Trout in the Classroom

Activity Guide

TROUT UNLIMITED

WILDLIFE & SPORT FISH RESTORATION

Trout in the Classroom Curriculum

Published by the Idaho Department of Fish and Game

Funding provided by Wildlife and Sport Fish Restoration

Writers/Editors

Adare Evans

Brenda Beckley

Elizabeth Crawford

Amy Parrish

Advisors and Contributors

Lori Adams

Sabrina Beus

Dave Cannamella

Joe Chapman

Jake Duplessie

Tom Frew

Annette Hanson

Kelton Hatch

Lauri Monnot

Carrie Prange

Richard Prange

Lorianne Riggin

Vicky Runnoe

Kris Albin-Stone

Activities modified and adapted from:

MinnAqua, Minnesota DNR

Nevada Department of Wildlife, TIC Program

Layout and Design

Kelly Kennedy Yokoyama

Table of Contents

Bold = highly recommended

Trout in the Classroom Journals

Summary

Students take time daily to observe and record details about their experiences raising trout.

Objectives

Students will...

- observe and record daily changes in the appearance and behavior of trout
- observe and record daily or weekly changes in water temperature and quality
- reflect upon the process of raising trout

Materials

- notebook or journal making materials
- copies of journal page master
- card stock or heavyweight paper for cover
- yarn or string for binding journal
- heavy hole punch
- colored pencils, pens, markers, watercolors, stickers, etc. to decorate journal covers

Background

A field journal is essential to any scientist's fieldwork. A journal is much more than a simple diary. Entries in a field journal draw heavily upon scientific information and data, but they are written in the first person and incorporate personal observations, feelings, questions and drawings. Field journals are a tool for recording what one sees, feels, hears and learns while conducting scientific work.

Field journals are personal and reflect a scientist's preferences and personality. Some scientists sketch simple pencil drawings while others paint colorful, detailed images. Some people record their observations in charts, lists and labels, while others write long, detailed descriptions. Encourage your students to try working with pens, pencils or watercolors to capture an image and to use many different recording methods to find their personal journaling style.

Procedure

1. First, introduce the idea of journaling and scientific journals to the class. This should start before the trout eggs arrive in the classroom, perhaps just as the tank is being set up.

Grade Level
k-12

Subject Areas
Language Arts, Science, Visual Arts

Time
Making Journals: 20 minutes or less

Recording Observations:
10-20 minutes daily

Vocabulary
adaptation, alevin, ammonia, behavior, behavioral adaptation, characteristic, coloration, competition, egg, eyed egg, fry, habitat, lateral line, nitrate, nitrite, observation, pH, structural adaptation, trait, yolk sac

2. Inform the students that they will be observing the growth of their trout as scientists would, by monitoring and recording water conditions, trout growth, trout health, trout behavior, and any other observable characteristics.

3. Have students create their own journals. Students may make covers for a bound book or use the following master to create their own journal. Run double-sided copies of the journal page and fold in half to create the internal pages. Fold an 8"x11" piece of card stock in half for the cover and place over internal pages. Punch three holes on the folded side of the journal. Thread ends of a string through the outside holes to the inside of the journal. Then thread both strings through the middle hole and tie on the outside of the book. Have students decorate the covers of their journals with drawings, stickers, etc.

4. Make journaling a regular event, whether it's daily, weekly, or something in between. Journal prompts can connect to a topic or theme of the day to help reinforce other lessons. Some ideas for prompts are below:

   - What is the temperature of the water?
   - What are the nitrate/nitrite/ammonia levels?
   - What is the water pH?
   - Is the water quality decreasing/increasing for fish? How do you know?
   - What are you looking forward to about having trout in the classroom?
   - Is the water level high/low?
   - Describe the characteristics of your trout.
   - Describe the trout eggs. What do they look like? What do you see inside the egg?
   -

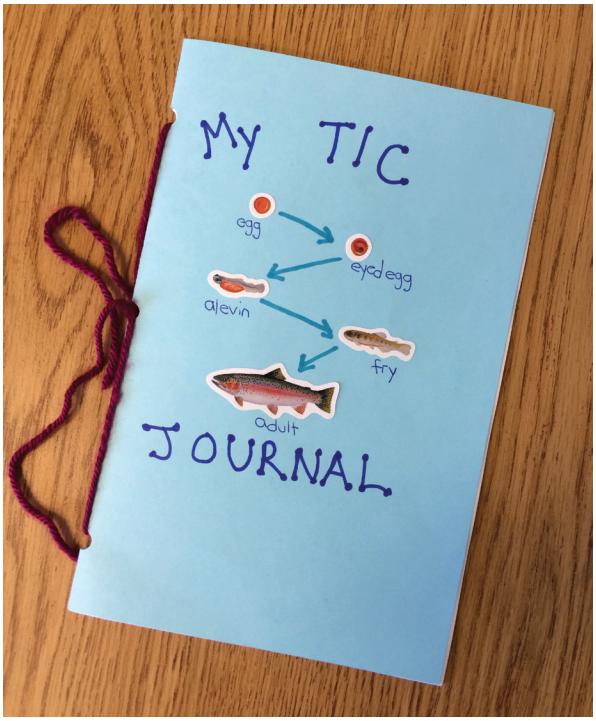
- Describe the alevin. What does the yolk sac look like? What does the yolk sac provide the alevin?
- What do alevin do when light shines on them? How might this help them in the wild?
- Describe the fry. What do they look like and how might this help them survive in the wild?
- What adaptations do you see that help your fish in their watery world?
- How are the fish moving? Do paired fins move together in the same way? What happens to the fish's fins when it is still?
- Observe one fish closely for one minute. Follow it with your eyes. What does it do?
- Do you see competition between the fish? Describe what you see.
- How do the fish act in the morning/afternoon?
- How do the trout act when it is light/dark in the tank?
- How do the trout act before feeding? After?
- What happens when you feed the trout? Why do you think this is happening?
- What color are the fish? Is the back color the same as the stomach? Why do you think it is this way?
- Is it easier to see a fish swimming near the top of the tank or near the bottom?
- Do you think fish have good eyesight? Why?
- Can fish "hear" or feel vibrations? How do you know?
- Are all the fish the same size? Explain why.
- Do some fish stay in established areas?
- How have the trout changed over the last few days/weeks?
- What are your predictions for the trout?
- Do you expect all to hatch/survive?
- What was the most important thing you learned about raising trout?
- What are some differences between the aquarium habitat and a natural habitat?
- What dangers would wild trout face?

5. Encourage students to draw pictures in their journals as well as writing text, but allow students to develop their journals in their own styles.

Evaluation

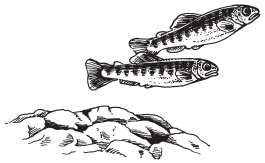
1. After releasing or right before releasing your trout, ask the students to look over their journals and pick a favorite entry or a few highlights to share with the class or a small group.

2. Have students choose one entry to expand and/or edit into a more formal essay or creative writing project complete with color illustrations.



Date: _____

Water Temperature: _____

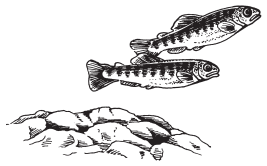


Test Results, Observations, Questions:

Sketches or Drawings:

Date: _____

Water Temperature: _____

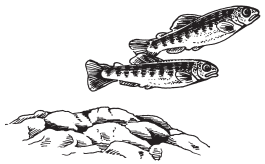


Test Results, Observations, Questions:

Sketches or Drawings:

Date: _____

Water Temperature: _____

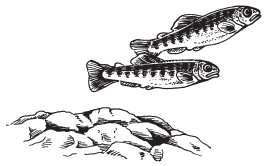


Test Results, Observations, Questions:

Sketches or Drawings:

Date: _____

Water Temperature: _____



Test Results, Observations, Questions:

Sketches or Drawings:

Predicting a Hatch Date

Grade Level
3-12

Subject Areas
Math, Science

Time
20 minutes

Vocabulary
eyed egg, fry, temperature unit

Summary

Students use calculations to estimate the hatch date of trout eggs.

Objectives

Students will ...

- calculate the expected date their TIC eggs will hatch
- explain the meaning of a temperature unit
- identify the factor that determines the rate of trout egg development

Materials

When Will They Hatch? worksheet, one per student

Background

One of the first things your class should do is predict a hatch date for your eggs. Egg development is dependent upon temperature. By taking daily temperature records, you can monitor egg development to predict an approximate hatching date. Trout egg development is measured in temperature units. A temperature unit (TU) is 1° above freezing for 24 hours. For example, if you plan on keeping your tank at 52°F, the following calculations can be done to determine Fahrenheit temperature units (FTUs).

Average temperature in a 24-hour period is 52°F.
52°F – 32°F = 20 FTUs gained each day.
Over a period of 5 days, 5 days x 20 FTUs = 100 FTUs for the school week.

A tank set in degrees Celsius gains the same temperature units as the tank temperature.
Tank is set at 11°C, the gain is 11 CTUs daily.
Over a period of 5 days, 5 days x 11 CTUs = 55 CTUs for the school week.

Below are rainbow trout development rates for trout raised at Idaho's Hayspur Hatchery. Variations do occur between species and certain strains of fish. A general rule of thumb is that the colder the water, the more TUs are required to reach the various stages of development; the warmer the water, the faster the rate of development.

Development Rates for Hayspur-strain Trout			
	To Eyed Stage	To Hatch	To Button-up, Fry Stage
Fahrenheit Temperature Units	420	550	1050
Celsius Temperature Units	233	306	583

The hatchery that supplied your eggs should have given you temperature units that your eggs have already accumulated. This information, along with the average temperature of your tank, will allow you to calculate the date your eggs will most likely hatch. Trout and salmon eggs need about 600 Fahrenheit temperature units (FTU) and about 300 Celsius temperature units (CTU) to hatch, so...

For Fahrenheit:

600 – hatchery FTUs (A) = FTUs need to hatch (B)
600 – A = B
Take your tank's average temp. (C) – 32 = FTUs accumulated in your tank (D)
C – 32 = D
FTUs needed (B) ÷ FTUs accumulated in your tank (D) = days until eggs hatch (E)
B ÷ D = E

For Celsius:

300 – hatchery CTUs (A) = CTUs to hatch (B)
Your tank's average daily temperature is the CTUs accumulated in your tank (D)
CTUs needed (B) ÷ CTUs accumulated in your tank (D) = days until eggs hatch (E)
B ÷ D = E

Add days until eggs hatch (E) on to the day you received your eggs and you should have a good approximation of when the eggs will begin to hatch.

Procedure

As a class or individually, have the students complete *When Will They Hatch?* worksheet.

Evaluation

1. Check worksheets for proper calculations.

   - *What factor is most important in determining the rate trout eggs develop?*
     Water temperature
   - *What does "temperature unit" mean in relationship to trout development?*
     Trout development is measured in temperature units. Trout need to accumulate a certain number of temperature units to reach each stage of development. A temperature unit is one degree above freezing for 24 hours.

2. Have the students record the predicted hatch date and button-up date (if calculated) in their journals.

When Will They Hatch?

Trout and salmon need about 600 Fahrenheit or 300 Celsius temperature units (TU) to hatch. A temperature unit is 1 degree above freezing for 24 hours. To estimate when your eggs will hatch, you need the TUs the eggs accumulated at the hatchery and the average daily temperature of your tank.

For Fahrenheit, FTU:

TUs accumulated at the hatchery: _____ (A)

600 – (A)_____ = _____FTUs needed to hatch (B)

Your tank's average temperature: _____ (C)

(C) _____ - 32 = _____FTUs accumulated in your tank (D)

How many days until your eggs hatch?

Divide TUs needed (B) by TUs accumulated (D).

B ÷ D = days until eggs hatch

(B) _____ ÷ (D) _____ = _____ Number of Days Until Eggs Hatch

For Celsius, CTU:

TUs accumulated at the hatchery: _____ (A)

300 – (A)_____ = _____CTUs needed to hatch (B)

Your tank's average temperature: _____ (D) = CTUs accumulated in your tank

How many days until your eggs hatch?

Divide TUs needed (B) by TUs accumulated (D).

B ÷ D = days until eggs hatch

(B) _____ ÷ (D) _____ = _____ Number of Days Until Eggs Hatch

What factor is most important in determining the rate trout eggs develop?

What does "temperature unit" mean in relationship to trout development?

Bonus:

Trout need to eat after they have "buttoned-up" or absorbed their yolk sacs. If it takes 1050 FTUs or 583 CTUs for your trout to button-up, what is the approximate date when the fish may need to be fed for the first time?

Trout Life Cycle

Summary

Students learn about the life cycle and development of trout.

Objectives

Students will...

- describe the life cycle of trout
- explain and write about the life cycle stages of trout
- identify the current life cycle stage of the class's trout

Materials

- copies of the *Wild Trout Life Cycle*
- copies of the *Hatchery Trout Life Cycle*, if desired
- copies of the *Trout Life Cycle* worksheet and/or the *Trout Life Cycle Maze*, one per student
- writing materials

Background

The typical life of a trout begins when eggs are deposited and fertilized in the gravel of a stream. Once fertilized, the eggs are covered by gravel which protects them from direct sunlight, strong river currents, and potential predators. After seven to 10 days, the head and body regions of the fish begin to form. The eggs are very fragile at this stage and any movement may prove fatal. About 30 to 90 days after fertilization, eyes begin to appear. This "eyed" stage means that the embryo is developing normally and is now able to withstand considerable movement. This is the stage at which you received your eggs. During incubation, the eggs are subject to many hazards such as disease, drought and flooding; many eggs do not make it through this vulnerable period.

As the fish continue to develop within their shells, it is believed that eventually the shells become limiting – the embryos cannot extract enough oxygen from surrounding water. The wiggling embryos then release enzymes to dissolve the eggshell, and eventually the trout break through the shell. The alevin, or sac fry, emerge when they are between $^{3}/_{4}$" to 1" long. The alevin discard their shell membranes, but the yolk sacs remain attached to their stomachs. Oxygen is now absorbed from water flowing over their gills.

Alevin will move up to the surface of the streambed but still remain hidden within the gravel. They are completely dependent upon the yolk sac's store of protein, minerals, salts and fats for nourishment. This fixed food supply must last for a few weeks up to four months. If sediment has not built up in the gravel and around the alevin (limiting the oxygen supply) their growth rate will be determined by the temperature of the water. High water temperatures will make the alevin develop faster. In warmer water, metabolic processes (digestion and respiration) occur more quickly.

Grade Level
3-12

Subject Areas
Language Arts, Science

Time
15-20 minutes

Vocabulary
adult, alevin, camouflage, egg, eyed egg, fingerling, fry, incubation, life cycle, milt, parr, parr marks, redd, sac fry, spawn, yolk sac

Once the yolk sac has been absorbed, the incubation period finally ends. The trout, now called fry, must leave the gravel in search of new food sources. At this point, the young fry are still heavier than water and must reach the surface of the water to inflate their swim bladders. The fry tunnel out of the gravel and travel up through the water. When fry make it to the surface of the water, they snatch air with a sideways, snapping motion of the head. They then drop back, keeping their mouth and gill covers tightly closed to swallow the air. Some young fry (depending on the species) begin a migration from their natal (home) stream to a habitat richer in food resources, such as a lake or river. The fry migrate inconspicuously in the dark, usually when stream levels are high and waters are turbid in the spring.

When young fish reach the size of a human finger, they are called fingerlings. Vertical marks (parr marks) along their sides help camouflage them from predators. At this time, the trout may also be called parr. The fish tend to live in gentle water near the stream bank. It is only when they get bigger and stronger that they move to the faster current.

Trout reach full maturity after about two years. Adults eat insects as well as other fish, even smaller trout. At this time, trout tend to reside in the main current of the stream. The age at which a trout reaches sexual maturity varies due to many different factors, such as genetics or availability of food. Trout may spawn when as young as three, but most trout do not spawn until they are six or seven. Trout are cued by changes in day length and temperature to reproduce. The fish swim upstream, spurred by the flow of the clear, cold snow melt, until they find the spot where they hatched.

Males will fight for spawning rights to the female. The most dominant male will win and spawn. The process of courtship and nest building will last for hours. Only when the female is ready will the spawning commence. The female finds an area with adequate gravel and water flow and creates a redd. A redd is a nest for the eggs. She fans her caudal (tail) fin to rearrange and clean the gravel. Redds can be up to a foot deep to protect the eggs. The female will signify to the male that she is ready to release her eggs by arching her back and quivering over the redd. The male will join her, and they both open their mouths. The female releases her eggs, and the male releases milt, which contains sperm. An average female rainbow trout will deposit roughly 2,000 eggs and will immediately begin to bury these eggs. Trout can spawn more than once, unlike most salmon, and may spawn every one to three years. Once the adult dies, its body will decompose in the water, giving nutrients back to the water and helping the cycle of life continue.

Procedure

Review the life cycle of trout with the *Wild Trout Life Cycle.* Compare the wild trout life cycle to that of a hatchery fish by reviewing the *Hatchery Trout Life Cycle,* if desired.

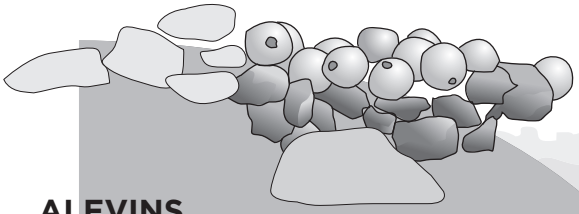
Evaluation

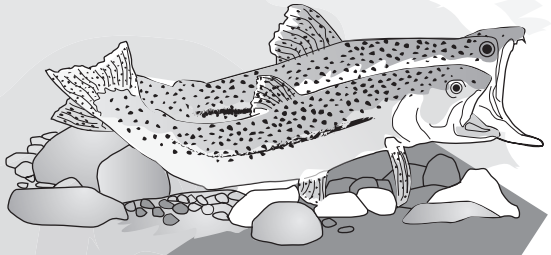
- Students complete the *Trout Life Cycle* worksheet and/or the *Trout Life Cycle Maze.*
- Have students write an informative text explaining the different life stages of trout and identifying the current life stages of the class's trout. Check for accuracy in the life stages, correct use of vocabulary and correct use of conventions.

