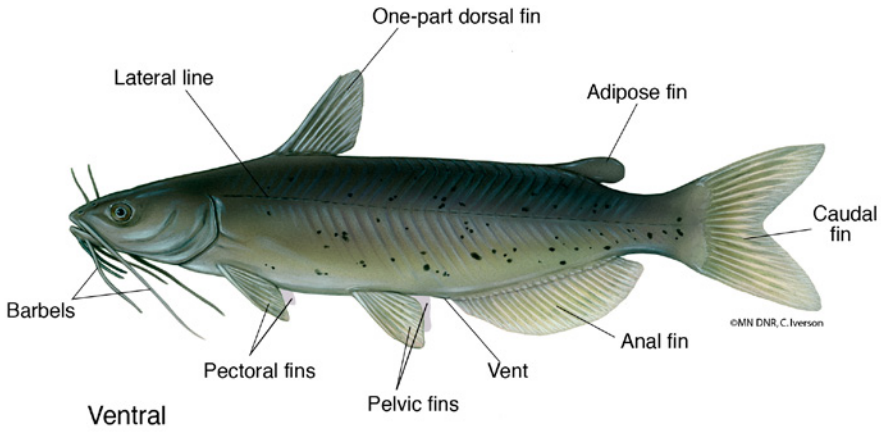


Table of Contents

Chapter 2 • Lesson 2

Please note: Academic Standards are updated regularly and our alignments will be updated on the DNR Academic Standards Website at: www.mndnr.gov/education/teachers/edstandards_intro.html

Fins: Form and Function

Minnesota Academic Standards

◒ Lesson *introduces* this Benchmark.
◒ Lesson *partially* addresses this Benchmark.
◒ Lesson *fully* addresses this Benchmark.

Language Arts

Grades 3, 4, and 5
I. Reading and Literature
B. Vocabulary Expansion:
Benchmark 1—The student will acquire, understand and use new vocabulary through explicit instruction and independent reading. ◒
II.Writing
A. Types of Writing:
Benchmark 1—The student will write in a variety of modes to express meaning, ◒ including:
a. descriptive
b. narrative
c. informative
d. friendly letter
e. poetic.
III. Speaking, Listening, and Viewing
A. Speaking and Listening:
Benchmark 1—The student will participate in and follow agreed-upon rules for conversation and formal discussions in large and small groups. ◒
Benchmark 2—The student will demonstrate active listening and comprehension. ◒

Science

Grade 3
I. History and Nature of Science
A. Scientific World View:
Benchmark 1—The student will explore the use of science as a tool that can help investigate and answer questions about the environment. ◒
B. Scientific Inquiry:
Benchmark 1—The student will ask questions about the natural world that can be investigated scientifically. ◒
Benchmark 2—The student will participate in a scientific investigation using appropriate tools. ◒
Benchmark 3—The student will know that scientists use different kinds of investigations depending on the questions they are trying to answer. ◒
IV. Life Science
B. Diversity of Organisms:
Benchmark 1—The student will describe the structures that serve different functions in growth, survival and reproduction for plants and animals. ◒

Grade 4
I. History and Nature of Science
B. Scientific Inquiry:
Benchmark 2—The student will collect, organize, analyze and present data from a controlled experiment. ◒
Benchmark 3—The student will recognize the impact of scientific and technological activities on the natural world. ◒

Grade 5
I. History and Nature of Science
A. scientific World View:
Benchmark 2—The student will recognize that clear communication of methods, findings and critical review is an essential part of doing science. ◒
B. Scientific Inquiry:
Benchmark 1—The student will perform a controlled experiment using a specific step-by-step procedure and present conclusions supported by the evidence. ◒
Benchmark 2—The student will observe that when a science investigation or experiment is repeated, a similar result is expected. ◒
IV. Life Science
E. Biological Populations Change Over Time:
Benchmark 1—The student will recognize that individuals of the same species differ in their characteristics and that sometimes the differences give individuals an advantage in surviving and reproducing. ◒

Environmental Literacy Scope and Sequence

Benchmarks

- Social and natural systems are made of parts. (PreK-2)
- Social and natural systems may not continue to function if some of their parts are missing. (PreK-2)
- When the parts of social and natural systems are put together, they can do things they couldn't do by themselves. (PreK-2)
- In social and natural systems that consist of many parts, the parts usually influence one another. (3-5)
- Social and natural systems may not function as well if parts are missing, damaged, mismatched or misconnected. (3-5)

For the full Environmental Literacy Scope and Sequence, see:
www.seek.state.mn.us/eemn_c.cfm

Chapter 2 • Lesson 2

Fins: Form and Function

 ISBN 0-7720-8576-6.

Grade Level: 3-5
Activity Duration: Part 1: 45 minutes
Part 2: two class periods
Group Size: any
Subject Areas: Language Arts, Expressive Arts, Science
Academic Skills: comparison, experimenting, identification, listening, modeling, observation, public speaking, small group skills, writing
Setting: Part 1: indoor or outdoor gathering area with tables
Part 2: area with wading pool, water tub, or water's edge
Vocabulary: adaptations, adipose fin, anal fin, caudal fin, dorsal fin, form, function, lie-in-wait predators, pectoral fins, pelvic fins, rays, rover-predators, spines
Internet Search Words: bullhead, carp, fish anatomy, fish fins, fish form and function, how fish swim, northern pike fins, perch, freshwater drum, sunfish, walleye

Instructor's Background Information

An amazing variety of fish species live in a tremendously wide range of environmental conditions throughout the world—in near-freezing Arctic waters, hot desert springs, high mountain lakes, cold water streams, muddy dried-up ponds, thermal vents on the ocean floor, and, of course, in Minnesota waters. Despite the great diversity exhibited by the 24,000 living species of fish, some general characterizations can be assigned to fish as a group.

> Fish are one of the oldest and most varied groups of animals on earth. Only insects have greater diversity—or more species. Biodiversity refers to the variety (or diversity) of all life forms in a given area. A lake habitat exhibits rich biodiversity if it contains numerous species of plants and animals, including fish.

Fish have **adaptations**, or specific features and behaviors enabling them to survive in their aquatic habitats. With some exceptions, most fish have fins and a long, streamlined body—or a thin, narrow body—enabling them to swim easily through water. The **form**, or shape, of a fish's body and body parts is often related to their **function**, or how those parts work. Function also depends on form. This relationship

Summary

How do fish move forward, up, down, slow down, turn, and stop? To find out, students observe the functions of different fin types in a classroom aquarium and record their observations. These observations guide students in designing models to investigate how some fins help to stabilize fish. Students learn the names of different fin types, and that fins are an adaptation that helps fish survive in their habitats.

Student Objectives

The students will:

1. Observe fish in a classroom aquarium.
2. Describe how fish use their different fins to move forward, up, down, slow down, turn, and stop.
3. Design models to investigate how some fin types function to stabilize fish.
4. Identify the following parts of a fish: dorsal fin, spines, rays, adipose fin, caudal fin, anal fin, pelvic fins, and pectoral fins.
5. Describe at least one function for each of these parts: dorsal fin, spines, rays, caudal fin, anal fin, pelvic fins, and pectoral fins.