Wild Trout Life Cycle

EGGS

Eggs are buried in the gravel of small streams and absorb oxygen through their shells. About 30 to 90 days after fertilization, eyes begin to appear. This “eyed” stage means that the embryo is developing normally. This is the stage at which you received your eggs.



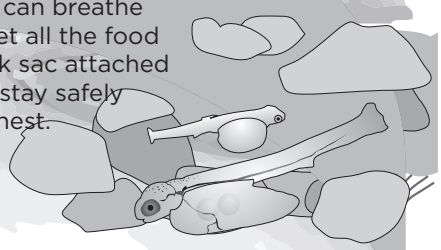


SPAWNING ADULTS

Most wild trout spawn, or lay and fertilize eggs, when they are six or seven years old. Spawning adults swim back to their home streams to lay eggs in gravel nests, called redds. Females dig redds with their caudal, or tail, fins. Females lay around 2,000 eggs in the redd, and the male sprays milt on the eggs to fertilize them. Trout often spawn several times in their lives.

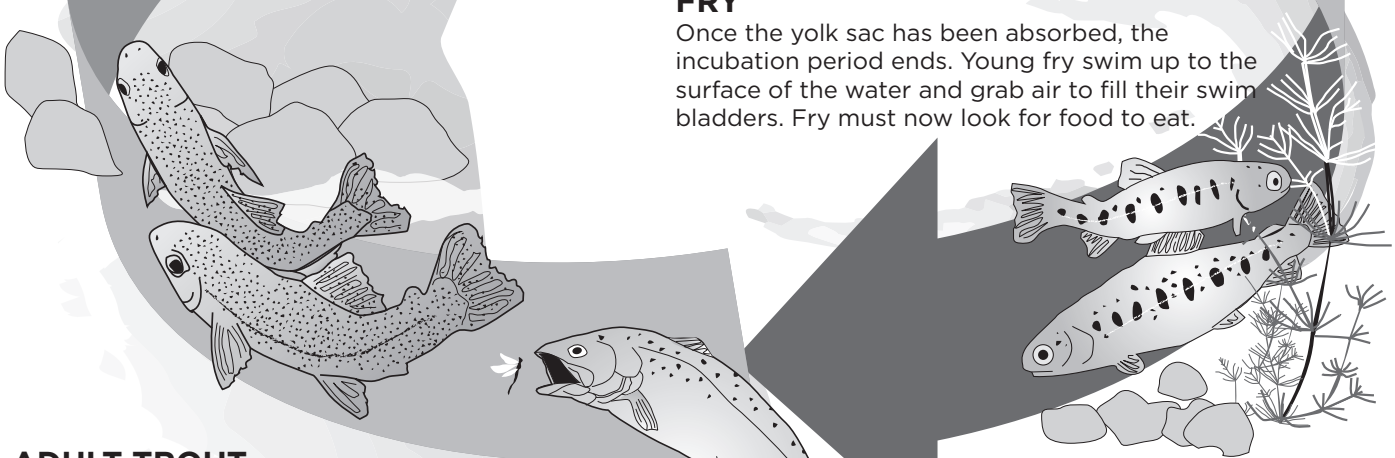
ALEVINS

Newly hatched trout can breathe with their gills and get all the food they need from a yolk sac attached to their bellies. They stay safely hidden in the gravel nest.



FRY

Once the yolk sac has been absorbed, the incubation period ends. Young fry swim up to the surface of the water and grab air to fill their swim bladders. Fry must now look for food to eat.

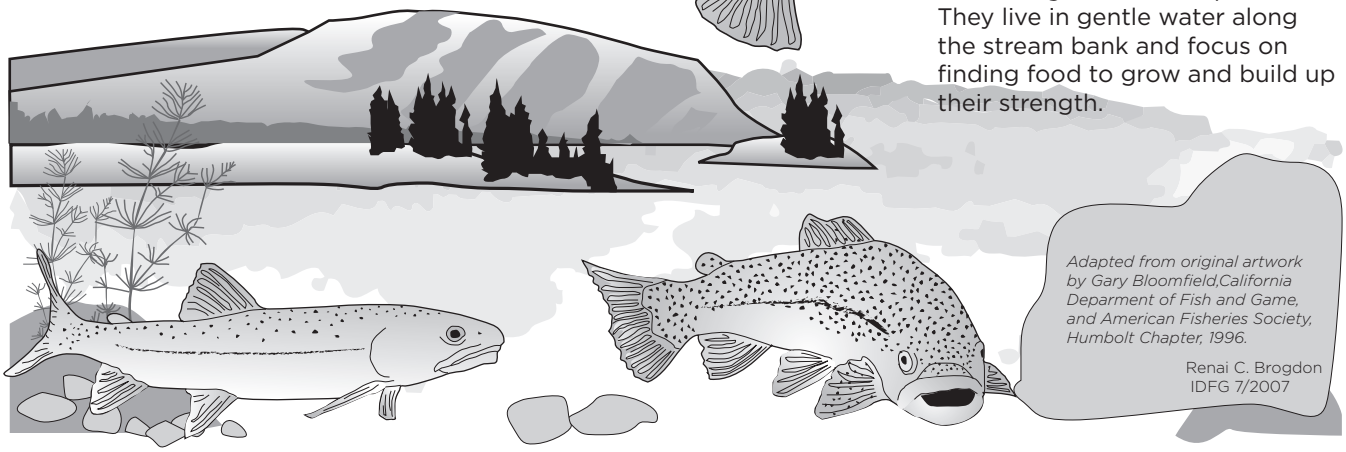


ADULT TROUT

Trout reach full maturity after about two years. They tend to live in the main current of the stream and eat insects, crustaceans and other fish.

FINGERLINGS OR PARR

Young fish about the size of a human finger are called fingerlings or parr. Vertical marks, called parr marks, help hide or camouflage them from predators. They live in gentle water along the stream bank and focus on finding food to grow and build up their strength.



Adapted from original artwork by Gary Bloomfield,California Deparment of Fish and Game, and American Fisheries Society, Humbolt Chapter, 1996.

Renai C. Brogdon
IDFG 7/2007

Hatchery Trout Life Cycle

FINGERLINGS
are from 2 - 5 inches. Most hatchery trout are stocked into lakes at this size.

One-year-old hatchery trout are usually 8 - 10 inch "legals." Wild trout are usually several inches smaller.

Some hatchery trout are stocked as 10-inch legal-sized fish. These fish contribute little to future generations.

A few hatchery trout are held for future egg production. Relatively few fish are needed to support hatchery production compared to the numbers required to sustain wild populations.

Eggs are taken from a brood trout reared in a hatchery or from wild fish trapped from a lake or stream.

Fertilized eggs are placed in hatchery or streamside incubator trays.

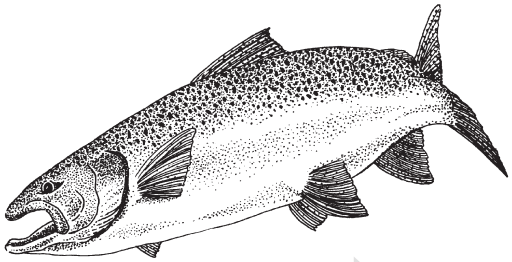
Growth begins in a hatchery tray.

SAC FRY
receive their food from the attached egg sac for 1 to 6 weeks after hatching. The yolk sac is absorbed into the belly providing nourishment until the young trout can feed.

FRY
begin to feed after the egg sac is absorbed.

Spawning for most trout begins at three years of age.

Trout Life Cycle



At this stage, trout swim back to their home stream to lay eggs in nests, or redds, on the bottom of the stream.

____ ____ ____ ____ ____ ____ ____ ____

26 12 15 8 12 10 12 1

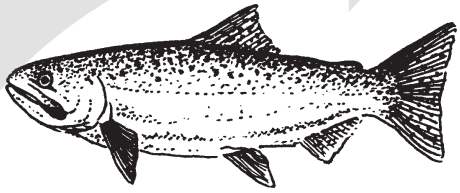
____ ____ ____ ____ ____

15 21 5 17 22

At this stage, trout are buried in the gravel of small streams and absorb oxygen through their shells.

____ ____ ____

6 1 1



At this stage, trout live in rivers, streams or lakes and eat insects, crustaceans or other fish.

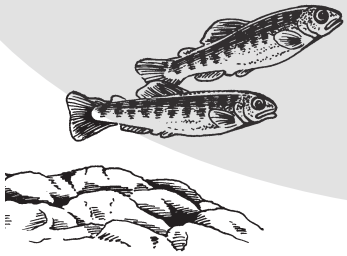
____ ____ ____ ____ ____

15 21 5 17 22

At this stage, trout can breathe with their gills and get all the food they need from a yolk sac attached to their bellies.

____ ____ ____ ____ ____ ____

15 17 6 16 10 12



At this stage, vertical marks camouflage the trout from predators. They live in gentle water along the stream bank.

____ ____ ____ ____

12 15 3 3

At this stage, trout swim up to the water surface to fill the swim bladder. They must now look for food to eat.

____ ____ ____

24 3 17

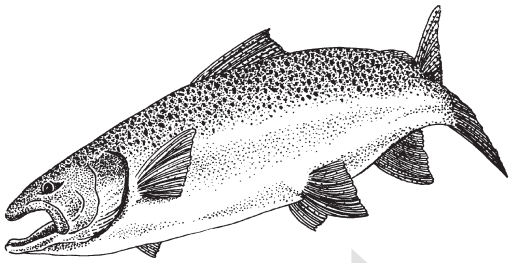
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
							4							20											

H H O ' O O .

22 4 10 26 4 20 17 21 26 15 12 15 17 6 16 10 12 26 24 20 20 21

Answer: _____

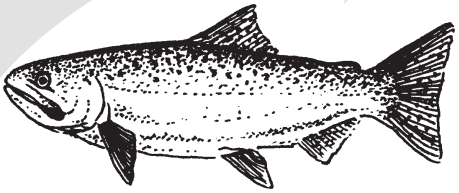
Trout Life Cycle – Answer Key



At this stage, trout swim back to their home stream to lay eggs in nests, or redds, on the bottom of the stream.

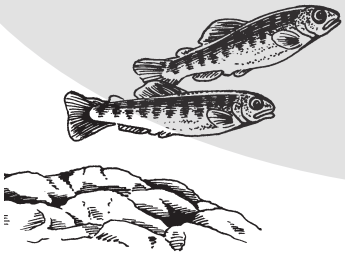
s	p	a	w	n	i	n	g
26	12	15	8	12	10	12	1

a	d	u	l	t
15	21	5	17	22



At this stage, trout live in rivers, streams or lakes and eat insects, crustaceans or other fish.

a	d	u	l	t
15	21	5	17	22



At this stage, vertical marks camouflage the trout from predators. They live in gentle water along the stream bank.

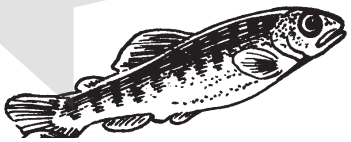
p	a	r	r
12	15	3	3

At this stage, trout are buried in the gravel of small streams and absorb oxygen through their shells.

e	g	g
6	1	1

At this stage, trout can breathe with their gills and get all the food they need from a yolk sac attached to their bellies.

a	l	e	v	i	n
15	17	6	16	10	12



At this stage, trout swim up to the water surface to fill the swim bladder. They must now look for food to eat.

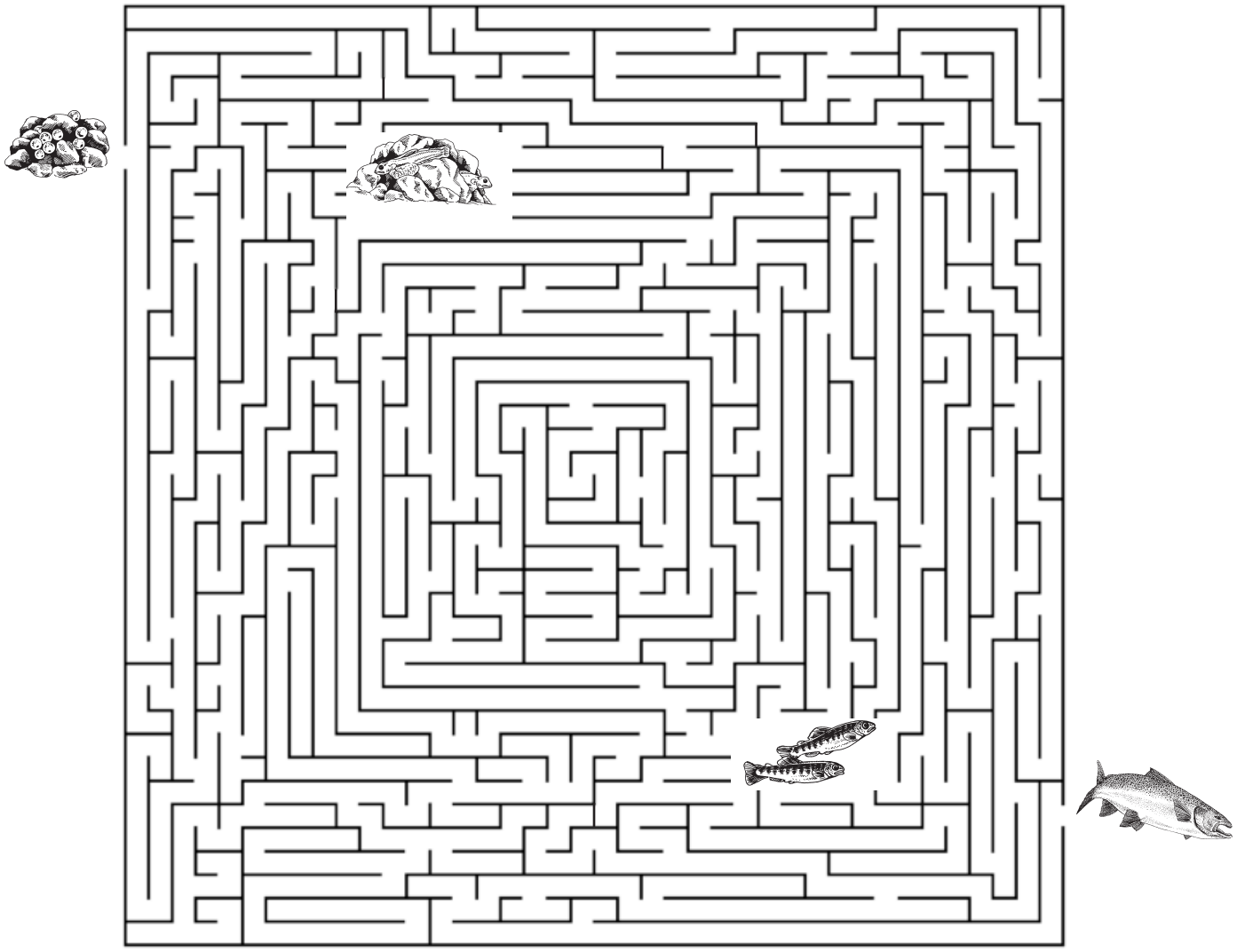
f	r	y
24	3	17

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
15			21	6	24	1	4	10			17		12	20	12		3	26	22	5	16	8		17	

T	H	I	S		H	O	L	D	S		A	N		A	L	E	V	I	N	‘	S		F	O	O	D	.
22	4	10	26		4	20	17	21	26		15	12		15	17	6	16	10	12		26		24	20	20	21	

Answer: Yolk Sac

Trout Life Cycle Maze



List the order of a trout's development:

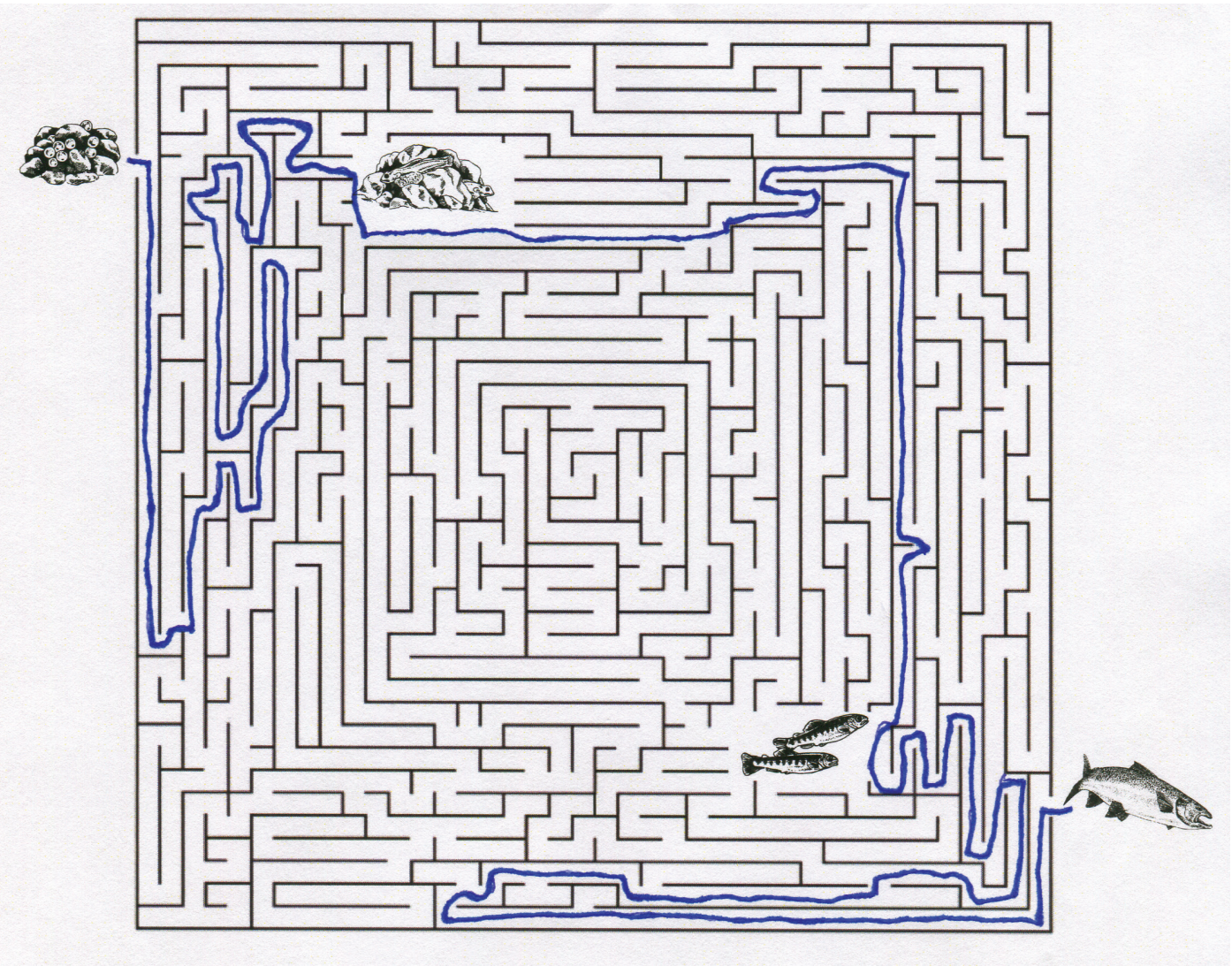
1. _____

2. _____

3. _____

4. _____

Trout Life Cycle Maze



List the order of a trout's development:

1. egg

2. alevin

3. fry

4. adult

Trout Life Cycle
Lower Elementary

Grade Level
k-2

Subject Areas
Language Arts, Science

Time
20-30 minutes

Vocabulary
adult, alevin, egg, fry, life cycle, redd, sac fry, spawn, yolk sac

Summary

Students learn about the life cycle and development of trout.

Objectives

Students will...

- order the stages of trout development correctly
- describe the life cycle of a trout
- identify the life cycle stage the class's trout are going through

Materials

- copies of the *Trout Life Cycle* booklet, one per student
- copies of the *Trout Life Cycle* sheet and *Trout Life Cycle Stages* sheet, one per student

Or

- copies of the *Trout Life Cycle Wheel,* one per student
- brads, if using *Trout Life Cycle Wheel*
- coloring materials

Background

The typical life of a trout begins when eggs are deposited and fertilized in the gravel of a stream. Once fertilized, the eggs are covered by gravel which protects them from direct sunlight, strong river currents, and potential predators. After seven to 10 days, the head and body regions of the fish begin to form. The eggs are very fragile at this stage and any movement may prove fatal. About 30 to 90 days after fertilization, eyes begin to appear. This "eyed" stage means that the embryo is developing normally and is now able to withstand considerable movement. This is the stage at which you received your eggs. During incubation, the eggs are subject to many hazards, such as disease, drought and flooding; many eggs do not make it through this vulnerable period.

As the fish continue to develop within their shells, it is believed that eventually the shells become limiting—the embryos cannot extract enough oxygen from surrounding water. The wiggling embryos then release enzymes to dissolve the eggshell, and eventually the trout break through the shell. The alevin, or sac fry, emerge when they are between $^{3}/_{4}$" to 1" long. The alevin discard their shell membranes, but the yolk sacs remain attached to their stomachs. Oxygen is now absorbed from water flowing over their gills.

Alevin will move up to the surface of the streambed but still remain hidden within the gravel. They are completely dependent upon the yolk sac's store of protein, minerals, salts and fats for nourishment. This fixed food supply must last for a few weeks up to four months. If sediment has not built up in the gravel and around the alevin (limiting the oxygen supply) their growth rate will be determined by the temperature of the water. High water temperatures will make the alevin develop faster. In warmer water, metabolic processes (digestion and respiration) occur more quickly.

Once the yolk sac has been absorbed, the incubation period finally ends. The trout, now called fry, must leave the gravel in search of new food sources. At this point, the young fry are still heavier than water and must reach the surface of the water to inflate their swim bladders. The fry tunnel out of the gravel and travel up through the water. When the fry make it to the surface of the water, they snatch air with a sideways, snapping motion of the head. They then drop back, keeping their mouth and gill covers tightly closed to swallow the air. Some young fry (depending on the species) begin a migration from their natal (home) stream to a habitat richer in food resources, such as a lake or river. The fry migrate inconspicuously in the dark, usually when stream levels are high and waters are turbid in the spring.

When young fish reach the size of a human finger, they are called fingerlings. Vertical marks (parr marks) along their sides help camouflage them from predators. At this time, the trout may also be called parr. The fish tend to live in gentle water near the stream bank. It is only when they get bigger and stronger that they move to the faster current.

Trout reach full maturity after about two years. Adults eat insects as well as other fish, even smaller trout. At this time, the trout tend to reside in the main current of the stream. The age at which a trout reaches sexual maturity varies due to many different factors, such as genetics or availability of food. Trout may spawn when as young as three, but most trout do not spawn until they are six or seven. Trout are cued by changes in day length and temperature to reproduce. The fish swim upstream, spurred by the flow of the clear, cold snow melt, until they find the spot where they hatched.

Males will fight for spawning rights to the female. The most dominant male will win and spawn. The process of courtship and nest building will last for hours. Only when the female is ready will the spawning commence. The female finds an area with adequate gravel and water flow and creates a redd. A redd is a nest for the eggs. She fans her caudal (tail) fin to rearrange and clean the gravel. Redds can be up to a foot deep to protect the eggs. The female will signify to the male that she is ready to release her eggs by arching her back and quivering over the redd. The male will join her, and they both open their mouths. The female releases her eggs, and the male releases milt, which contains sperm. An average female rainbow trout will deposit roughly 2,000 eggs and will immediately begin to bury these eggs. Trout can spawn more than once, unlike most salmon, and may spawn every one to three years. Once the adult dies, its body will decompose in the water, providing nutrients back to the water and helping the cycle of life continue.

Procedure

1. Hand out copies of the *Trout Life Cycle* booklet to students. Have them fold the paper "hamburger style" and then in half to make a book.

2. Explain the life cycle of a trout to the students using the *Trout Life Cycle* booklet. Supplement information with the following, as needed. Have the students write the name of the life stage in the blanks provided.

   - **Egg:** The female lays her eggs in a nest, called a redd, that she builds by flipping her tail up and down. She makes a hole in the gravel to lay her eggs. By moving the rocks around, she also makes a clean home. When the rocks rub against each other, the algae and dirt are rubbed away, too. The mother will lay about 2,000 eggs. When she is done laying her eggs, she covers the eggs with rock to help protect them from predators and sunlight. Once the eggs are safe in the nest, the mother and father trout do not help the eggs in any way. The eggs are left to develop and grow on their own. The egg absorbs oxygen from the water through the egg shell.
   - **Alevin or sac fry:** Young trout that hatch from eggs are called alevin or sac fry. They are between $^{3}/_{4}$" to 1" long. The alevin leave their shells, but the yolk sacs remain attached to their stomachs. Alevin now use their gills to absorb oxygen from water. Alevin will move up to the top of their rock nest but still remain hidden within the gravel. They "eat" the food in their yolk sacs to stay alive. Their yolk sacs have enough food to last a few weeks or up to four months. It all depends of how fast the alevin grow.
   - **Fry:** When the yolk sac has been fully absorbed and is all gone, the trout must leave their gravel nest to look for food. They are now called fry. At this point, the young fry are heavier than water. To float, they must inflate their swim bladders. The fry tunnel out of the gravel and travel up through the water. When the fry make it to the top of the water, they grab air with their mouths. They swallow the air and push the air into the swim bladder. Fry must hide from predators and find enough food to grow.
   - **Adult:** Trout are fully grown when about two years old, but they usually don't spawn, or lay eggs, until they are six or seven. They have to stay alive and eat until it is time for them to spawn. When it is time for them to spawn, the trout swim upstream until they find the spot where they hatched. This is where the adults will spawn and lay their eggs.

Evaluation

1. Hand the students the Trout Life Cycle Stages sheet. Have them color the stages and cut out the squares.

2. Hand the students the Trout Life Cycle sheet. Have students glue the stages in the correct squares.

3. Ask the students to circle the life stage their trout are in at this time.

4. Check that the life stages are in the correct order and the current life stage is correctly identified.

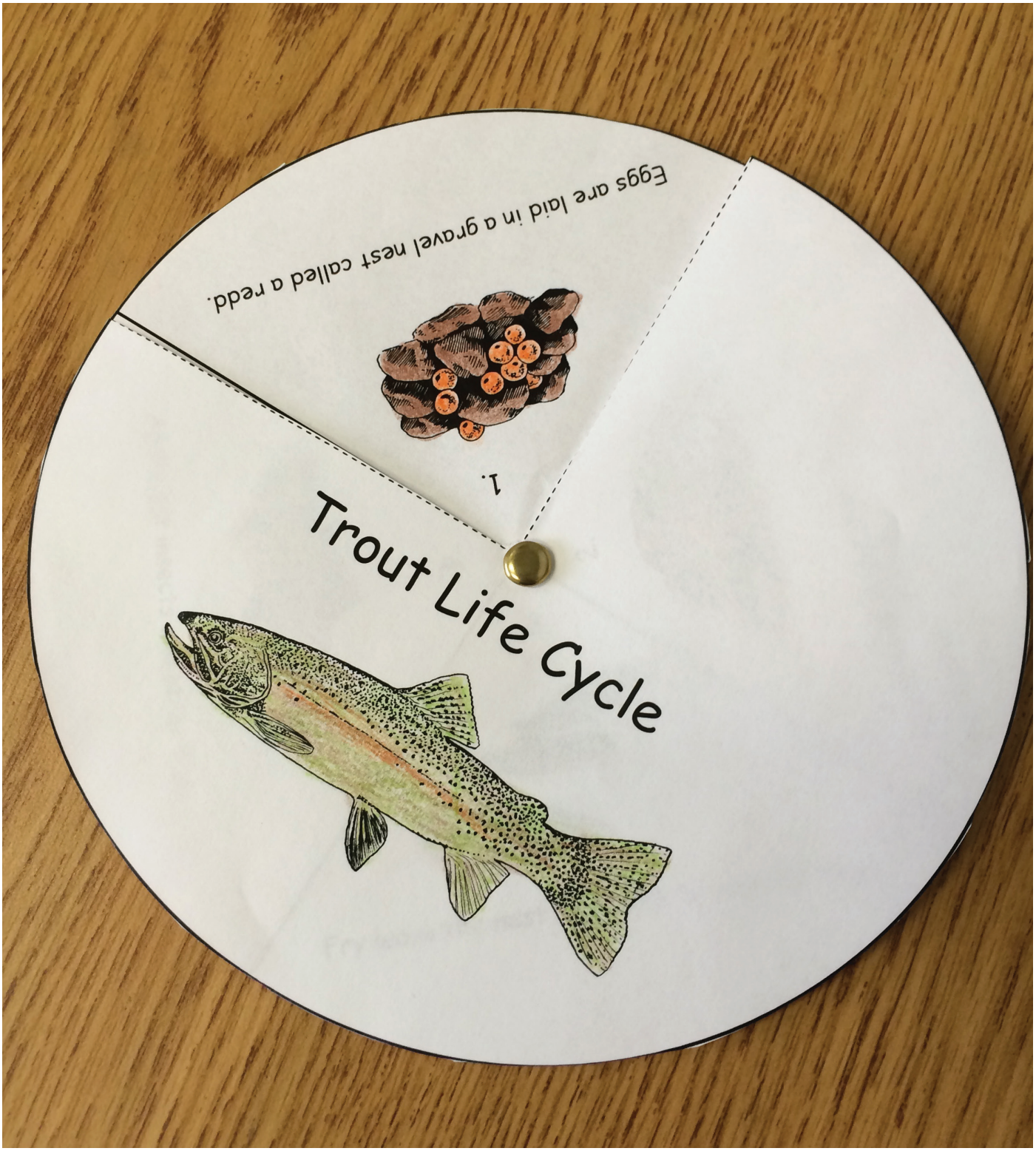
5. As a class or individually, have students recite the life stages and briefly describe what is happening during each stage.

   OR

6. Hand out the Trout Life Cycle Wheel to the students. Have them color the stages/pictures on the wheel and cut out the circles and pie piece on the top circle. Place the top circle over the bottom circle, poke a hole in the small center dot, and hold together with a brad. For added strength and stability, you may want to have students glue the circles onto construction paper and cut the circle and pie piece out again before securing with a brad.

7. Ask the students to move the cutout to the life stage their fish are in at this time. Check that all students have their wheel in the correct location.

8. As a class or individually, have students recite the life stages of a trout and briefly describe what is happening during each stage.

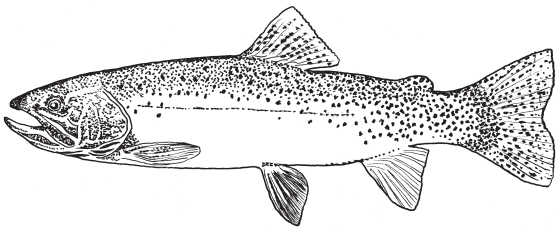

Eggs are laid in a gravel nest called a redd.
1.
Trout Life Cycle

Trout Life Cycle

_____ _____ _____

A trout begins its life as an egg. The egg is in a gravel nest called a redd.

Name: _____

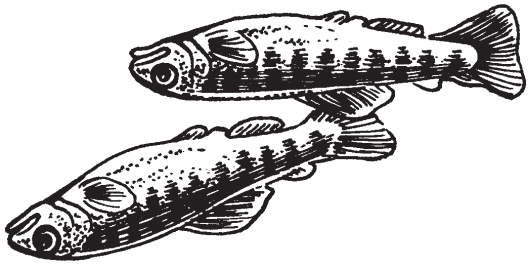


_____ _____ _____ _____ _____

An adult eats bugs and other fish. It may be 6 or 7 years old before it lays eggs.

_____ _____ _____ _____ _____ _____

A trout that just hatched is called an alevin. It gets its food from a yolk sac stuck to its belly.

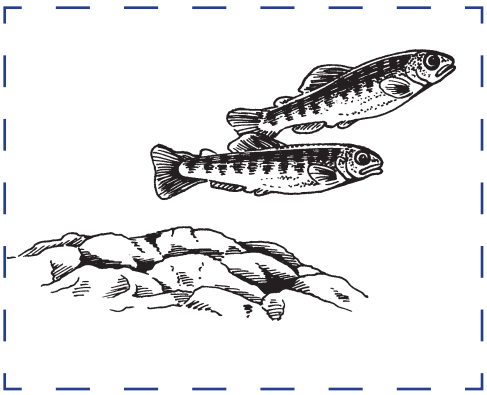


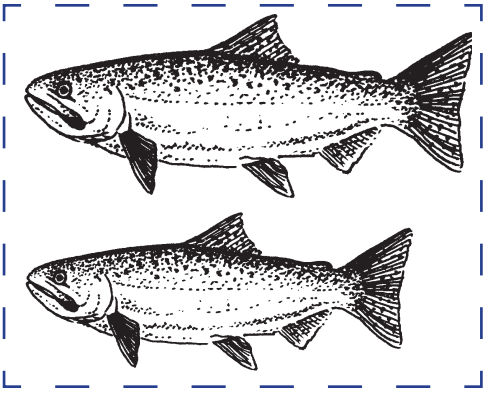
_____ _____ _____

A trout that has used up its yolk sac is called a fry. It must now look for food to eat.