Materials

Part 1: Watching Fish

- Several common objects of different shapes, such as a ball, wheel, bowl, shovel, umbrella (see Warm-up)
- Several illustrations or specimens of different plant and animal parts, such as a beaver's tail, giraffe's neck, cactus spines (see Warm-up)
- Class aquarium and fish; minnows require cold, well-oxygenated water; beta fish or goldfish work well (If live animals aren't allowed in your classroom, you could plan a trip to a pet store or aquarium so that students can observe fish movements.)
- Six- or eight-ounce capacity wide-mouth glass jars, one for each group of four or five students (wide-mouth jars provide more surface area, which keeps water oxygenated longer)
- Small fish net
- 8.5" x 11" images of fish from the *MinnAqua Leader's Guide* CD, or a variety of fish illustrations cut from sports and fishing magazines, or the video programs *Bigmouth* or *Bigmouth Forever*, available through the Minnesota DNR MinnAqua Program
- Notebook, one for each student
- Pencil or pen

continued

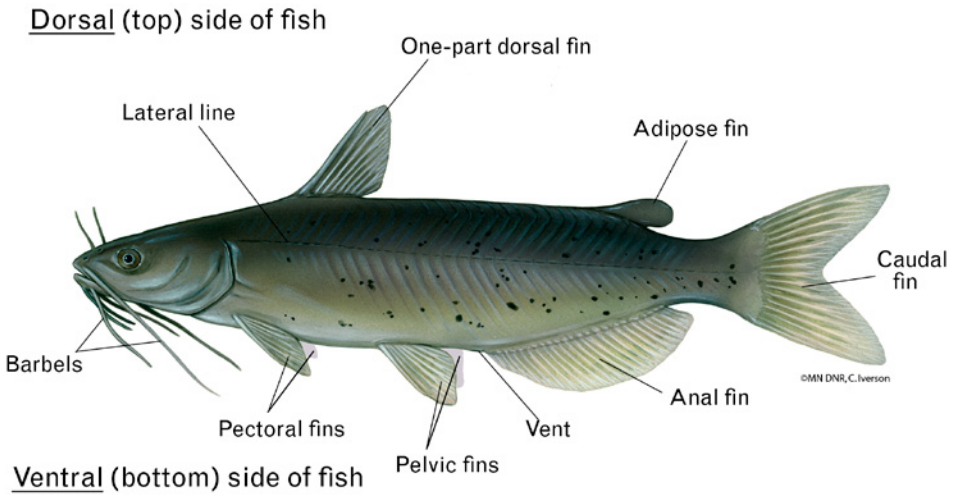
between form and function exists in the natural world, but it also pertains to things people invent and construct. A beaver's flat tail helps it steer as it swims, a duck's webbed feet helps it swim, the streamlined shape of a submarine moves easily through water, and an umbrella opens to form a wide, rounded surface that sheds water and protects its user from rain.

By observing and studying the different body parts of a fish you'll learn how the fish's body functions, why it is able to live where it does, and how it is able to capture food. One means of studying structures is to make models that, when tested under a variety of conditions, offer explanations for how the parts function and why they behave as they do. Models can be used to investigate how different types of fish fins enable various fish species to survive in their environments.

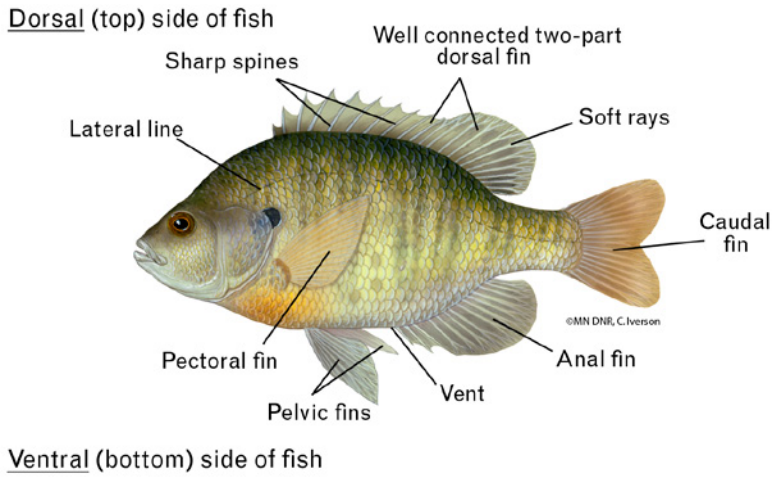
> Making observations using models is one way to look at the world as scientists do. Scientists study the world by making observations, posing questions, making predictions, designing experiments, gathering data, interpreting data, and sharing their results with others. This is how scientific knowledge about the world is continuously supported, refined, or challenged.

Fin Function Follows Form

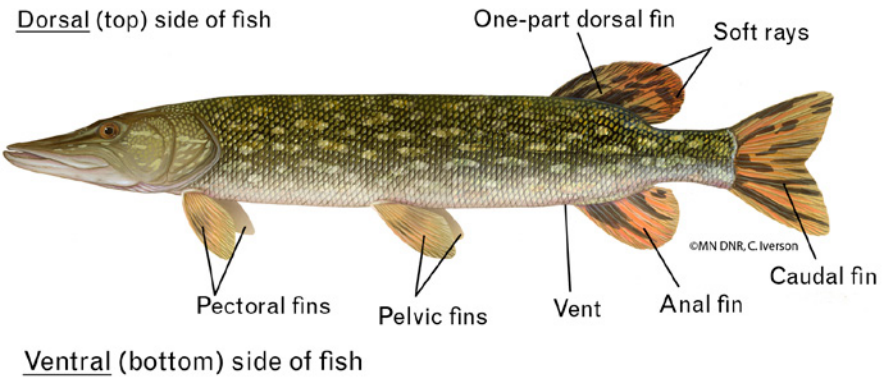
Taking a closer look at fins provides the opportunity to see that different body parts are **adapted,** or have special features that specifically function to help a fish survive in aquatic environments. Almost all fish have fins that they use for swimming (locomotion), balance, stability, and steering.



A catfish has dorsal, adipose, caudal, anal, paired pelvic, and paired pectoral fins.



Unlike a catfish, a bluegill lacks an adipose fin. A bluegill does have a large, two-part dorsal fin.



A northern pike lacks an adipose fin. Its one-part dorsal fin is located near its caudal fin.

Fin Structure

Fins consist of a membrane supported by rod-shaped structures called **rays** and **spines**. Rays are soft, flexible fin supports; spines are rays that are stiff and sharp. Spines in the dorsal fin can be used to raise the dorsal fin high enough to make the fish appear larger and less appetizing to a predator. Sharp spines can stick in the mouths and throats of predators. Small and medium-sized fish, such as those in the sunfish and catfish families, have well-developed spines that protect them from larger predators. However, some very small fish, such as gobies and sculpins, have spines that are as soft and pliable as rays, and minnows have no spines at all. These small fish spend much of their time camouflaged and hiding in tight spaces under logs and rocks.