Trout Life Cycle Stages

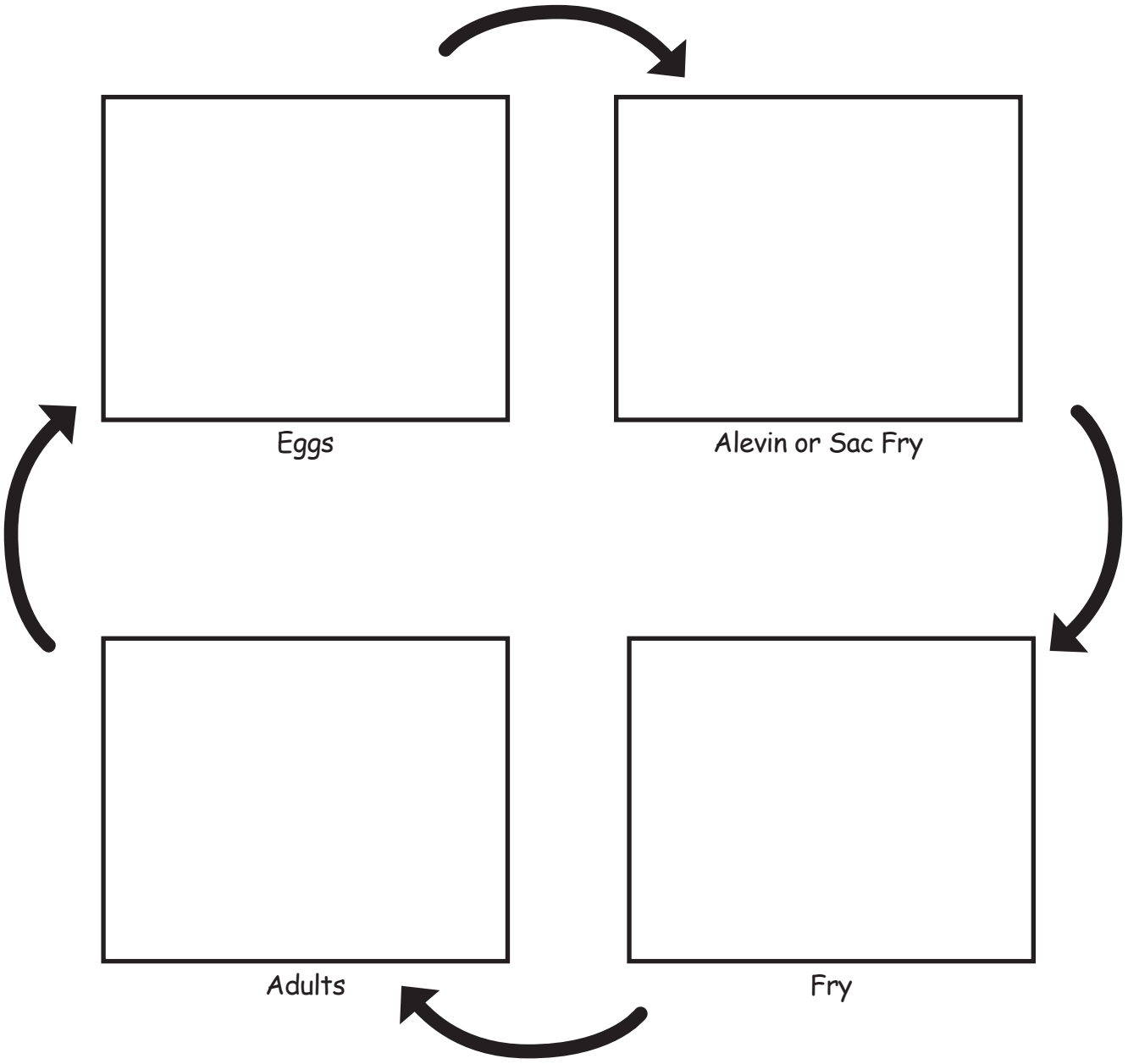
Color the trout life cycle stages and cut out the squares. Glue the squares in the correct box on the Trout Life Cycle sheet.





Trout Life Cycle

Glue the stages of the trout life cycle in the correct box. Circle the life cycle stage of your trout.

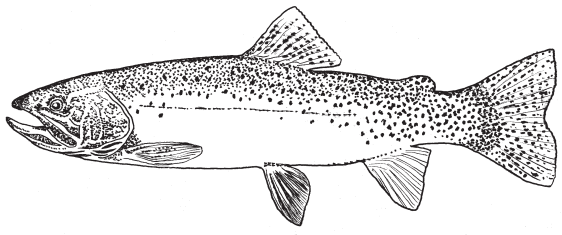


Trout Life Cycle Wheel Top

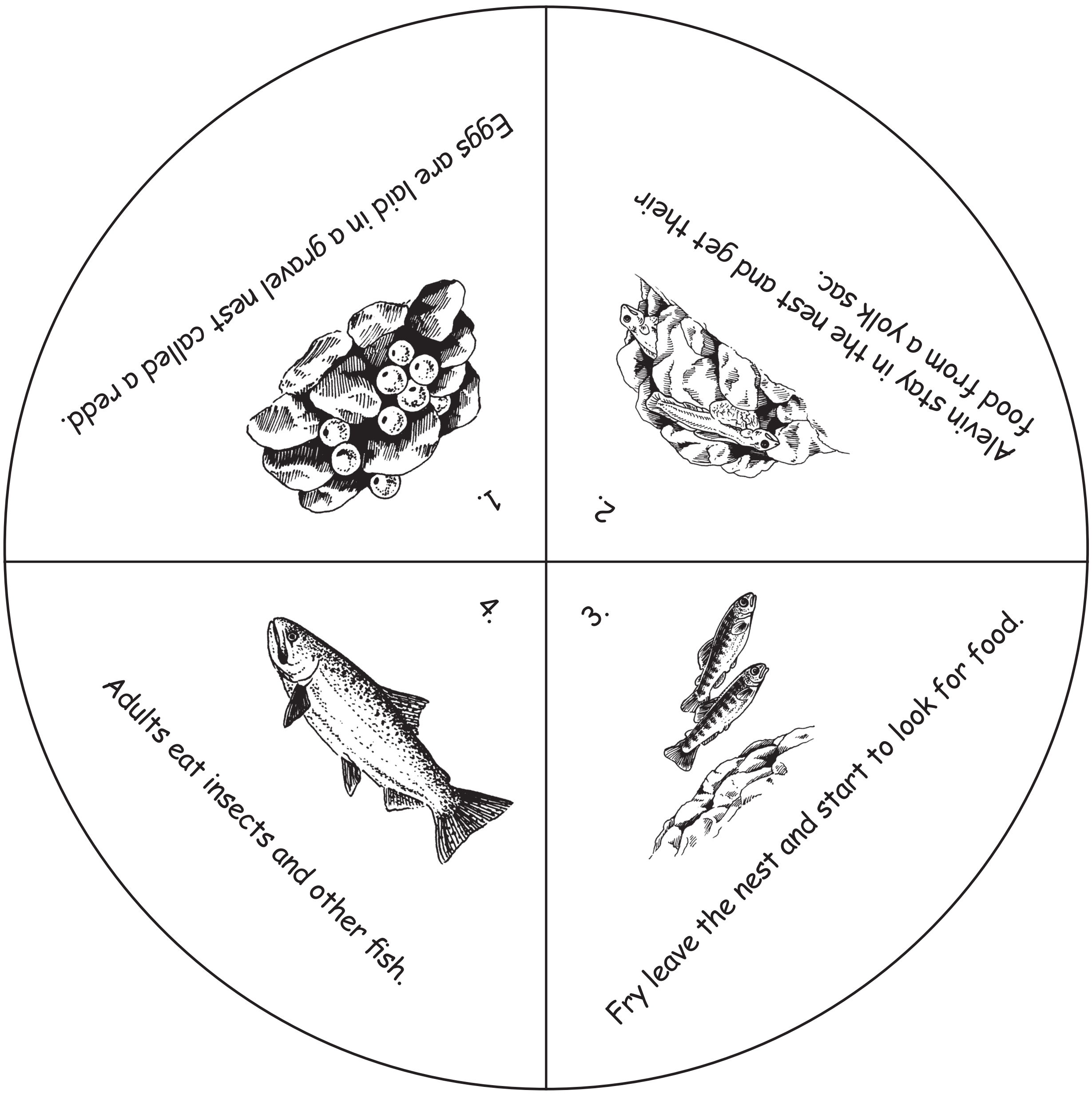
Color and cut out the circles. Place the top on the bottom and hold together with a brad.

Cut out

Trout Life Cycle



Trout Life Cycle Wheel Bottom



Only the Strong (and Lucky) Survive!

Grade Level
3-12

Subject Areas
Math, Science

Time
20 minutes

Vocabulary
erosion, egg, fry, macroinvertebrate, riparian, sac fry, silt

Summary

Students calculate the survival of trout eggs to spawning adults.

Objectives

Students will...

- use subtraction to solve a problem
- formulate a mathematical equation from a word problem
- calculate percent of fish that survive
- name situations that might affect trout survival from eggs to adults

Materials

copies of *Only the Strong (and Lucky) Survive!* worksheet

Background

Trout face many obstacles and challenges while developing. The main reason why trout and other prey animals have a large number of offspring is to help ensure that some young live to carry on their genes. Trout eggs, juveniles and adults are eaten by many different predators. Drought may affect the levels and temperatures of water. By far, the largest threat to trout, like most wild animals, is habitat destruction. Habitat destruction may happen from natural causes or from human activity.

This activity gives students an idea of some situations that may affect trout survival. The number of trout eggs laid (2000) and the number of trout that may survive to spawn (300), are realistic numbers. Only about 15% of trout eggs laid will live to spawn as adults.

Procedure

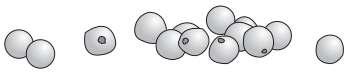
1. Brainstorm and discuss with the students things that might affect whether trout live to spawning age.
2. Hand out the *Only the Strong (and Lucky) Survive!* worksheet.
3. Complete the worksheet as a group or individually. Help younger students, as needed, to figure the percent survival.

Evaluation

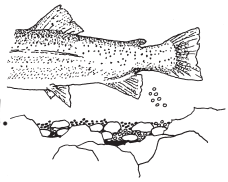
1. As a class, go over and correct the worksheet.
2. Have the students mention some ideas that they thought might affect trout survival that were not examples on the worksheet.
3. Were the students surprised by the number of trout that survived? Why or why not? Mention that this scenario is accurate for trout survival.

Only the Strong (and Lucky) Survive!

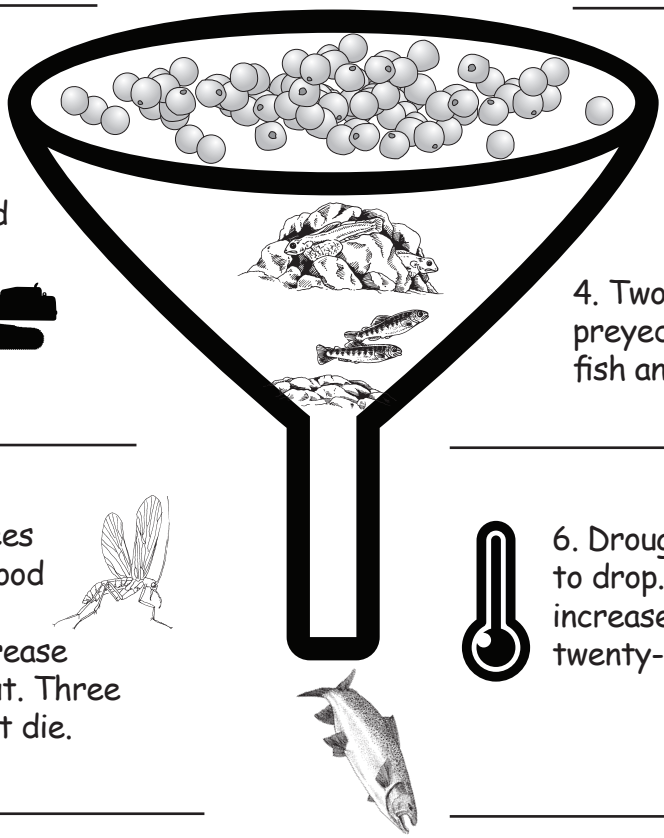
Trout lay thousands of eggs, but a much smaller number survive to spawn. At each stage of life, trout face a number of obstacles that may threaten their survival. Use the numbers below to find out how many rainbow trout typically survive from egg to spawing adult.



1. A female deposits two thousand eggs in a redd. Two hundred eggs are not fertilized.



2. Twenty-eight eggs are washed out of the gravel after a careless ATV driver crosses the stream.



3. A construction site upstream causes erosion and silt kills four hundred ninety alevins.

4. Two hundred four fry are preyed upon by herons, larger fish and other predators.

5. A grove of riparian trees is cut down leaving less food for macroinvertebrates. Macroinvertebrates decrease leaving less food for trout. Three hundred fifty-three trout die.

6. Drought causes the water level to drop. Water temperatures increase and kill four hundred twenty-five adult trout.

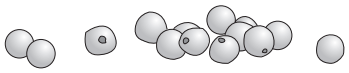
How many trout are left to spawn?

What percentage of the eggs survived to spawn?

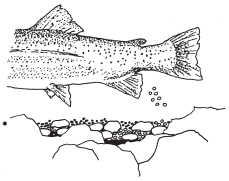
List things that might affect trout survival. Add two that are not listed above.

Only the Strong (and Lucky) Survive! Answers

Trout lay thousands of eggs, but a much smaller number survive to spawn. At each stage of life, trout face a number of obstacles that may threaten their survival. Use the numbers below to find out how many rainbow trout typically survive from egg to spawing adult.



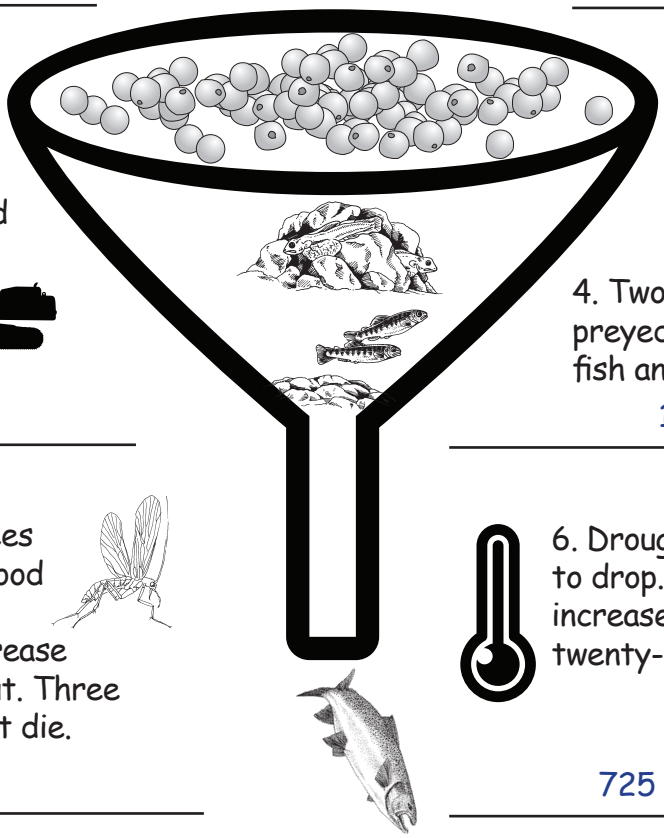
1. A female deposits two thousand eggs in a redd. Two hundred eggs are not fertilized.



2000-200 = 1800

2. Twenty-eight eggs are washed out of the gravel after a careless ATV driver crosses the stream.

1800 - 28 =1772



3. A construction site upstream causes erosion and silt kills four hundred ninety alevins.

1772 -490 = 1282

4. Two hundred four fry are preyed upon by herons, larger fish and other predators.

1282 -204 =1078

5. A grove of riparian trees is cut down leaving less food for macroinvertebrates. Macroinvertebrates decrease leaving less food for trout. Three hundred fifty-three trout die.

1078 - 353 = 725

6. Drought causes the water level to drop. Water temperatures increase and kill four hundred twenty-five adult trout.

725 - 425 = 300

How many trout are left to spawn?

300

What percentage of the eggs survived to spawn?

300/2000 = 3/20 = 15%

List things that might affect trout survival. Add two that are not listed above.

habitat destruction, human carelessness, predators, water dries up, pollution, water temperature too hot, silt, flood washes away redd or young fish, no food, over fishing, diseases, invasive species

Tale of a Scale

Summary

Students "read" a steelhead's life history by examining a scientifically accurate drawing of a steelhead scale.

Objectives

Students will...

- identify the stages in a steelhead's life cycle
- correlate different seasons with a steelhead's growth
- discover the effect life cycle events have on fish's health
- propose ways people can help steelhead and salmon

Materials

- copies of enlarged fish scale for each student
- transparency of scale to lead class in labeling
- markers, colored pencils, or crayons in the following shades: red, pink, light green, dark green and blue

Background

In this activity, we will examine a steelhead trout's scale. Although steelhead trout are the same species as rainbow trout, they have a different life cycle. Steelhead are anadromous, like salmon, meaning they hatch in freshwater streams, travel to live in the ocean for a few years, then return to freshwater to spawn (reproduce). Ocean-going forms of the trout can convert back to resident forms during droughts or when a dam blocks access to the ocean. Unlike salmon, steelhead do not always die after spawning and may live to spawn multiple times.

As we will learn, a trout's life history can be read in its scale. Steelhead and rainbow trout have very similar scales. However, because the steelhead is anadromous, its scales will "read" a little differently and show more life events than a rainbow trout.

There are four types of fish scales - placoid, cycloid, ctenoid (pronounced 'ten-oid'), and ganoid. Trout, salmon, and most bony fish have cycloid scales. Fish with cycloid scales have the same number of scales their entire lives - the scales enlarge to accommodate growth. This results in a pattern of concentric growth rings on the scale, which look similar to the growth rings in the trunk of a tree. The growth rings on a scale are known by scientists as circuli (singular circulus).

Just like counting the rings of a tree, biologists can determine a great deal of information about a steelhead by reading its scales with a microscope. The age of the fish, time spent at sea and the number of times it has spawned can all be determined.

Grade Level
4-12

Subject Areas
Language Arts, Science

Time
45 minutes

Vocabulary
anadromous, circuli, cycloid scale, migration, otoliths, scale, smolt, smoltification, spawn

So, how do biologists do this? Actually, aging fish is fairly easy. The development of circuli is similar to that of tree rings. During periods of rapid growth, the rings are widely spaced and when growth slows, the rings are more tightly spaced. Rings are formed on a cycloid scale every few months, so biologists can read into seasons, rather than just years with trees. Steelhead grow rapidly in the summer months when water temperatures and food availability are highest; they experience slower growth during the colder winter months. Therefore, steelhead scales typically exhibit alternating bands of widely spaced (summer) and narrowly spaced (winter) growth rings.