Types of Fins

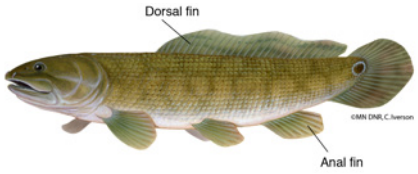
Dorsal and Anal Fins

A fish's dorsal and anal fins aid in turning, and serve to keep the fish upright (or prevent it from rolling over) in the water during sudden direction changes. The **dorsal fin** is located on the top of a fish, along

Materials (continued)

Part 2: Models

- Round plastic bottles, such as gallon juice bottles or one-or two-liter pop bottles, with caps, one per student (students can bring these from home; different sizes and shapes represent different types of fish bodies: long, round bottles represent northern pike or stream trout; shorter bottles represent perch or sunfish)
- One plastic bottle with flat sides, such as a half-gallon or gallon milk bottle, or flat plastic lids for cutting out fin shapes, two or three per student
- Sturdy scissors, two pairs for each group of four or five students
- Hot glue gun or roll of duct tape, one for each group of four or five students
- String, one six-foot length for each group of four or five students
- Gravel, sand, or water for filling fish models, as needed
- One large tub of water or a children's wading pool filled with water (or take class to a nearby swimming pool or lake pier to test models)
- Whiteboard
- Whiteboard markers
- **Fish Fins Sheet**, one per student
- **Fins: Form and Function Sheet**, one per student
- Pencil or pen

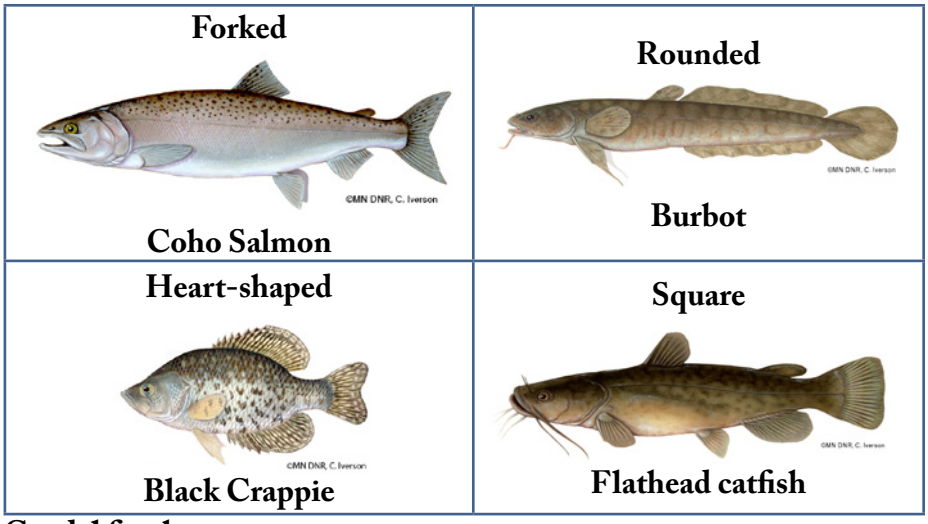


The bowfin (*Amia calva*) is also known as dogfish.

its back and between its head and tail. It may be a single fin, with or without spines, or consist of two connected or unconnected parts—a sharp-spined part and a soft-rayed part. The **anal fin** is located on the underside (or ventral portion) of a fish between the tail and pelvic fins, near the anus or vent. The anal fin provides stability, functioning like a keel on the bottom of a boat. Deep-bodied or laterally compressed fishes like the sunfish require greater stability to help keep them upright in the water, and generally have longer dorsal and anal fins. Dorsal and anal fins also tend to be long on eel-like fishes (such as the bowfin, burbot, and American eel), where they work in a sinuous fashion to assist the fish in swimming.

Caudal Fin

The **caudal fin**, or tail fin, is located at the end of the fish and provides the power that propels the fish forward, like a motor. It also acts as a rudder to assist in steering. Caudal fins come in varying shapes and can be forked, rounded, heart-shaped, or square.



Caudal fin shapes.

The shapes of caudal fins tend to correspond to the cruising speed of fishes. Fish that require speed or continuous movement, such as r**over-predators** (fish that spend much of their time cruising and searching for prey, including lake trout and channel catfish), typically have forked caudal fins. A forked caudal fin has less drag than a rounded or squared caudal fin. When the fish locates a potential meal, quick flicks of the forked caudal fin provide a sudden burst of speed, enabling the predator to overtake and capture its prey. **Lie-in-wait predators** also capture their prey with a sudden burst of speed, but instead of cruising to seek prey, they remain still, mimicking a stick or log (like the longnosed gar), or lying hidden in cover (like the muskellunge and northern pike). These fish lie still, wait for unsuspecting prey to swim nearby, and dart out to ambush it. Lie-in-wait predators have torpedo-shaped bodies with large caudal fins. Their dorsal and anal fins are typically located toward the backs of their long bodies, close to a large caudal fin. All of these fins work together to propel the fish forward with a burst of power.

Within a family of fish, the species with deeply-forked caudal fins move the fastest. Within the catfish family, for example, the channel catfish has a deeply-forked caudal fin and swims faster than the flathead catfish, which has a square caudal fin. Slower yet is the yellow bullhead, which has a rounded caudal fin. Deeply forked caudal fins enable speed in water because they generate less drag, or resistance, than other types of caudal fins. Similarly, square caudal fins with pointed tips are more efficient than rounded caudal fins..

A forked caudal fin allows a channel catfish to swim quickly.

A flathead catfish moves less quickly with its square caudal fin.

A rounded caudal fin makes the yellow bullhead the least speedy of these fish.

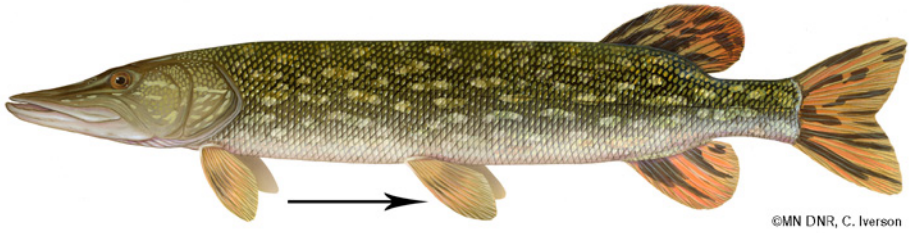
Most Minnesota fish are bony fish with homocercal tails, meaning that the upper and lower tail lobes are the same size. The sturgeon has a heterocercal caudal fin—the upper lobe is larger and longer than the lower lobe, resembling a shark's tailfin.

The lake sturgeon has a heterocercal caudal fin.

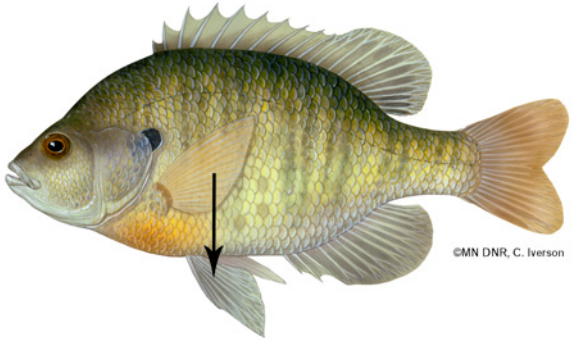
Pelvic and Pectoral Fins

Pelvic and pectoral fins are usually paired, allowing a fish to fine-tune its movements. **Pelvic fins,** located on the bottom of the fish in front of the anal fin, help balance the fish, keep it level, and prevent it from rolling from side to side. Fish sometimes rest by sitting on their pelvic fins. The **pectoral fins**, located on either side of the fish near the gills, do everything that pelvic fins do, and also help steer and control depth. Soft-rayed fish (pike, trout, and minnows) have pelvic and pectoral fins separated widely on their bodies. Both sets of fins are attached more-or-less horizontally, like wings on an aircraft.

Other fish, like most deep-bodied or laterally compressed panfish (sunfish, bass, and crappie), have pelvic and pectoral fins located closer together vertical to one another, with the pectoral fins higher on their sides close to the gill covers, and the pelvic fins below the pectoral fins on the bottom of the fish. Both fin pairs are closer to the fish's center of gravity, and provide maneuverability. The pectoral fins of these fish are attached to their bodies vertically rather than horizontally compared to the pelvic fins and often have a "wrist-like" function. This adaptation allows greater maneuverability through a variety of habitats. For a bluegill, which often lives in dense vegetation, the paired fins aid in moving between stalks, and in remaining stationary to pick insects off of plants.



Pectoral and pelvic fins of a northern pike, a lie-in-wait predator, are oriented horizontally.



The pectoral and pelvic fins of a bluegill sunfish, a panfish, are oriented vertically.

Adipose Fins

Fish in the salmon and catfish families have an **adipose fin** between their dorsal and tail fins. Adipose (or fat) fins have no spines or rays, and they're soft and fleshy, like an ear lobe. The function of the adipose

fin is being studied by biologists. Experiments suggest that the adipose fin helps reduce drag and controls vortices, that is, improves swimming efficiency.

The adipose fin of a lake trout.

Procedure

Preparation

Part 1: Fish Watching

1. Collect a set of everyday objects and photos or specimens of plant and animal parts with varied shapes and functions. Some suggestions include: a ball (rolls and bounces), wheel (rolls), bowl (holds objects), shovel (scoops and digs), and umbrella (sheds rain). You also could also find specimens or photos of: cactus spines (which discourages animals from eating it), the flat tail of a beaver (helps the beaver steer as it swims and is used to create loud slapping sounds on the water if frightened by a predator), the long neck of a giraffe (helps it reach food in high places), a lion's teeth (holding, tearing, and eating prey), a Venus fly trap plant (catches insects), a duck's webbed feet (swimming), a bird's wings (flying).
2. Set up a classroom aquarium with fish or display fish identification posters, 8.5" x 11" fish illustrations, or photos of Minnesota fish cut from sports magazines. (Or show the video programs *Bigmouth or Bigmouth Forever*.) It's permissible for instructors to set up aquariums containing native Minnesota fish if a permit for education tanks is obtained. Contact the Minnesota DNR Central Office, 651-296-3327, for details and requirements for education permits for school aquariums.
3. Fill the wide-mouth glass jars with water from the aquarium. Using a small net, to transfer one fish from the aquarium to each jar.)
4. For each student, copy one **Fins: Form and Function Sheet** and one **Fish Fins Sheet.**
5. Each student should have a notebook and a pen or pencil.

It's illegal to release aquarium fish into any water body in Minnesota. Fish released from aquariums can carry fish diseases or spread through lakes, streams, or rivers.

It may be difficult for students to make the initial cuts into the plastic bottles and to cut through the rims of the plastic lids they're using to make fish fins. Keep an eye on the cutting, and be ready to assist if necessary.

The activity in Part 1, observing and recording observations of how a fish swims and uses its fins, can work well as part of a classroom learning center. A fish parts-themed learning center, for example, can be set up as a series of large or small stations with hands-on, open-ended, or interactive learning materials containing a variety of resources and activities relating to fish and external features of fish. Some stations could support different learning styles; others could enhance different teaching methods. Still others could provide opportunities to practice skills learned in the unit or address current issues related to the topic. Students can work in cooperative learning groups and rotate through the stations, or visit them throughout the unit as assignments are completed. The learning center creates a backdrop for the topic that the class is working on, and stimulates interest and questions throughout the duration of the unit.

Part 2: Models

1. Each student needs two plastic bottles (one round bottle with a cap, and another bottle with flat sides) or one round bottle and two or three flat plastic lids, a sturdy pair of scissors, and duct tape or a hot glue gun. (Assist the students as they use hot glue guns.)
2. Before the lesson, you may wish to cut and remove the necks of the flat-sided bottles so that the students won't stab their scissors into the bottles as they try to cut out fins.
3. You'll need a large tub, wading pool, or a children's water table filled with water or access to a nearby swimming pool, pond, or lake so that the class can test the models. The tub or pool can be placed outdoors or, if feasible, in the classroom.

Activity

Warm-up

1. Explain to students that the shape or structure of an object can tell us something about what it does. Hold up the various everyday objects or tools (or pictures of tools) and ask students what each is used for, or how to figure out how the object functions by considering its shape.
2. The shape of objects in nature can tell us something about how a plant or animal functions, too. Show pictures or specimens such as the objects from nature mentioned in the Materials List. Ask students if they can figure out how the organism or the part of the organism functions. Explain that, generally, the form or shape of an object is related to how the object functions.

Lesson

Part 1: Watching Fish

1. Tell students fish have unique parts that help them survive in their habitats. Observing the parts of a fish will help us figure out some interesting things about it. We can learn how a fish moves, how it might behave, why it lives where it does, or what it might eat. This information can be quite helpful if you plan to go fishing!
2. Divide the students into teams of four or five. Give each group one jar with a fish from the aquarium. If you have no classroom aquarium, visit a local pet store. Or students can record observations from fish illustrations (fish images from the *MinnAqua Leader's Guide* CD printed on 8.5" x 11" sheets, fish identification posters, or fish photos cut from magazines), or from the video programs *Bigmouth* or *Bigmouth Forever*, which are available for checkout from the Minnesota DNR MinnAqua Program.
3. Tell students they will be working in groups and observing how a fish moves in water. They will record their observations in their notebooks so they can use their notes to help them design fish models later. Ask students to think about the shapes and positions of the different fins as they watch how the fins work. They should record their observations in their notebooks and include:

- written observations about how the fish moves up, down, forward, or backward, and how it turns, stops, and remains still
- drawings and descriptions of the different fins
- explanations of what the different fins seem to do

4 What other animals move in water? Do they have features that work like fins? How do these features move? In this discussion, you can introduce the concept of human movement (such as people swimming) and any personal experiences can be discussed. Can students remember what kind of hand, foot, and body motions they made to start, stop, change direction, or move up and down in the water?

5 Ask students about the way fins look—why do fins have flat, thin webbing, firm rays, and stiff spines? Ask students to discuss how some fish parts are quite different from human body parts. Which parts help a fish move in its watery environment? Why is movement important? (Fish move to get their food, to get away from other fish that might eat them, to seek shelter, and so forth.) Summarize the discussion by talking about how fins help fish survive in their watery environments. Tell students that the features and characteristics they've listed, including fins, are called adaptations. Define adaptation (a characteristic that helps an organism to survive in its environment); have students write the definition in their notebooks.

- Ask students to write a description in their notebooks of how the various fins of the fish they observed would be considered adaptations (how they function to help the fish survive where it lives). Have them sketch their fish, paying close attention to the shape and location of each fin.

Part 2: Models

1 In the classroom, draw the outline of a generic fish (football shape) on the whiteboard.

2 Give each student a **Fins: Form and Function Sheet**.

3 Remind students that each part of the fish has a specific function. Now they will learn more about the fins of a fish. They will have noticed from observing fish that fins consist of membranes supported by rod-shaped structures called rays and spines. Rays are soft and flexible and spines are rigid and sharp. Fish have different kinds of fins.

4 One feature at a time, draw a fin (dorsal fin, spines and rays, tail fin, adipose fin, anal fin, pectoral fins, pelvic fins) on the fish body outline on the whiteboard and label each fin.

5 Have students label the parts on their own fish diagrams as they follow along.

6 Expand the discussion—distribute a **Fish Fins Sheet** to each student, and draw examples of different species of fish on the board (or use illustrations of fish) so the students can see how fin characteristics and arrangements vary among different species. Discuss and compare the functions and how they may benefit the

The students may not be familiar with the names of the different types of fins yet. Observing the fish lets them discover the function of the different fins on their own, before learning the names of the fins.