Two specific life events can also be seen in a steelhead's scale—smolting and spawning. As a young steelhead prepares for life in saltwater, its body undergoes tremendous change. A silvery sheen replaces the parr marks, and they undergo a complex internal transformation to survive in saltwater. This process of adapting and migrating to saltwater is called smoltification. The steelhead's scale shows a smolt mark—a bold band separating circuli formed previously in freshwater from those formed in saltwater.

The other life event impacting steelhead is spawning. While a steelhead migrates and fights its way back upstream to its place of birth, it is beaten up by the current, is hurdled over rocks and falls, and is weakened by bacteria and fungus. In addition, steelhead do not eat while spawning and rely solely on energy reserves built up in the ocean. Spawning steelhead decrease in size as they use up their energy reserves to fight the current. It is believed that the scales soon become too big for a shrinking steelhead, and the scales' edges become worn and eroded, forming spawning scars.

In addition to viewing a trout's scales to age a fish, biologists can also collect and examine otoliths. The otolith (which literally translates to "ear stone") is a small bone that floats in a fluid-filled capsule located near the base of a fish's skull. They help a fish balance and maintain

equilibrium. Otoliths also show growth rings so may be used to age fish. They are generally considered more accurate than scales (particularly for older specimens). However, the fish must be dead before an otolith is removed. Therefore, scale reading is less invasive.

Procedure

1. Discuss the life cycle of a steelhead. Explain that steelhead are the same species as rainbow trout, with one important difference - steelhead are anadromous. This background will allow students to hypothesize and interpret the meaning of the scale's markings.

2. Begin by asking the class if the small fry in their aquarium will grow more scales as they get bigger. Will they have all the scales right now that they will have for the rest of their lives?

    - Explain how steelhead (just like trout) have the same scales throughout their lives and that the scales grow with the fish.

3. Pass out copies of the scale drawing and coloring utensils. Have students observe the scale. Does this remind them of anything else found in nature?

    - A tree's rings. If you have a picture or tree cookie, compare it to the drawing of the scale.

4. Discuss tree rings and how they are formed. Each tree ring is a layer of wood cells produced in one year. Does a tree grow the same amount every year? Are the rings all the same size? Why not?

    - Each year brings different weather and a different growing season. A drought one year won't allow the tree to grow much while a wet and warm year will promote tremendous growth.

5. We can see the same is true with steelhead. The rings are not all the same size. Trout, however, grow rings every few months (not every year). Knowing what we do about trees, what do you think causes changes in the growth rate of a steelhead?

    - Summer brings warm weather and lots of food for growth. The opposite occurs in the winter.

6. Point out and label the core of the scale and explain that the first growth rings, or circuli, are formed from this point. The first circuli form when the fish is in its early stages. We see that the first rings are widely spaced apart, so what season do you think the steelhead emerged from its egg?

    - The fry emerged sometime in the late spring/early summer—depending on weather, water temperatures, etc.
    - Label these first, widely-spaced circuli as 'summer in freshwater' and color red.

7. The next set of circuli was formed closely together. What does this tell us about the fish's growth and the time of year?

    - The steelhead's growth slows. These rings were formed in the fall and winter.
    - Label this section 'winter in freshwater' and color pink.
    - There may be discrepancy over when summer growth ends and winter begins. Just estimate since we are only labeling with two seasons.

8. The fish then spends another year in freshwater. Find the summer and winter growth rings for the second year. Label the 'second summer in freshwater' and color red. Label 'second winter in freshwater' and color pink.

9. Next there is a bold, dark circulus. What happens in a steelhead's life after about two years in freshwater? What does the process entail?

    - At this point, the steelhead prepares for its migration to the sea. The steelhead is called a smolt at this stage. Its body goes through some major changes and the scales show a dark band.
    - Label this 'smolt mark or scar'.

10. The next few circuli are spaced far apart. Label these rings 'first summer at sea' and color light green.

11. This is followed by a winter at sea. Label these rings 'first winter at sea' and color dark green.

12. Next you will see a scar, or blank spot, on the scale that stands out from the rest of the growth rings. What might a steelhead do as an adult, after a year at sea? What could cause a strain on the fish, leaving a scar on the scale?

    - The steelhead returns to freshwater to spawn. During this time it doesn't feed and the scales develop special marks or scars.
    - Label this mark 'spawning scar' and color blue.
    - Rings around the scar may be eroded so the spring/summer spent in freshwater spawning is not easily distinguished.

13. The steelhead spends the winter in freshwater and then returns to the ocean the next spring.

    - Label this 'winter in freshwater' and color pink.

14. After another summer and winter at sea, it travels back to freshwater to spawn again.

- Label the 'second summer at sea' and color light green. Label 'second winter at sea' and color dark green. Label 'second spawning scar' and color blue.

15. Ask the students how the scales of the trout they are raising would compare to the scale of this wild steelhead. Do you think hatchery trout or steelhead would show the same markings on their scales as wild fish?

- No, hatchery fish are fed the same amount every day, so their growth rings are perfectly even. Wild fish will almost never have perfect growth, so if you see a scale with evenly spaced rings at the center, it was probably stocked by a hatchery.

16. Compare the growth at sea with the growth in freshwater. Does the growth seem to increase when at sea? Why?

- The steelhead is older and bigger with more choices of prey.
- The ocean provides more food than freshwater. This is why the fish will make that dangerous journey.

17. Review the life cycle of the steelhead. Discuss dangers the steelhead faces at each stage of the life cycle – including predators in freshwater and the ocean, commercial harvesting, travel through dams, and habitat degradation.

18. Encourage the students to think of things we can do to help keep steelhead and salmon populations healthy.

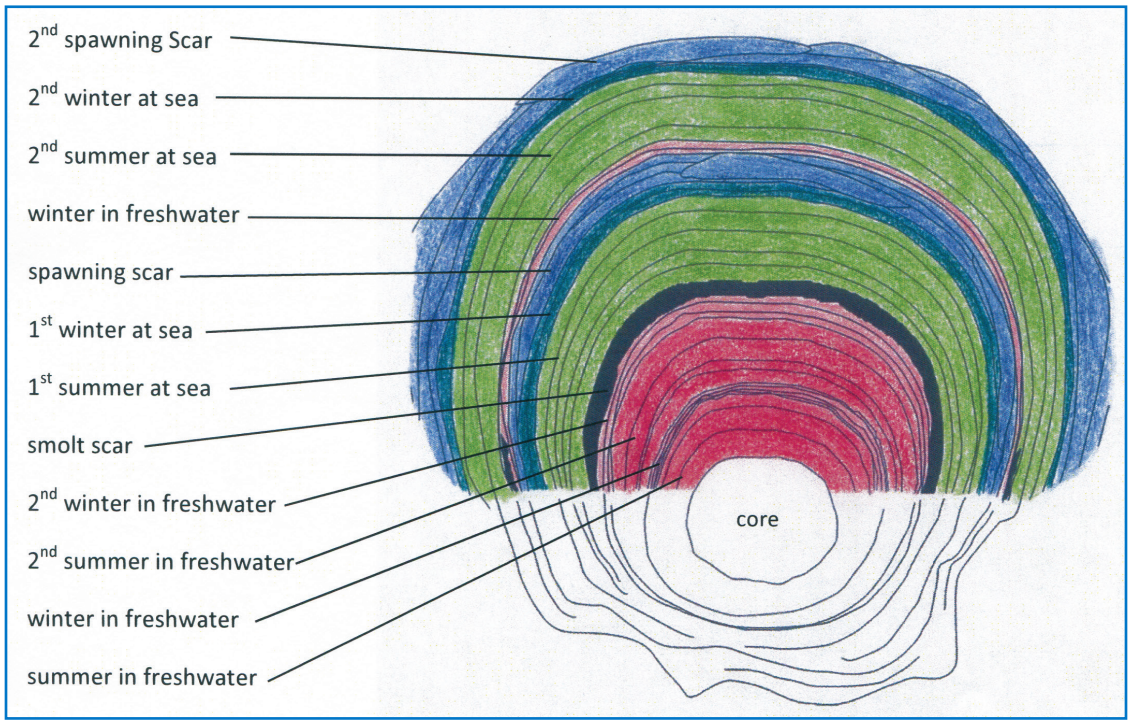
Evaluation

Write a first-person narrative as a steelhead trout that hatches in an Idaho creek, describing life at each stage of its life cycle. Conclude the story by suggesting ways we can lessen our impact on steelhead and salmon in Idaho.

Extension

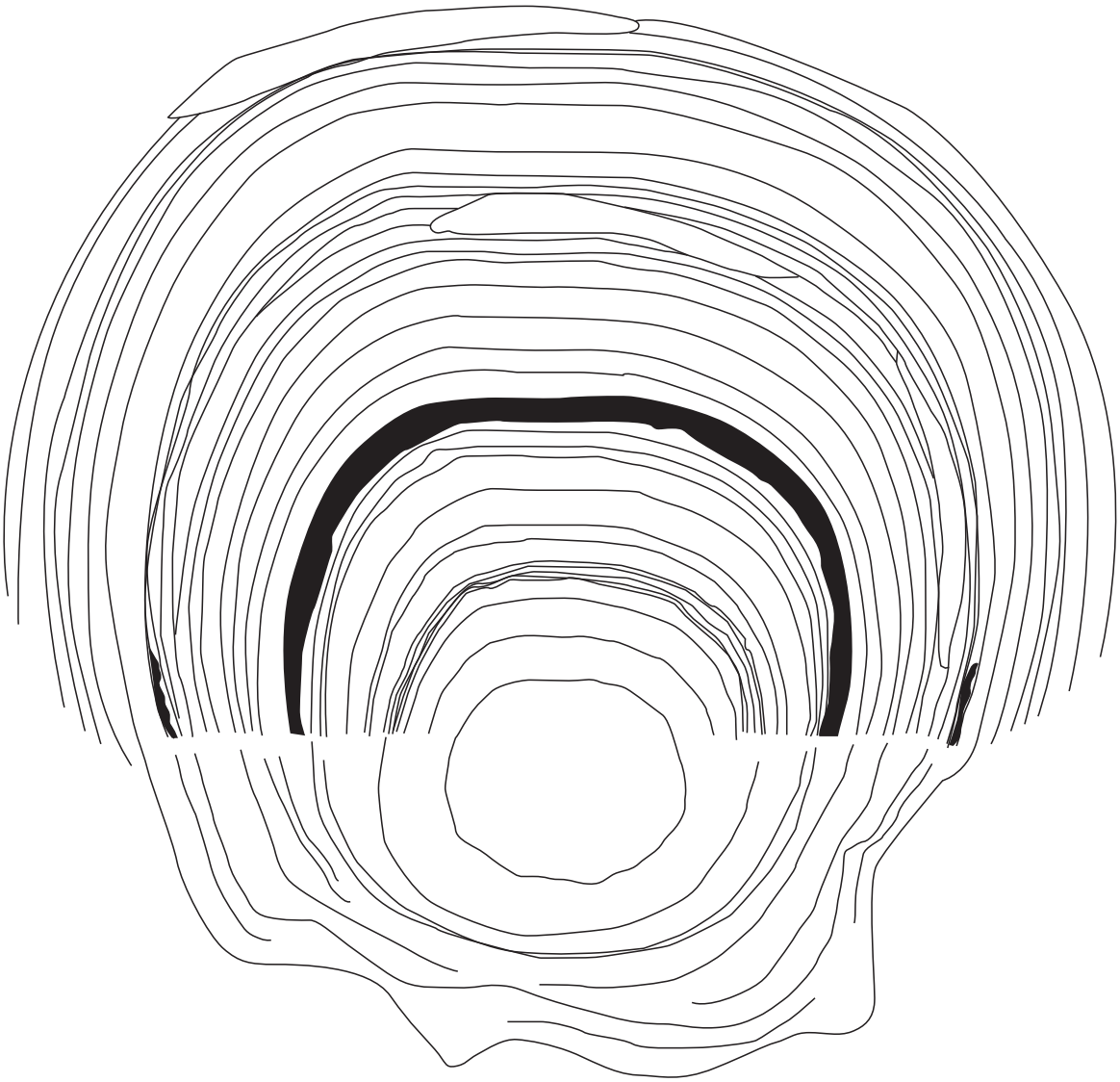
View real fish scales under a microscope. You may make your own slide or order one from a science teaching supply source. If you plan to conduct a fish dissection, you can easily use a scale from the rainbow trout you dissect. Remove scales by rubbing a finger nail up a small section of the trout – from tail toward head. Place the scale and a drop of water on a slide. Cover the scale with a slip cover to observe under a microscope.

Fish Scale Answer Key



Name: _____

FISH SCALE



Aquatic Food Chain Collages

Summary

Students learn energy is passed from one organism to another when animals eat. Students construct food chains.

Objectives

Students will...

- identify components of a food chain
- describe connections between components of a food chain
- explain how energy flows or is passed through a food chain

Materials

- copies of the *Aquatic Food Chain Links*, one per student if using
- 12" X 18" construction paper if students make their own food chains
- coloring materials

Background

A river, and the green strip of land around it (the riparian zone), is a living community. The organisms living in this community are connected in many different ways. One way animals are connected is by what they eat. All life depends on the sun and the ability of green plants to use sunlight to synthesize simple sugars from carbon dioxide and water. Through this process, known as photosynthesis, plants take energy from sunlight and make it available to animals. Plant eaters, or herbivores, eat the plants directly; animal or flesh eaters, carnivores, eat both herbivores and other carnivores. Omnivores eat both plants and animals. When an animal eats other plants or animals, a food chain is formed. A food chain is a simplified way of showing energy relationships between plants and animals in an ecosystem. For example, a food chain of **sun → algae → mayfly → rainbow trout → bald eagle** shows that the sun provides energy to the algae (producer), which in turn is eaten by a mayfly (primary consumer and herbivore). The mayfly then becomes energy for a rainbow trout (secondary consumer and carnivore). Finally, a bald eagle (tertiary consumer and carnivore) eats the trout. However, this is a very simplified version of what actually happens in nature. Rarely does an animal eat only one type of food; most animals consume many types of food and are, in turn, consumed by many types of predators.

Grade Level
k-7

Subject Areas
Language Arts, Science, Visual Arts

Time
45-90 minutes

Vocabulary
aquatic, carnivore, community, consumer, decomposer, food chain, food web, herbivore, omnivore, photosynthesis, predator, prey, primary consumer, producer, scavenger, secondary consumer, tertiary consumer, trophic level

Procedure

1. Begin a discussion with the students on how animals get the energy they need to live. Help guide the discussion along to the idea that animals eat many different types of food to get the energy they need to survive. Just like humans, animals may eat plants, other animals (meat) or both plants and animals to survive. Animals that eat plants are called herbivores; meat eaters are called carnivores. Animals that eat both plants and meat are called omnivores. These differences can be broken down into even more specific distinctions. Frugivores eat fruit; insectivores eat insects.

2. Ask the students where plants get their energy. Most plants need water and the nutrients found in soil to survive, but without the sun giving them the energy to make sugar, plants could not survive. Plants use the sun's energy to turn water and carbon dioxide into sugar. This process is called photosynthesis.

3. Define a food chain. A food chain is formed when animals eat something to survive. A mouse eats a plant; a snake eats the mouse, and an owl eats the snake. Each animal gets the energy they need by eating a plant or animal. The energy is passed from one animal to another when it is eaten.

4. Ask the students, "What starts most food chains?" All food chains have to start with a source of energy. The energy that begins most food chains comes from the sun. In the ocean, there is another energy source – boiling-hot deep sea vents. Sunlight cannot reach the ocean floor, so bacteria use minerals and chemicals from hot vents to make energy and start food chains deep in the ocean. The sun is the start of almost all food chains. Without the sun's energy giving plants what they need to make sugar, animals would not have plants to eat. Sun gives energy to a plant→ animal eats plant→ animal eats animal that ate plant.

5. For older students, introduce the trophic levels of

the food chain. Producers (plants) use the sun's energy to make their own food. Primary consumers (herbivores) eat producers. Secondary consumers (carnivores or omnivores) eat primary consumers. Tertiary consumers (carnivores and omnivores) eat secondary consumers. Quaternary consumers (almost always carnivores) eat tertiary consumers. Scavengers clean up dead animals; decomposers (bacteria, fungi, molds) break down and feed on the tiny elements and nutrients that make up an animal or plant. Decomposers return these basic nutrients back to the soil where they become available to plants and, in turn, the animals that eat plants.

6. Have the students brainstorm some aquatic (water) food chains. How might a trout fit into a food chain? What do trout eat? (insects, snails, leeches, fish) What does an insect eat? (algae, moss, cattails, other insects) How would these organisms make a food chain (don't forget the sun)? (sun – algae – insect - trout) What might eat the trout? (other trout, human, bass, river otter, raccoon, great blue heron, eagle, osprey) Add one of these animals to the food chain and you get a food chain of sun→ algae insect→ trout→ river otter.

7. For younger students:

   Tell the students they will be making a food chain. Show the students a completed food chain made from the *Aquatic Food Chain Links* provided and post for reference.

   a. Pass out the *Aquatic Food Chain Links*. Ask the students to identify the links in the food chain and write the food chain on the board. Sun→ leaf bug→ fish

   b. Have the students cut out the links on the dotted lines. Do not cut out the fish.

   c. Glue the sun onto the circle on the leaf. Glue the leaf onto the insect's open mouth. Glue the insect onto the fish's open mouth.

   d. Color the fish and its mouth; color the insect and its mouth; color the leaf and the sun.

   e. Have the students write the food chain on the bottom of the page. You may want to substitute words for the arrows. (leaf uses sun; bug eats leaf; fish eats bug or sun energy goes into leaf; leaf eaten by bug, bug eaten by fish)

8. For older students:

   a. Show the students examples of the food chain collages they will be making. Some examples follow.

   b. Have the students brainstorm aquatic food chains to design and make. You may want to require that the students have two to three animals, a plant and the sun represented in the food chain. It may be helpful to have the students sketch an outline of their food chain with the animals "eating each other" and get the teacher's approval before beginning the next step with construction paper.

   c. Using 12"x 18" construction paper, have the students select a background color.