You can obtain a few fish from the grocery store or fish market and have the students look at the fins and other features.

different types of fish. For example, draw a two-part connected dorsal fin (bluegill). Next, draw a longer, narrower fish shape with a smaller one-part, soft-rayed dorsal fin located back near the tail (as in the pike family). Discuss how this location of the dorsal fin gives a muskellunge or northern pike the ability to quickly propel itself forward through the water to catch its prey. All the power is in the back, like a motor on a boat. On soft-rayed fishes, like the pike and trout/salmon families, pelvic fins are located far back on the body. On spiny-rayed fishes, like the bluegill and perch families, pelvic fins are moved forward underneath vertically oriented pecotral fins. This arrangement may increase manueverability in short-bodied species such as bluegill.

7 Remind students that members of the catfish and salmon family (including trout) have an adipose fin. Other Minnesota fish don't have adipose fins.

8 Students should label the following parts on the fish diagram on the **Fins: Form and Function Sheet**: dorsal fin, spines, rays, adipose fin, caudal (tail) fin, anal fin, pelvic fins, pectoral fins. The functions of the fin types should also be noted on the sheet. The diagrams can be kept in students' notebooks.

9 Option: Find illustrations of the types of fish that live in your local water body. Have students identify the fins and discuss their shapes and forms with a partner.

Using What You Know to Make Models

1 Students will make a static model to test how static fins may contribute to the movement of a fish. Tell students that making models is one method that scientists use to study different structures. Tell students that they'll make models to test how different fins work in water. Models simulate real objects or events and, when tested and used in experiments, they can provide data resulting in scientific explanations for how objects function and behave.

2 The fin shapes can be cut either from the bottle with flat sides (the neck should be removed in advance) or from the flat plastic lids. The round bottle will serve as the model fish's body, to which the fins will be attached. In groups, have students use a permanent marker to draw four to six fins of different shapes and sizes on the plastic bottle or on the flat plastic lids. Cut out the fins. Remind students to think about how the fin's design will fit its function. What "jobs" do these fins have to perform? (Propelling the fish forward, stabilizing the fish in the water, helping it move up, down, backwards, and helping it turn or stop). The different fin shapes and sizes should reflect the form of an actual fish to simulate how it would function in the real world.

3 Tell students to keep the following in mind when making and testing their models:

- In order to provide accurate information about how the fins of real fish work, the models should resemble real fish and fins as

Students may have trouble cutting out fin shapes without first drawing fin designs on a sheet of paper to get a size and shape that is proportional to the body size of their model. When they have drawn fin shapes that please them, they can cut them out and use them as templates for making the four to six plastic fins for their models.

much as possible.

- It will be helpful for students to refer to their notes from observing fish parts, from studying illustrations, or from watching the video program in Part 1 while making their models. Do they remember how the fins on the real fish looked?
- Their teamwork skills will be evaluated as they work within their groups to design, create, and test their fish models.
- It's important to record their observations of how the different fish models work in the water so they can use their team's best fin designs to make their final model.
- As they design their final model, they should think about what their fish needs. Does it need to be more stable in the water? Does it need to turn quickly and make sharp turns in vegetation? Does it need to speed to propel it through the water? How do the shape and placement of fins on the body affect these abilities?
- The students will design two or three different models as a group to compare various shapes and designs of fins, saving two bottles to use for a final model that incorporates all of their best designs. This final model can be tested in a local stream or lake to gauge its stability and how it moves in the water.

4 As they finish cutting out their fins, have each group (one at a time) bring one of their capped, intact plastic bottles with no fins attached to the pool or tub of water and place it in the water. Have students blow on the bottle to see how it moves and spins. Remind students to record their observations in their notebooks.

5 Each team can work together to design two or three different models to compare. In these groups, students should choose a different size and shape of fin to attach to their intact bottles to form an anal fin, which acts like a keel on the underside of a boat. The groups should mark where they want to attach their fins on the bottles. Help students attach the fins with duct tape, a glue gun, or by cutting a slit in the bottle and plugging any leaks in the bottle. If they cut a slit in the bottle, they should secure the fin to the bottle with a water-resistant glue or duct tape that also seals the slit around the fin.

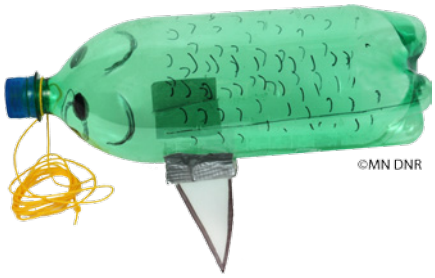
6 As the anal fins are secured, one group at a time should go to the tub or pool, place its model in the water, and blow on the it to see how the model with the anal fin moves. Students should record their observations, comparing how the different models move and speculating why the different models look or behave the way they do in the water. The bottles may tip to one side or the other in the water—ask students what would give tip-prone models more stability in the water. They may say they need two more fins, one on each side of the model, or one more fin facing another direction.

7 Have the groups modify their models with another fin attached to the end or bottom of the bottle like a tail fin (or caudal fin) to act as a rudder. They can choose to attach it straight or at an angle facing to the left or right. Which fin shape and orientation—vertical or

A plastic bottle fish with an anal fin.

A plastic bottle fish with a caudal (tail) fin.

horizontal—would make a good rudder? (Vertical, as illustrated.) Help students use the glue gun or duct tape or help them cut slits. As each group secures the tail fins to their bottles, have them test their models in the tub or pool of water. Partially fill the bottles with gravel or water to evenly submerge the bottle so that its tail is underwater. Blow on the models and record observations on their movement. The group members should observe and compare the function of the various tail fins on the models. Students should draw the models with the anal and tail fins they designed, recording in their notebooks the observations and explanations for what they observe.



A plastic bottle fish with two pectoral fins--one is not visible.

8 Empty the bottles and have students attach two more plastic fins to opposite sides of the bottles like pectoral fins. Ask students to consider the fin size they might require, and how these fins should be oriented on the fish's body—vertically, horizontally, or angled. Partially fill the bottles with enough gravel or water to partially submerge them so the fins are underwater. Blow on the models and record observations about their movements. Have students test, observe, and compare how their fish models function in the water. What function do the pectoral fins seem to serve? Did it make a difference if the pectoral fins were placed vertically or horizontally on the body? Up near the gill cover or lower on the body?

9 In their groups, have students review the observations they recorded in their notebooks and decide which fin designs were the most stable and helped their fish models move most efficiently. They can then incorporate the best fin designs to make a final fish model for their group to test in a nearby stream or lake. (If this isn't possible, the student teams can test their final models in the tub or pool.) This time, the student groups may include dorsal fins and pelvic fins if they choose. They should identify the functions their fins must perform to allow their fish to swim effectively in water, and they should create the designs on paper first—specifying, for example, the size of the fins, the number of fins, and where and how the fins should be placed on the fish. A group recorder can list the various functions of the different fins and draw the corresponding design features. Have the groups make their final fish model from their completed design.

10 Have each group attach a six-foot length of string to the bottle cover after partially filling the bottle with water or gravel to submerge—but not sink—the model and all of its fins during the test. Test each model in a nearby water body by holding the model by its string and placing it in the current of a stream or pulling it through the shallow water of a lake.

11 Back in the classroom, ask students to record in their notebooks their observations on how their models functioned. You may also ask them to identify the types of fish with a forms similar to the their designs. Have students draw their group's final design in their notebooks. Label the drawing to reflect the functions the fins performed.

Always use caution near water. Set boundaries for students. Test models in shallow water.