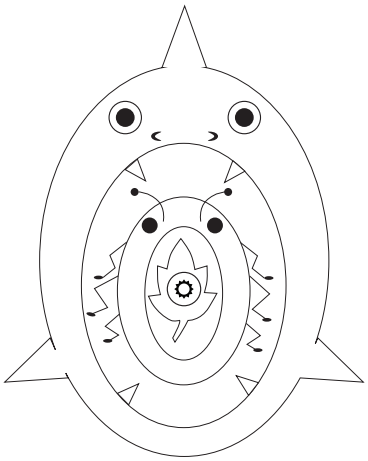
   d. Now, have the students select a color for the top predator in the food chain. Fold the paper vertically and draw half of the predator face on the paper. The middle of the face will be on the fold. This will make the face symmetrical. Cut out the predator face; draw or make eyes, nose and teeth from scraps of paper. Glue the top predator onto the background paper.

   e. Now make the next link in the food chain the same way. Make this link smaller so it fits into the mouth of the top predator. Check for size, adjust as needed and glue it into place. Continue until all the links are completed and glued into place.

   f. Have the students write informative paragraphs explaining their food chains. Make sure they include the relationships between the links and the way energy flows or is passed between the links. They should correctly use vocabulary words learned or mentioned in the lesson. Or, have the students write a narrative story about the community where the food chain links live. Students need to again mention how all the links pass energy to each other and how the links interact with each other.

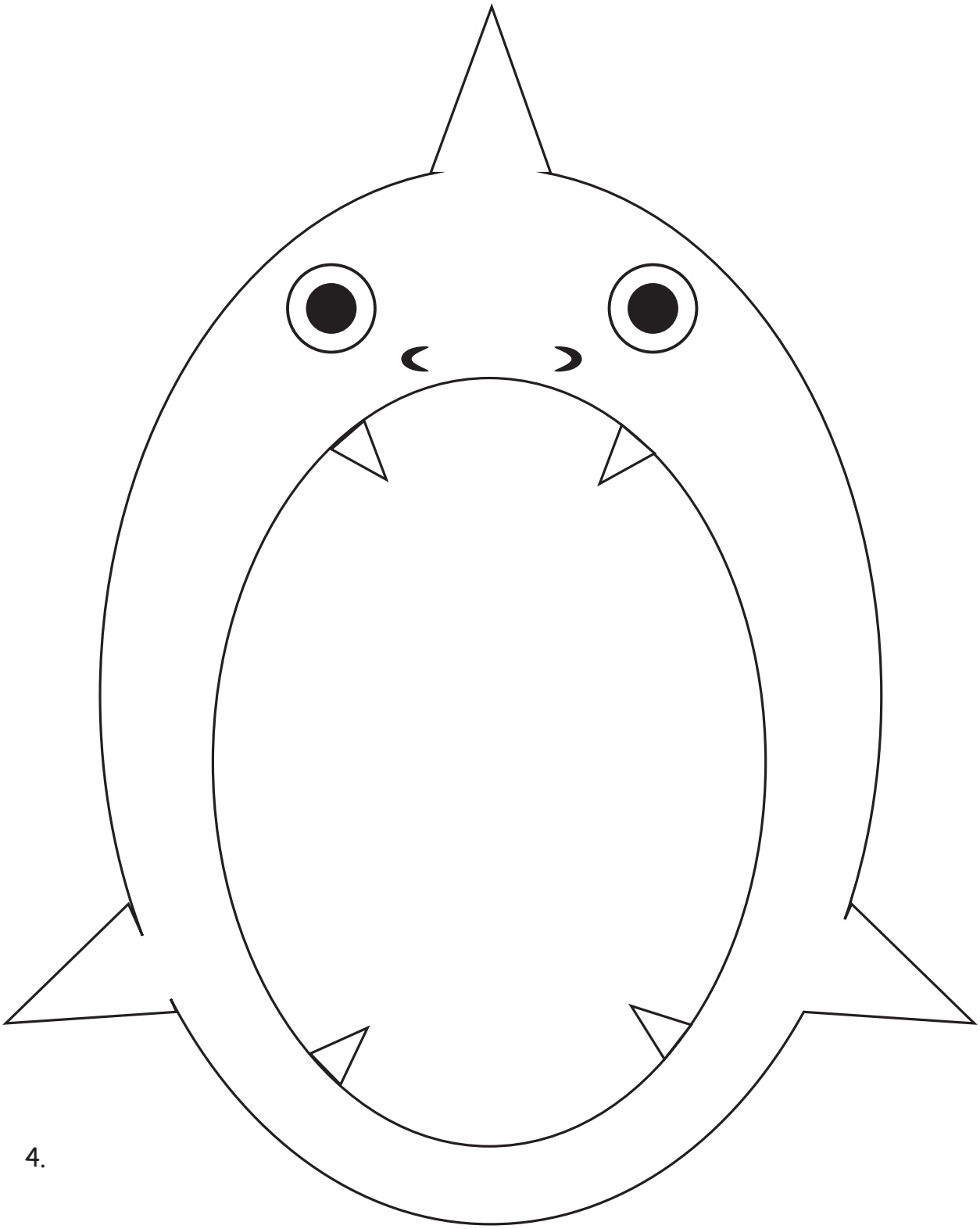
Evaluation

Check the collages for accuracy. Evaluate older students' writing. Check that all parameters were met and that students used correct writing conventions.



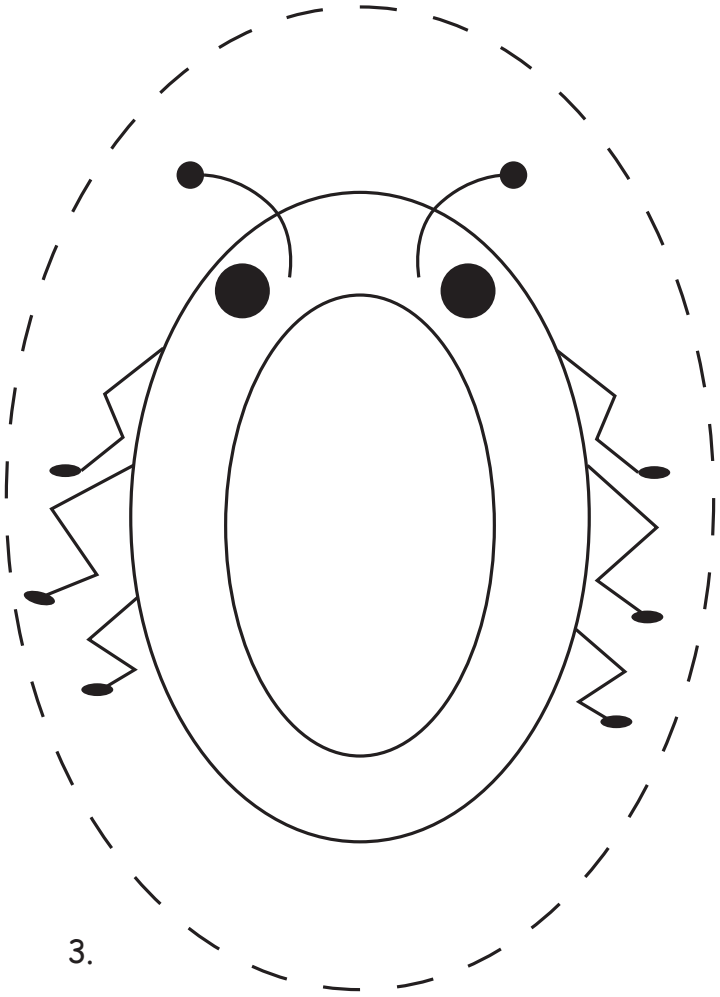
Aquatic Food Chain Links

Aquatic Food Chain Links

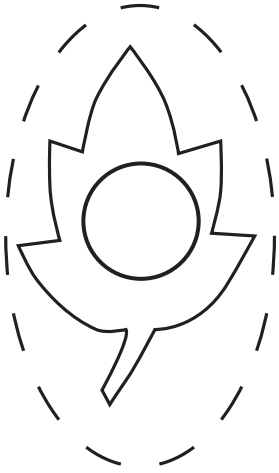


4.

Aquatic Food Chain Links



3.



2.

1.

Aquatic Web of Life

Summary

Students take on a role as part of an aquatic ecosystem; explore the interactions within this ecosystem; and make hypothetical changes to test the idea of interdependence.

Grade Level
4-12

Subject Areas
Language Arts, Science

Time
Part one: 30-60 minutes

Part Two: 60-90 minutes

Vocabulary
aquatic, biodiversity, carnivore, community, competition, consumer, decomposer, ecosystem, environment, food chain, food web, habitat, herbivore, interdependence, niche, omnivore, organism, photosynthesis, predator, prey, primary consumer, producer, relationship, scavenger, secondary consumer, tertiary consumer, trophic level

Objectives

Students will...

- identify components of an ecosystem
- describe connections between components of an ecosystem
- discuss hypothetical changes in an ecosystem and the effect of the change
- explain how energy flows through an ecosystem

Materials

Part One

- 3" x 5" index cards (one for each student), with holes punched out of two adjacent corners

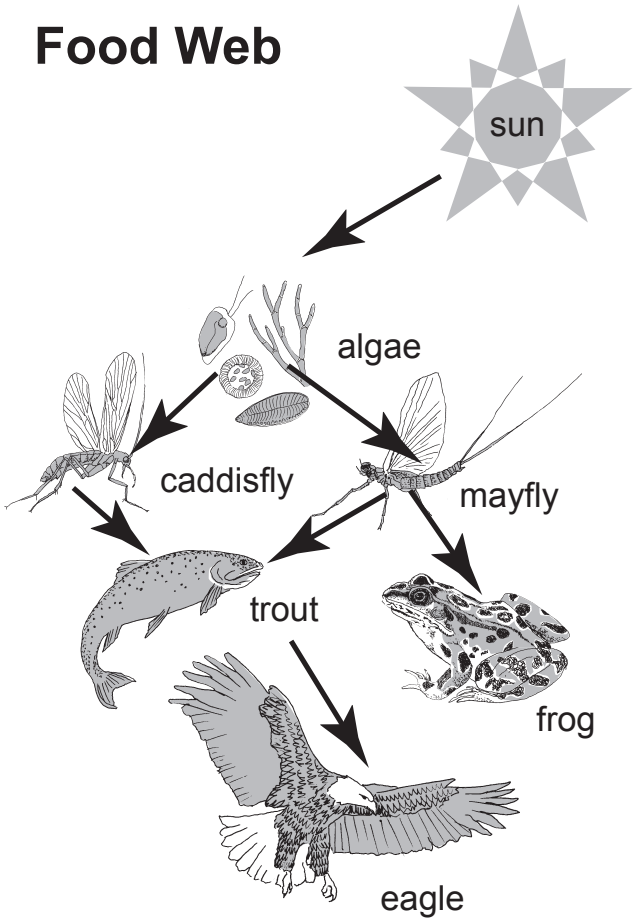
Part Two

- students' index cards on their researched organism
- yarn cut into three foot lengths for making organism index cards into name tags, one for each student and the sun card
- one index card to represent the sun, with holes punched in top corners and made into a name tag
- ball of yarn for making a web

Background

A river, and the green strip of land around it (the riparian zone), is a living community. The organisms within this ecosystem are connected in what is often called "the web of life." How can so many different organisms occupy the same ecosystem without wearing out all of the resources? The answer is that each organism has evolved to have its own niche, or role in the community. W.B. Saunders made the analogy that, "the habitat is the organism's 'address', and the niche is its 'profession', biologically speaking." With all of these different professions, each species contributes to the health of this interwoven community.

One way the animals living in and around a river are connected is by what they eat. All life depends on the sun and the ability of green plants to use sunlight to synthesize simple sugars from carbon dioxide and water. Through this process, known as photosynthesis, plants take energy from sunlight and make it available to animals. Plant eaters, or herbivores, eat the plants directly;



animal or flesh eaters, carnivores, eat both herbivores and other carnivores, thus forming a food chain. A food chain is a simplified way of showing energy relationships between plants and animals in an ecosystem. For example, a food chain of **sun** → **algae** → **mayfly** → **rainbow trout** → **bald eagle** shows that the sun provides energy to the algae (producer), which in turn is eaten by a mayfly (primary consumer and herbivore). The mayfly then becomes energy for a rainbow trout (secondary consumer and carnivore). Finally, a bald eagle (tertiary consumer and carnivore) eats the trout. However, this is a very simplified version of what actually happens in

nature. Rarely does an animal eat only one type of food; most animals consume many types of food and are, in turn, consumed by many types of predators. A food web, as opposed to a food chain, is a more accurate way of demonstrating the interconnections of various organisms in an ecosystem. A food web extends the food chain concept from a simple linear pathway to a complex network of interactions.

Organisms in an ecosystem are connected in additional ways beyond the food web. They can also provide habitat for other species. For example, trees provide habitat for nesting birds, and a beaver's dam creates a pool in the river, providing habitat for certain aquatic insects. Furthermore, species may rely on others to aid in some way with reproduction. Certain flowering plants need insects or other animals to carry pollen from one flower to another. Additionally, species of birds help spread a cottonwood's soft seeds while using it to build a nest each spring.

The web of life created in this activity suggests that all living things are connected. No matter how unrelated organisms may seem, they are, in fact, connected.

Part One: Researching a River Ecosystem

Procedure

1. Write out John Muir's quote, "When you try to change a single thing, you find it hitched to everything else in the universe," on the board. Ask students to share their ideas about what Muir meant. Do the students agree? Prompt them to list examples of connections.

2. Discuss the terms ecosystem, producer, consumer, herbivore, carnivore, omnivore, scavenger, and niche. Ask the class to brainstorm all the living components they think they would need to make a healthy river ecosystem. Don't forget bacteria, fungi, algae, insects, snails and all the plants and animals living in and along the river. Write down the list on the board.

3. Explain to your students that they will get to become an expert on one species in an aquatic ecosystem. Assign or have students choose a species and give the students an index card.

   - If they are assigned an animal, have them research:
     a. what the animal eats; if it is an herbivore, carnivore, omnivore, and/or scavenger
     b. what eats the animal; if it is a carnivore, omnivore, an/or scavenger
     c. what niche or role the species fills in the ecosystem
     d. any fun/weird trivia about the organism
   - If they are assigned a plant, bacteria or fungi have them research:
     a. what the species gives others
     b. what eats the species if it is a producer or decomposer
     c. what niche or role the species fills in the ecosystem
     d. any fun/weird trivia about the organism

5. Students should record this information on one side of their card or in paragraph form on a separate piece of paper. On the other side of the card, the student should display a picture of the organism.

Part Two: Weaving a Web

Procedure

1. Have each student give a mini-presentation to the class describing their animal or plant, and its role in the ecosystem. Students may also give short PowerPoint presentations to the class.

2. Give the students a piece of yarn to attach to their card, making a name tag to wear around their necks. Have each student wear their card so the photo of their organism is visible. The class then gets up and stands in a circle, preferably outdoors. Ask the class what starts most food chains and webs – the ultimate source of energy, the sun. The class leader (or an assigned student) can be the sun. The ball of yarn starts here.

3. What would be next in the chain? It would be some sort of producer. The sun is what provides energy to the producer, allowing it to make food. While holding on to the end of the ball of yarn, the sun passes the ball to someone with a plant/producer card.

4. Continue through the web. The ball of yarn must then be passed to a species that depends on that plant – either for food or for habitat (to nest in, etc.). Go through the whole web, making sure everyone has become 'woven' into the web. It is okay to go to one member of the web more than once.

5. When all the organism cards have been used, ask the "sun" to tug gently on the yarn. As each member of the web feels the tug, they should also start tugging. Soon everyone is tugging, showing the connectivity between all the organisms in the ecosystem.

6. Have the class stop tugging and pull the yarn taut. Now have one member drop the yarn. As each person feels the tightness go away, they also drop the yarn. Soon no one is holding the yarn. This shows the web 'unraveling'.

7. Regroup and discuss the following questions...

   - What happens when we remove a link in the aquatic ecosystem? (Organisms that depend on it are affected.)
   - Would the effect of losing a 'link' be more or less dramatic if there were fewer members in the ecosystem. (Should be more dramatic.)
   - What can we say about the relationship between the number of parts the ecosystem has (its complexity or diversity) and how stable it is? (In general, complexity makes it more stable.)
   - How do humans play a role in the web? What can we do to help ecosystems stay healthy?

Evaluation

Students create concept maps depicting the relationships between ten organisms from the aquatic web of life.

- Have the students choose ten of the organisms from the web activity.
- The students then create a concept map to demonstrate the relationships between these organisms.
- To create a concept map, the students should write down the organisms' names in a large circle on a piece of paper. The names should be spread out in the circle. This will allow room for the students to draw linkages between the organisms. Draw a box or circle around each name to designate it.
- Link the organisms with an arrow and verb or phrase describing the relationship such as 'eats' or 'lives in'.

Extension

1. Research the term 'keystone species' and investigate why Yellowstone cutthroat trout are considered a keystone species in Yellowstone National Park. What species depend upon this trout?

2. Re-create your web of life on a bulletin board visible to the school. Post the class's species and yarn to link them. Describe the links between two species on covered tabs so that other students have a chance to guess and then discover the connection.

Macroinvertebrate Research & Mock Fly-Tying

Summary

Students research macroinvertebrates that trout eat; make mock fishing flies; and give speeches and write short informative texts using knowledge gained.

Objectives

Students will...

- research and read informational text to gain information on the habitat, habits and appearance of aquatic macroinvertebrates
- identify aquatic macroinvertebrates' place in an aquatic food web
- create models of aquatic macroinvertebrates similar to fly-fishing flies
- give short speeches to communicate knowledge and steps in a process
- write clear informative texts to demonstrate their knowledge

Materials

- images and information on aquatic macroinvertebrates and their flying adult counterparts. Depending on students' abilities, students may research macroinvertebrates themselves or use the information sheets included:
  - Constructing Caddisflies - Word Count 400, Flesch-Kincaid Grade Level 4.8
  - Toothed Dragons - Word Count 410, Flesch-Kincaid Grade Level 5.7
  - Meet the Mosquito - Word Count 469, Flesch-Kincaid Grade Level 6.2
  - Marvelous Mayflies - Word Count 403, Flesch-Kincaid Grade Level 3.6
- actual fly-fishing flies
- chenille stems, yarn, feathers, beads and other craft supplies in various colors
- tape or glue
- writing materials or computer access

Background

The cold, clean rivers and streams in Idaho attract fly-anglers from across the country who come to fish for trout in a pristine environment. Fly-anglers use artificial flies as bait. Artificial flies look similar to the trout's natural diet of aquatic macroinvertebrate species. Macro means large enough to see with the naked eye and invertebrate means they have no backbone.

Grade Level
4-12

Subject Areas
Language Arts, Science, Visual Arts

Time
Research: 45 minutes or longer

Mock fly-tying & Presentation: 30–45 minutes

Writing: 45 minutes or longer

Vocabulary
adaptation, food chain, food web, habitat, larva, larvae, life cycle, macroinvertebrate, naiad, pupa, pupae

These animals live on rocks, logs, sediment, debris and aquatic plants during some period in their life. Macroinvertebrates include crustaceans such as crayfish, mollusks such as clams and snails, aquatic worms and the immature forms of aquatic insects such as stonefly and mayfly nymphs. Aquatic macroinvertebrates, such as insect larvae, are a large part of a trout's diet. The flying adult forms of the aquatic insects are also food for trout. Different species of macroinvertebrates have different characteristics, including body shape, exoskeleton color, feeding preferences and in-stream behaviors.

To make their fishing flies, anglers closely study the species they are imitating. They then wrap hooks with thread, yarn, feathers, and other materials of various colors to mimic the macroinvertebrate. To be successful, fly-anglers need to have knowledge of what fish eat and need knowledge of the food being eaten. Anglers need to know what the macroinvertebrates look like and their habits to trick a fish into biting their flies.

Procedure

1. Explain to students that they will be researching and creating macroinvertebrates. Share the background information on fly-fishing and show the students examples of fly-fishing flies.

2. Assign, individually or in groups, species of macroinvertebrates for the students to research. Depending on ability, students may research species on their own or use the following information sheets. Students should find pictures and information on appearance, habits, food preferences, adaptations and other interesting facts. Have students take notes on what they learn.

3. Once research is completed, tell the students they will be creating a mock fly-fishing fly of the macroinvertebrate they researched just like a fly-angler. Show students examples of fly-fishing flies and allow them to look closely at how the artificial flies are constructed—wrapping techniques, materials used to recreate body parts, etc.

4. Give the students a chenille stem and have them bend the chenille stem into a hook shape at least three inches long. Using the craft supplies available, have the students create a version of the macroinvertebrate they studied.

Evaluation

1. Once students have created their "flies" have the students give a short speech to the class. They should include the name of the macroinvertebrate they created, brief information on its appearance, adaptations and habits. They should also include a step-by-step description of the process they took to recreate the macroinvertebrate and the distinct features they added to their design to make it resemble the macroinvertebrate they studied.

2. Using their notes taken while researching, have the students write an informative text about their macroinvertebrate and its role in aquatic food chains. Students should include information on appearance, habits, food preferences, adaptations and other interesting facts.

Constructing Caddisflies

Can you think of an insect that lives most of its life in water and builds a home for protection? It's the caddisfly. In North America, there are over 1,200 different kinds of caddisflies; worldwide there are over 7,000! Many species of caddisflies look similar and telling them apart can be difficult.

Caddisflies are insects that have four stages in their life cycle. They lay their eggs in water. The eggs hatch, and caterpillar-like larvae crawl out. The larvae turn into pupae, and the pupae into adults. Only the adults can survive out of water.

Caddisfly larvae are builders. They make a silk from the spit in their mouths. Some caddisflies use the silk to spin webs or tunnels. These caddisflies are predators. They trap very small animals in the sticky webs. Most caddisflies are not predators. They eat dead and sometimes living plants. These caddisflies use the silk as glue. As they spin silk, they mix in sand, twigs or grass. This makes a case, or shell, around their soft bodies. The case is held in place by a pair of hooks on the tip of the insect's body. As the insect grows, it just adds onto the case. The case protects the caddisfly. It looks like a little twig or rock in the water. This camouflages the caddisfly and makes it harder for predators to see it.

Caddisfly larvae need oxygen to survive. They use the same thing fish use to get oxygen out of the water – gills. Adults do not live in water, so they do not have gills. Air enters and leaves their bodies through spiracles. Spiracles are holes in the insects' abdomens.

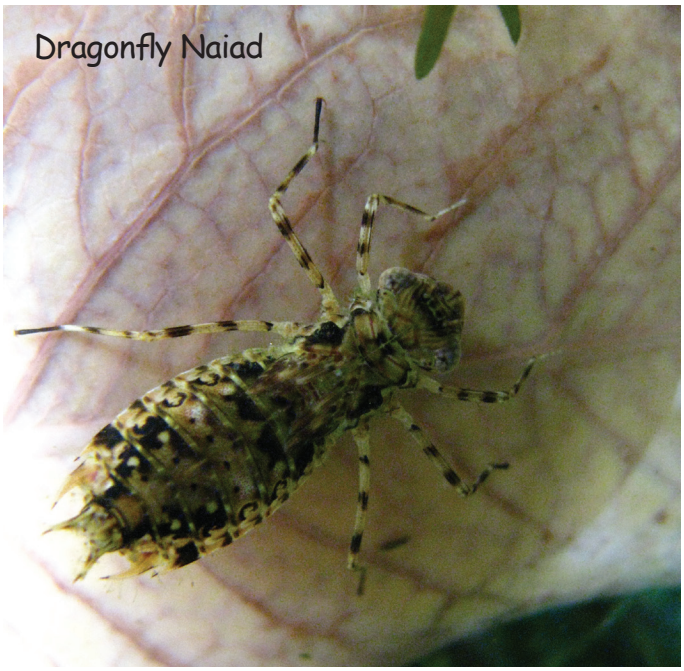
Caddisfly adults look very different from the larvae. They look like moths that have lost the scales on their wings. Long, silky hairs cover caddisfly wings. Adults are brown to yellowish-brown in color. They have big eyes and long antennae. When resting, caddisflies place their wings like a tent over their bodies. Caddisfly adults do not live long. Once they leave the water, most never eat again. They breed, lay their eggs and die. Adult caddisflies are nocturnal or active mostly at night. During the day, they hide in cool, moist places around riverbanks, lakes and ponds. At night, caddisflies often swarm around lights.

Caddisflies are very interesting insects. Look for their cases next time you are wading in a stream or pond.

Toothed Dragons

Toothed dragons are flying around Idaho! Actually they are just dragonflies and damselflies. Dragonflies and damselflies are in the insect order Odonata. Odonata comes from the Greek word for "toothed." Dragonflies have chewing mouth parts that have a serrated edge; they look a bit like teeth.

Dragonflies lay their eggs in water. The eggs hatch out into something called a naiad (NI-add). The naiad gets bigger and bigger until one day it crawls out of the water. The back on the naiad splits open, and out crawls the adult! Some species stay in the naiad stage for up to five years.



By David Eickhoff from Pearl City, Hawaii, USA (Dragonfly naiad (sp.?) Uploaded by Tim1357) [CC BY 2.0 (http://creativecommons.org/licenses/by/2.0)], via Wikimedia Commons

An amazing part of a dragonfly is the mouth. They have a powerful set of mandibles that are used to chop up their prey, but the really amazing part is the labium (LAY-bee-um). It is sort of like a lower jaw. When a dragonfly is immature and living in water, it likes to eat slimy things. Tadpoles, small fish and other insects are all on the menu. To help the dragonfly grab its slimy prey, the dragonfly can shoot the labium out to almost its body length. The labium has hooks on it so the prey can be dragged back to the mouth. As adults, dragonflies eat other flying insects. The adult dragonfly's legs point forward like a basket. The basket is used to scoop insects right out of the air. Once a dragonfly has food in its grasp, dinner is served!

Have you ever sat along a pond on a summer day and watched dragonflies zip and buzz around you? Some might swoop down a little too close for your comfort! What you are witnessing is a battle over territory or space. It's the males, not the females, madly buzzing around the pond. Some dragonflies are very territorial. They will try and chase off anything that gets too close. They will chase off dragonflies, birds, and even humans!

The largest dragonfly in Idaho is the green darner. The adults can reach a size of just over three inches. This dragonfly is a strong flyer. A group of bird watchers along the eastern coast of America saw an amazing event during the fall migration of green darners. They actually saw a green darner take down a ruby-throated hummingbird. Now that's some amazing flying!

Idaho has 67 species of dragonflies and damselflies. Get outside this summer and look for them. You can find a dragonfly just about everywhere in Idaho where there is water!

© Catherine Zinsky

© Catherine Zinsky

Meet the Mosquito

EEEEE - A high-pitched whine buzzing in your ear. You may hear it while sitting around a campfire or while playing in your backyard. Just mention mosquitoes, and the skin on some people starts to itch and crawl. Whether you love them, hate them or just tolerate them, one thing's for sure, mosquitoes are interesting insects.

There are about 2,700 species of mosquitoes in the world. They may live in hot tropical forests or cold northern lands. Mosquitoes can be found from sea level to over 10,000 feet above sea level. Although they may be found in many different places, all mosquitoes need water. Mosquitoes lay their eggs in water and develop and grow in water. They have four life stages: egg, larva, pupa and adult. All life stages of a mosquito, except for the adults, are aquatic.

Male and female mosquitoes do not look the same. Females are usually larger than males and have thin antennae. Males have bushy, hairy antennae. Mosquitoes have short lives. It takes between seven to 14 days for a mosquito egg to become an adult. Adult female mosquitoes can live several weeks. Males usually live less than a week.

© James Gathany

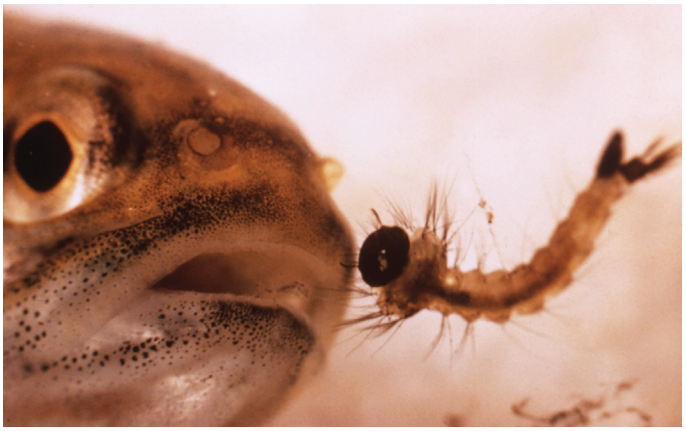
© James Gathany

Mosquitoes eat different things at different stages of their lives. Larvae eat plants. They also filter food from water. Both male and female adult mosquitoes eat nectar. Only female mosquitoes suck blood. They need a protein found in blood to make their eggs. Mosquitoes use their senses of sight and smell to find a blood meal. They see movement and infrared light given off by warm bodies. They can also smell chemicals, like carbon dioxide, on your breath, as well as smell chemicals on your skin. A mosquito can smell you when it is over 100 feet away! Have you ever noticed that mosquitoes seem to bite certain people more often? It's true. Everyone has a different smell. Mosquitoes do like the smell of some people over other people.

The tip of a mosquito's mouth has six needle-like parts for cutting and sucking. To suck blood, a mosquito slips the tip of its mouth into the skin. The mosquito then injects anticoagulants (an-ti-ko-AG-yu-lents) into the cut. This keeps the blood runny and thin, so the mosquito can suck up the blood. The anticoagulants are not supposed to be in your body. Your body tries to break up and get rid of the chemicals, causing an itchy bump.

Although mosquitoes may drive you crazy with their biting, they are an important part of nature. Mosquitoes are food for many animals. Some bats eat 600 mosquitoes in just one hour of hunting. Mosquitoes also help pollinate flowers when drinking nectar.

Next time you hear EEEEE, try to think of something positive about mosquitoes. They may irritate you with their biting, but they are important to have around.



CDC Organization

Marvelous Mayflies

Mayflies are classified in the order Ephemeroptera (e-fa-mer-OP-ter-a). This long, funny name comes from Greek words that mean "living a day." This is a good name for mayflies; as adults they only live for a few hours or days.

Mayfly adults are gray, brown or yellow in color. They have a slender abdomen that slants upward with two or three long "tails" at the end. Their front wings are large and shaped like a triangle. The wings look a bit like the sail on a sailboat. Their back wings are very small and often difficult to see. Some mayflies do not have back wings at all.

Adult mayflies have one thing to do as adults. They need to mate and lay eggs. Adult mayflies cannot eat. Their mouths are small and not made for eating. This is one reason why they die soon after becoming adults. Male mayflies gather in large swarms. They move in a kind of dance together looking for females. Females lay their eggs in different ways. It all depends on the type of mayfly. Some mayflies fly close to the water, dip their abdomen on the water surface and lay the eggs while flying. Other females lay their eggs in strands attached to plants and other things in the water. Some just lay their eggs and let the eggs fall where they may. The females will die as soon as their eggs are laid. The males die after mating.

Mayfly eggs may hatch very quickly. Some eggs will hatch as soon as they hit the water. Others may take a while longer. A naiad (NI-add) emerges from the egg. They have biting mouthparts. Most mayfly naiads are scavengers. They scrape algae from rocks in the water and eat whatever plants or tiny water animals they can find. The color of a naiad may be green or brown. Their color varies depending on what they eat! Naiads may stay in the water for up to four years. When they leave the water they molt. This mayfly is called a subimago. Subimagoes have cloudy or smoky wings. Think of them sort of like short-lived teenagers. They molt and then they are adults. The adult mayflies have clear wings. Mayflies are the only insects that molt after they have wings!

Mayflies really are marvelous. Look for mayflies in the spring and summer. They are not only seen in the month of May!

Trout Body Parts

Grade Level
2-7

Subject Areas
Science

Time
45-90 minutes

Vocabulary
adipose fin, anal fin, bile, caudal fin, digestion, dorsal fin, fin ray, gallbladder, gill arch, gill filament, gill raker, gills, kidneys, lateral line, liver, nares, operculum, pectoral fin, pelvic fin, pyloric caeca, scales, spleen, swim bladder

Summary

Students learn about trout anatomy and compare trout anatomy to human anatomy.

Objectives

Students will...

- learn basic trout anatomy
- learn some functions of trout anatomy
- compare trout and human anatomy

Materials

- *Trout Body Parts* illustration with anatomy labeled, projected for class to see or one per student
- *Trout Body Parts* worksheet, one per student
- *What do trout and people have in common?* Venn diagram worksheet, one per student
- Colored pencils

Background

Even though trout and humans are fairly different creatures, the two do have some organs and body features that are very similar. Similarities include:

- bones
- muscles
- skin
- teeth
- brain
- heart
- kidney
- liver
- gall bladder
- stomach
- spleen
- intestine

Although trout and humans may have some of the same organs, the design and functions of the organs may be different. Below is more information on some trout anatomy.

Skin and Scales

Trout have a specific type of scale known as a cycloid scale. These oval-shaped scales are quite thin and partially embedded in the skin in an overlapping pattern. They are only found on fish for which speed and reduced friction are essential. Thin scales help with buoyancy, because they are light. The thinness increases speed, but does not shield the trout from predators. Growth rings are deposited throughout the year, similar to the growth rings of a tree.