Wrap-up

1. In their notebooks, have students write a concluding paragraph for this lesson, explaining which aspects of the fins they designed for their models were effective, and how fins help a fish survive in its environment. Did their models imitate the functions of real fish fins? (A real fish can move its fins.) What didn't work? What could have worked better? Students should consider fin size, shape, placement on the model body, and the concept that different fins work together to stabilize the model. They should use the names of the fin types in their descriptions.
2. Ask students to remember the function of each type of fin they described in their notebooks while observing the fish, and to describe the functions for each type of fin listed on the diagram on their **Fins: Form and Function Sheet**. As students complete the descriptions of how each fin type functions, guide the discussion to ensure that they list the correct functions of the fins.
3. Have student groups present their findings and results on how their models performed in the water. Have them explain why their fins functioned effectively, or how they would change the shape or location of the fins to improve how the model moves in the water.

Assessment Options

1. Assess each group's models using the following parameters:
   - The models should resemble real fish and fins as closely as possible.
   - Did students refer to their notebooks and to earlier notes from observing fish parts, studying illustrations, or viewing the video program (during Part 1) while making the models?
   - Did they work cooperatively in teams to design, create, and test their fish models?
   - Did they carefully and thoroughly record in their notebooks their observations of how the different fish models worked in the water? Did they use the best fin designs from their team for their final model?
   - As they designed their final model, did they consider the needs of their fish? (Does it need great stability in the water? Does it need to make fast, sharp turns? Does it need to swim through the water quickly?) Do the models reflect deliberate thought on how the shape and placement of fins affect these abilities? Did students consider how different fins could work together to perform a particular function such as providing stability or maneuverability?
2. Review student notebooks. Do the fish illustrations have fins drawn and labeled accurately? Are the functions of each fin type described?
3. Have students verbally explain fin functions and how their models function. Ask them to state two reasons why scientists use models in experiments. Ask them to describe how replacing the fins on their models with different-shaped fins would affect their model's performance in the water.
4. Assessment options include the Checklist and Rubric on the following pages.

Fins: Form and Function Checklist

Possible Points	Points Earned Student	Points Earned Instructor	
3	_____	_____	Student observes fish and watched fin movement for clues as to how fins help fish move in water.
3	_____	_____	Student neatly and accurately records observations of aquarium fish.
5	_____	_____	Student identifies all five fish fin types, including tail fin, dorsal fin, pectoral fins, pelvic fin, and anal fin.
5	_____	_____	Student describes shape and location of fins on fish.
5	_____	_____	Student describes how each type of fin helps a fish move through water.
4	_____	_____	Students contributed to design and creation of fish model.
3	_____	_____	Student worked cooperatively in the group.
4	_____	_____	Student neatly and accurately records observations of how models worked during testing.
4	_____	_____	Student records model-testing results for both fin location and fin shape were recorded.
2	_____	_____	Student explains two reasons why scientists use models in experiments about organisms.
Total Points			
38	_____	_____	**Score** _____

Checklists are tools for students and instructors. Checklists involve students in managing their own learning. They help students understand and set learning goals before the lesson begins, and help them monitor their progress during the lesson, ensuring that they meet learning goals and objectives by the end of the lesson. Students can also use checklists to discover areas that may need improvement. Checklists help instructors monitor each student's progress throughout the lesson, facilitating appropriate adjustment of instruction to ensure learning by the end of the lesson. The instructor may wish to have students add several of their own learning goals to the checklist to personalize it, and to accommodate varied learning needs and styles.

Grade

35-38 points = A
Excellent. Work is above expectations.

31-34 points = B
Good. Work meets expectations.

24-30 points = C
Work is generally good. Some areas are better developed than others.

18-23 points = D
Work does not meet expectations; it's not clear that student understands objectives.

0-17 points = F
Work is unacceptable.

Fins: Form and Function Scoring Rubric

Models Criteria	3 Excellent	2 Good	1 Fair	0 Unacceptable
Observation of fish in aquarium	Observes fish and watched fin movement for clues as to how fins help fish move in water. Observations neatly and accurately recorded.	Observes fish and watched fin movement for clues as to how fins help fish move in water. Observations weren't clearly recorded.	Observes fish, but didn't watch fin movement for clues as to how fins help fish move in water. Observations inaccurately recorded.	Observes fish. Didn't record observations.
Fin identification	Identifies all fish fin types, including tail fin, dorsal fin, pectoral fins, pelvic fin, and anal fin.	Identifies four fish fin types.	Identifies three fish fin types.	Can't identify fish fin types.
Fin form and function	Describes shape and location of fish fins and how each fin type helps a fish move through water, for example, a tail fin acts as rudder and propeller.	Describes shape and location of at least three types of fish fins and how each fin type helps a fish move through water, for example, a tail fin acts as rudder and propeller.	Describes shape and location of fish fins, but not how each fin type helps a fish move through water, for example, a tail fin acts as rudder and propeller.	Can't describe shape or location of fish fins or how each fin type helps a fish move through water.
Design contributions	Contributes to design and creation of fish model. Works cooperatively in the group.	Contributes to design and creation of fish model. Works cooperatively in the group with occasional correction from instructor.	Doesn't contribute as much as others to design and creation of fish model. Doesn't work cooperatively in the group.	Doesn't contribute to design and creation of fish model.
Experiment observations	Records observations on how models worked during testing. Records results for both fin location and shape.	Records observations on how models worked during testing. Records results for either fin shape or fin location	Records observations on how models worked during testing. Results not specific for either fin location or shape.	Didn't record observations on how models worked during testing.

Score _____ (Calculate score by dividing total points by number of criteria.)

Diving Deeper

Extensions

1. Dissect a fish. Use a large fish specimen—obtained from the fresh fish counter at a grocery store, a fish used in **Lesson 2:1—Fish Sense**, or a fish that you have caught—for this demonstration. Go over the external parts and their functions. Dissect the fish to show the internal anatomy and discuss functions of internal parts, including physiology of the circulatory, nervous, digestive, and reproductive systems. (See the **Fish Anatomy Sheet** in **Lesson 2:1—Fish Sense**. Fish anatomy models are also available from science supply catalogs.)
2. Students can research the behaviors—including reproduction, spawning, schooling, and migration—that help fish species survive in particular environmental conditions. Have students list or discuss the features (or physical adaptations) that help the fish perform each behavior.
3. Have students research the functions of other parts of a fish, including gills, scales, vent, nostrils, barbels, operculum, slime, and lateral line.
4. Instead of making models with plastic bottles and testing them in water, you can adapt this lesson by having students create model fish from cardboard paper towel and toilet paper tubes. The longer tubes can be bodies of longer fish like northern pike and gar. The shorter tubes can represent the bodies of fish like sunfish and bass. Have the students design and cut fin shapes from tagboard or cardboard from things like cereal boxes. Remind students to add a tab on the end of each fin to use to attach the fin to the body. Squeeze the back end of the tubes vertically around the tail fin and staple or tape them shut. Trim edges of tube around tail. On the front end of the tube, cut a one and one-half-inch slit towards the middle of the tube on the top (dorsal) side and on the bottom (ventral) side. Squeeze the front ends of the tubes together, overlapping the cut sides of the slits to form an oval shape at the front. Use masking tape or staple these overlapped slits to make the mouth of the fish. Attach the rest of the fins using glue or tape. Have the students paint their fish, using tempera paint mixed on plastic ice-cream bucket covers, adding details such as eyes, gills, and scales. Stand the fish on their nose ends to dry. After drying, attach wiggly eyes. Have students explain the function of the fins on their fish models. Display the fish by hanging them from the ceiling, or by creating an "underwater" display in a glass display case in the school hallway. Hang the fish using clear monofilament line; add vegetation, driftwood, rocks, and other details. Lily pads "floating on the surface" on a glass shelf in the case are a nice touch!
5. Have students make a fish model out of a smashed pop can. You'll need one empty aluminum soda can for each student, silk flower petals or leaves, scissors, wiggly eyes, glue (527 Bond or other craft

A smashed can fish.

glue), small paintbrushes for detail work, acrylic spray-paint in colors that match the body colors of the fish you're making (dark green, gray, white, bluish-gray, brown), bottled acrylic paint in a spectrum of colors for stripes, spots, and gills. (Metallic acrylic paint gives the fish a slight shimmer.) Rinse the cans and let them dry. Flatten each can at an angle, so that the top and bottom of the can aren't directly on top of each other. Squeeze the can by hand to start the flattening process. The entire bottom of the can should be facing up when finished (it becomes the mouth), and the top of the can should crunch to the side, completely behind the body. Finish the flattening process by stepping on the can. (Wear shoes!) Paint the can. Spray a base coat of body color on the front of the fish (the "mouth" end, or bottom of the can facing up). If making a largemouth bass you could use green, for example. Allow the can to dry, then flip it over and spray-paint the back. Allow the can to dry. Spray additional colors (such as a lighter belly underneath) on the front side, if needed for the type of fish you're making. Allow the can to dry. Add finer details with the paintbrush. Paint the crunched round bottom of the can black. (This represents the open mouth of the fish.) Add a pink tongue. Paint fish scales, spots, gills, and any other details. Allow the can to dry. Make fins using silk flower petals or leaves. Some will already be an appropriate shape; others can be cut into the correct shapes. Fins may also be painted or drawn with acrylic paint or magic markers. Glue the fins to the can in the correct positions and let them dry. Glue on the wiggly eyes. Finish the back of the can. Attach a loop of string or wire for hanging, or glue a bamboo skewer on the bottom to display in a garden. You can also mount the smashed can fish on cardboard covered with black felt, and label the fins for a very finished look!

For the Small Fry

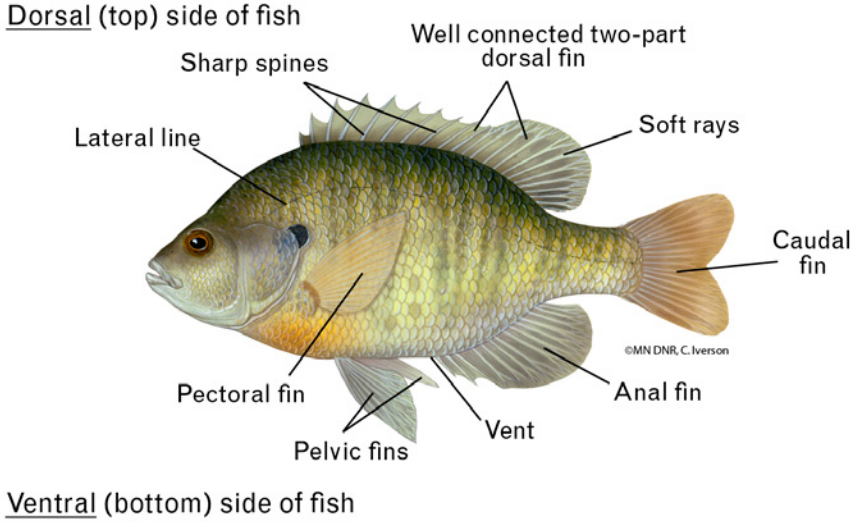
K-2 Option

1. Have the students observe fish in a classroom aquarium to look at the different parts of a fish. Then play a game of Pin the Part on the Fish. Draw and cut out pictures of the various external parts of a fish, laminate them, and attach a piece of tape or Velcro to the back of each piece. Have students "pin" the fish part on a large poster showing a generic (football-shaped) fish body. Compare the fish parts to the body parts of children. Ask the students to figure out how each part helps a fish survive in its water habitat. Students can then draw a fish, showing the parts that help it survive in water.
2. Construct a variety of fish models as described in the lesson. Allow the students to test the models in a classroom water table. Have the students talk about their observations and tape record or dictate them to an adult. Discuss why each model worked differently in the water. Follow up by having students construct their own fish with distinctive fins and describe how their fish's fins help it swim in the water.

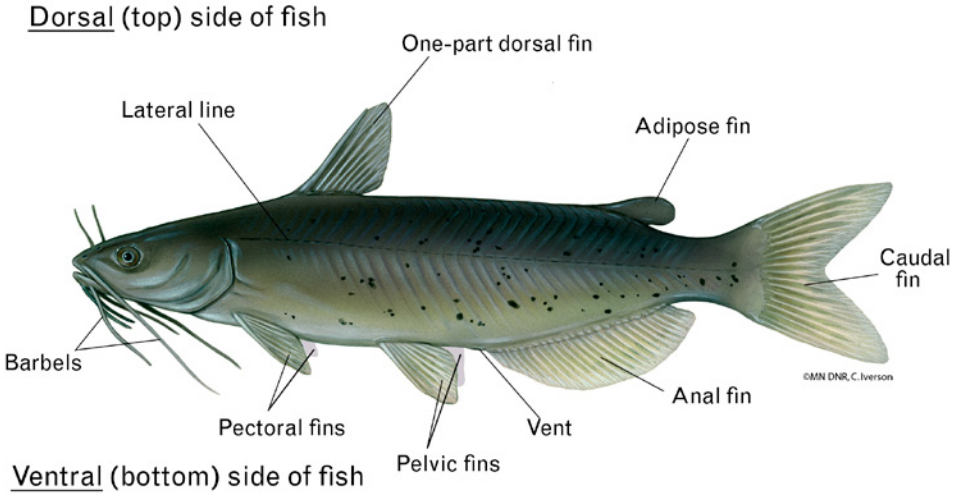
STUDENT COPY

Fish Fins Sheet

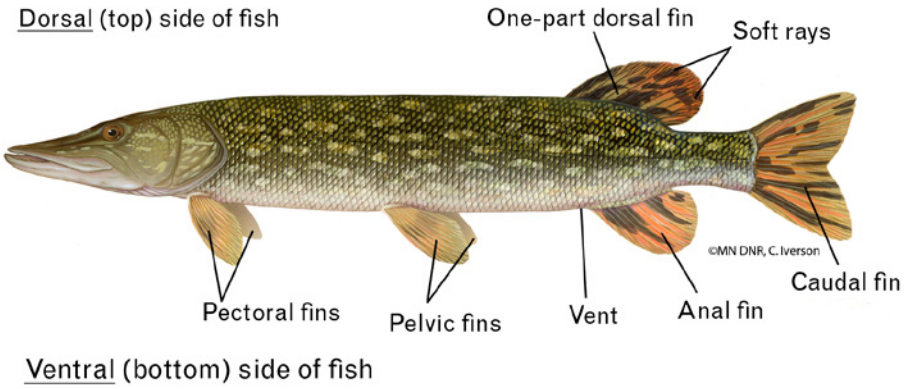
Sunfish Family: Panfish



Catfish Family: Rover predators



Pike Family: Lie-in-wait predators



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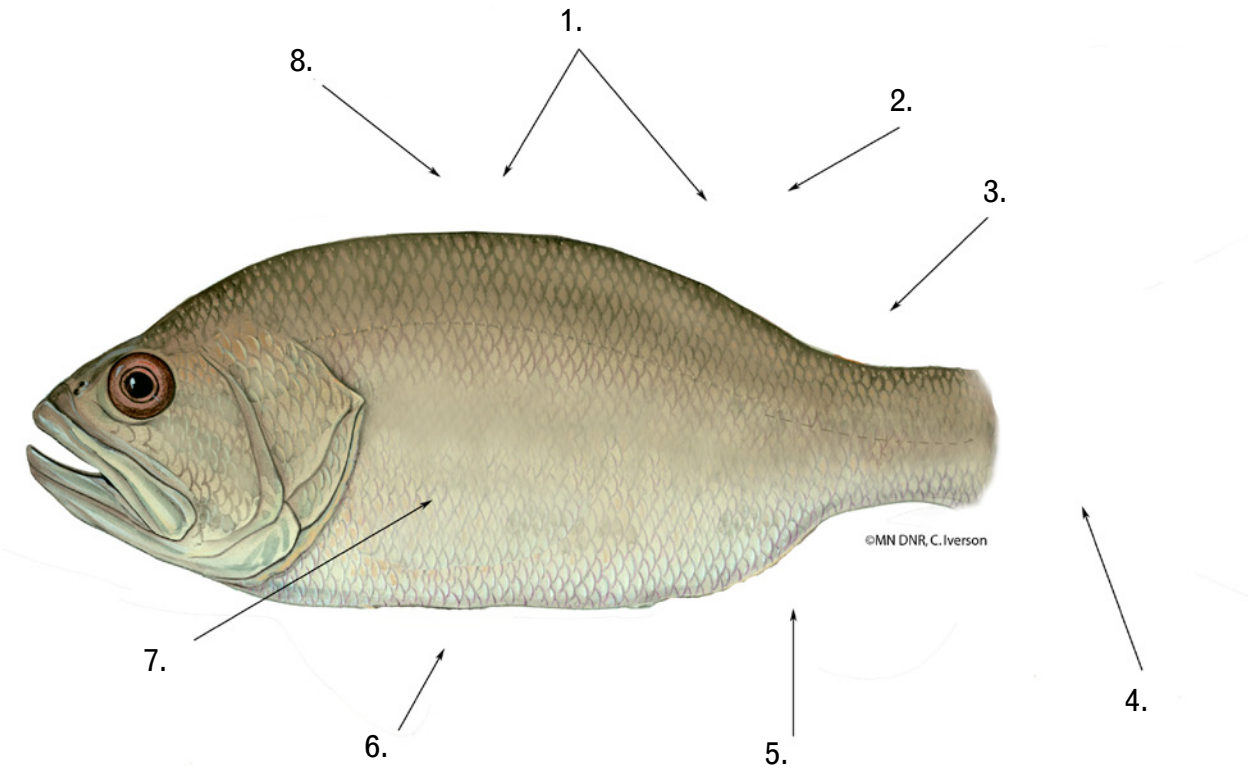
Name _____ Date _____

Fins: Form and Function Sheet

Draw and label the fins, spines, and rays on this fish shape.
Then complete the table to describe the function of the fins, spines, and rays.

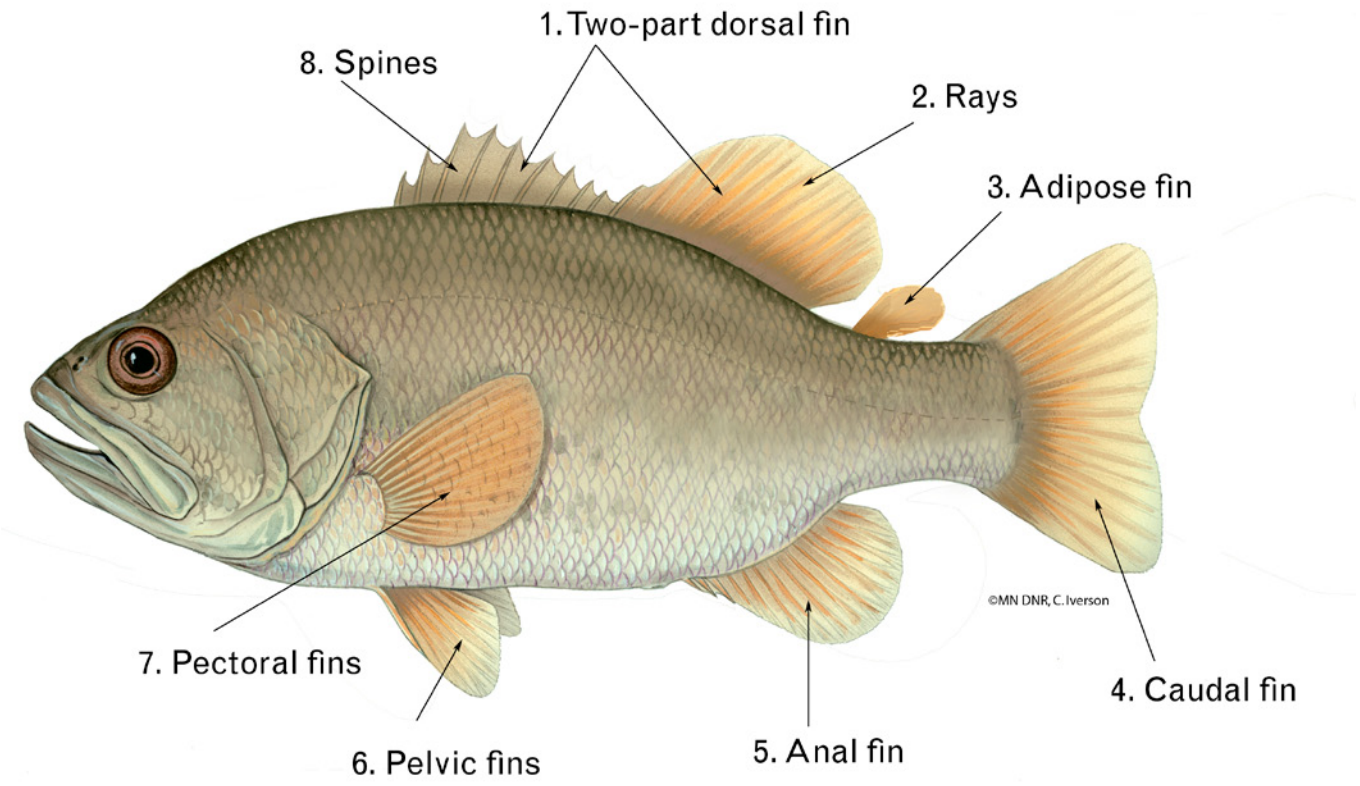


Fish Fins	Function
Caudal (tail) fin	
Dorsal fin	
Spines	
Pectoral fins	
Adipose fin (Salmon and catfish families)	
Anal fins	
Rays	
Pelvic fins	

INSTRUCTOR COPY

Fins: Form and Function Sheet Answer Key

Draw and label the fins, spines, and rays on this fish shape. Then complete the table to describe the function of the fins, spines, and rays.



Fish Fins	Function
1. Dorsal fin	Stability, defense that helps fish look bigger, help in steering
2. Rays	To support fins
3. Adipose fin (Salmon family and catfish families)	Reduces drag and improves swimming efficiency
4. Caudal (tail) fin	Steering like a rudder and propelling forward like a motor
5. Anal fins	Stability, help steer, and prevent rolling over in sharp turns
6. Pelvic fins	Balance, resting, and maneuverability.
7. Pectoral fins	Maneuverability, going up, down, backward, forward steering, and remaining still
8. Spines	Sharp protection and defense, to hold up dorsal fin to look bigger and more difficult to swallow, to support fins