Fins

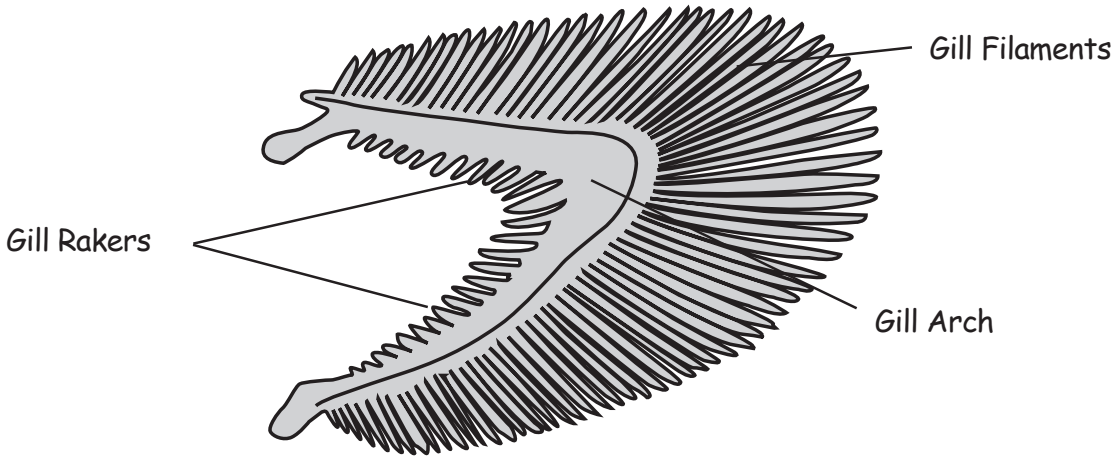
Fins are used to move, steer, stop and maintain position. Most fins are composed of fin rays covered by skin. The fin rays provide support and are necessary for fin movement. Trout have three unpaired fins: dorsal fin, anal fin and caudal fin. The dorsal and anal fins are essential in helping the fish stay upright. The caudal fin is the 'tail' of the fish and thrusts the fish through the water. It also acts as a rudder to steer the fish. Trout also have two paired fins: pectoral fins behind the gills and pelvic fins below and behind the pectoral fins. The pectoral fins act as brakes and help with side-to-side movement. The pelvic fins help with up and down movement. Trout also possess an adipose fin which lacks fin rays. It is believed to help reduce drag and improve swimming efficiency.

Mouth

The trout's mouth is covered in teeth. Teeth are even found on the roof of the mouth and on the tongue! All of these teeth are not used for chewing but are instead used for grabbing prey.

Gills

Trout take in oxygen and give off carbon dioxide, just like humans. However, they have gills to extract oxygen from water and to eliminate carbon dioxide and other gasses back into the water. Opercula are hard plates that cover the fragile gills on each side of the head. Trout take in water through the mouth and as water runs along the gills, the opercula open to allow the water to pass out of the fish. Gills are composed of four gill arches; each arch has both gill rakers and gill filaments. The gill filaments are where the exchange of gasses occurs. Water with oxygen in it passes over the thin skin of the gill filaments and into the blood stream. Carbon dioxide passes out of the blood and into the water. Gill rakers are bony projections which point forward and inward from the gill arches. They strain particles from the water to prevent injury and help strain out potential food, such as plankton.



Lateral Line

Have you ever wondered how a school of fish manages to move together so smoothly and quickly? The lateral line allows each fish to instantly sense a change in water pressure and stay in-line with the rest of the school. The lateral line is a series of sensory pores along the midline of each side of a fish. Trout use this feature to detect movement and vibrations in the water. The lateral line also allows them to sense objects in their path and sense certain chemicals in the water. Trout have one lateral line on each side of the body, unlike some other species of fish that have two.

Eyes

With eyes on the sides of their head, rainbow trout can see in front, on the sides and most of the way behind them. Triangular shaped pupils also help them to see in front, to the side and behind their bodies. Trout do not have eye lids but have a thicker cornea than we do. Trout have large pupils which allow light to enter the eyes. Their pupils do not constrict with an increase in ambient light, which is probably why trout tend to stay away from sunny areas. It is believed that fish can see colors. Fish retinas contain both rods which help see in dim light and cones which help detect color.

Nare or nose

Nares are located on each side of the snout. They are a closed sac. The nares are covered with flaps that guide water into the nasal sac, which contains the smell receptors. Sense of smell is important to fish. They can detect the smallest change in the smell of water. It is the sense of smell that guides migratory fish back to their natal waters.

Ears

While trout don't have external ears, they do have internal ears. It is believed that because sound moves so quickly through water fish do not need an external opening to "catch" sounds like humans. The inner ear is composed of chambers that contain small pieces of bone. As the trout moves through the water, the bones move and hit against nerve endings sending messages to the brain. A trout's inner ear is also an organ of equilibrium, helping the fish keep its balance and stay upright.

Skeletal and Muscular Systems

The skeletal and muscular systems are closely linked, providing physical support and overall shape to trout. Muscular contractions, made possible by the backbone's support, make the body bend for swimming and turning and enable the fish to put on the sporadic bursts of speed often needed to catch its food. Muscles constitute 40% of a fish's weight. Similarly, an average human adult male is made up of 40-50% of skeletal muscle, and an average adult female is made up of 30-40%.

Brain

The trout's brain is encased in a bony skull. The brain can be broken down into different lobes. The olfactory lobe processes information from the nares; the optic lobe processes information from the eyes. The cerebellum controls muscle movement, and the medulla oblongata controls vital processes, such as heart rate and respiration. Just as in humans, nerves send impulses to the brain, which reacts to stimuli.

Heart

A trout's heart is located at the base of the throat in front of the abdominal cavity. Trout have a single pass circulatory system in which blood goes from the heart to the gills and then to the rest of the body. This differs from our circulatory system, called a dual pass circulatory system. Our circulatory system sends blood to the heart twice in one pass through the body—from the heart to the lungs, back to the heart, and then to the rest of the body.

Spleen

Unlike warm-blooded animals, fish lack bone marrow. Fish make blood cells in the kidney and the spleen. The spleen makes and stores blood.

Kidney

The kidney's main function is to clean the blood, but it also helps in blood formation. The kidney first develops in the trout embryo as a pair of structures. The pair unites in the adult trout to become one obvious organ. Because the trout kidney is primitive, it is incapable of excreting nitrogenous wastes like ammonia. Instead, a part of these compounds is deposited under the skin of the fish in the form of guanine. It is this guanine that reflects light and renders the fish silvery.

Swim Bladder

The swim bladder is a long, thin sac located underneath and parallel to the kidney. It gives the fish buoyancy and allows the fish to move up and down in the water. Trout inflate the swim bladder by taking in air through the mouth and forcing it through a duct into the bladder. They can deflate the swim bladder by 'burping' out air. This allows the fish to sink in the water.

Stomach

Trout have a J-shaped stomach. The stomach is broken down into two regions: the cardiac and pyloric regions. The cardiac region, near the heart at the top of the stomach, releases enzymes and acid to aid in digestion. The pyloric region, at the back of the stomach, grinds and pushes the food into the intestine.

Pyloric caeca

At the junction of the stomach and intestine, there are hollow, finger-like projections called pyloric caeca. It is similar in function to our small intestine. This is the primary place that digestion and absorption of nutrients take place.

Intestine

The last place nutrients can be absorbed from food before food wastes leave the body.

Liver

The liver is in front of the stomach. It produces bile, a green fluid released into the intestine to neutralize stomach acids. Bile helps in the digestion of fat.

Gall Bladder

The gall bladder is a round dark-purple or greenish sac. It sits on top of the liver and stores bile.

Procedure

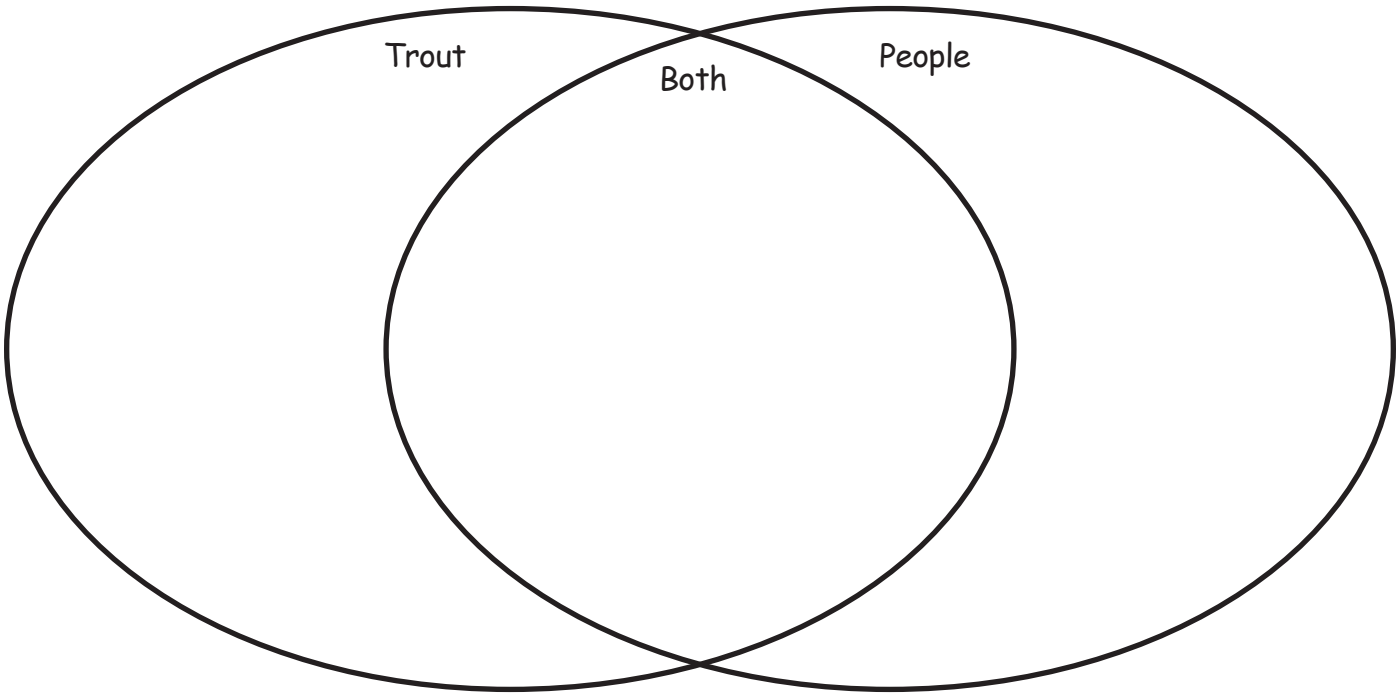
1. Start a discussion with the students asking them what organs or body parts they have that help them to survive? Do they know the function and purposes of these body parts? Make a list of the body parts and functions/purposes mentioned by the students.
2. Do trout have the same organs and body parts as people? Discuss some of the differences that the students bring up.
3. Pass out the Venn diagram. What do trout and people have in common? Depending on the level of your students, have students complete the diagram individually or complete the diagram together as a class.
4. Tell the students that they are going to be learning more about trout organs and body parts and their functions and purposes. Project the Trout Body Parts diagram for all students to see or give each student their own copy.
5. Go over the organs and body parts on the diagram discussing their functions and purposes. Have students take notes where appropriate. Discuss similarities and differences that the students bring up and help discussions as needed.
6. Once all organs and body parts have been discussed, pass out a *Trout Body Parts* worksheet to each student. Have students complete the worksheet. Depending in the level of your students, you may want to have the students complete the worksheet in groups or use their notes.

Evaluation

Check the Venn diagram and *Trout Body Parts* worksheet for accuracy.

What do trout and people have in common?

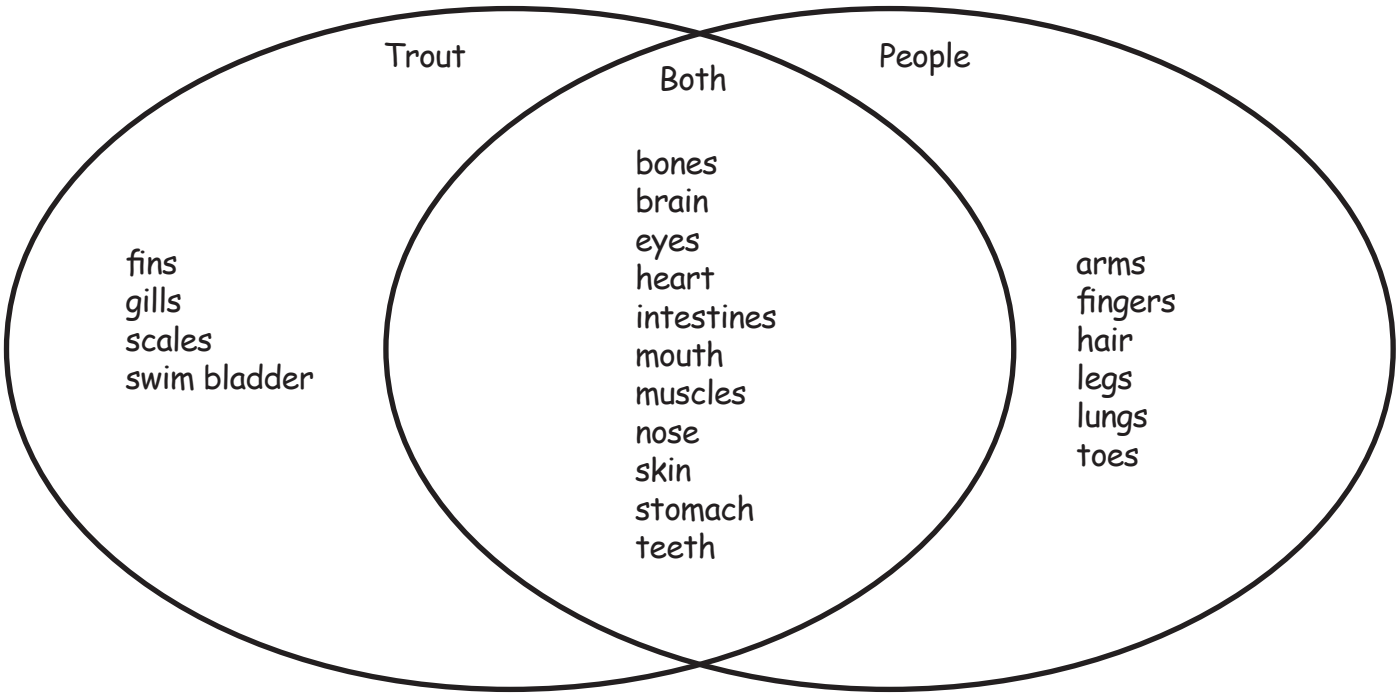
Look at the list of body parts below. Is the part found on the bodies of trout, people or both trout and people? Write the name of the body part in the correct space.



arms	eyes	gills	intestines	mouth	scales	swim bladder
bones	fingers	hair	legs	muscels	skin	teeth
brain	fins	heart	lungs	nose	stomach	toes

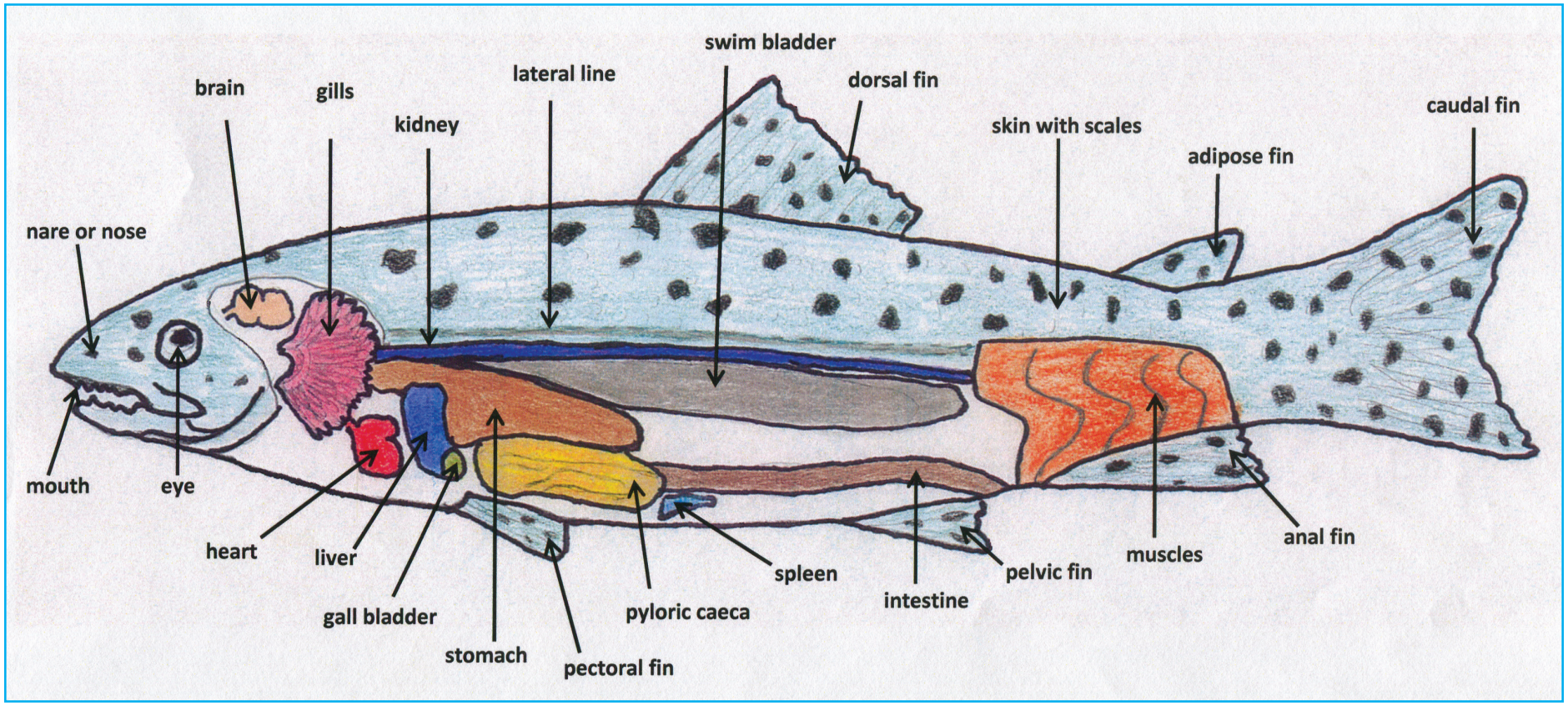
What do trout and people have in common? Answers

Look at the list of body parts below. Is the part found on the bodies of trout, people or both trout and people? Write the name of the body part in the correct space.

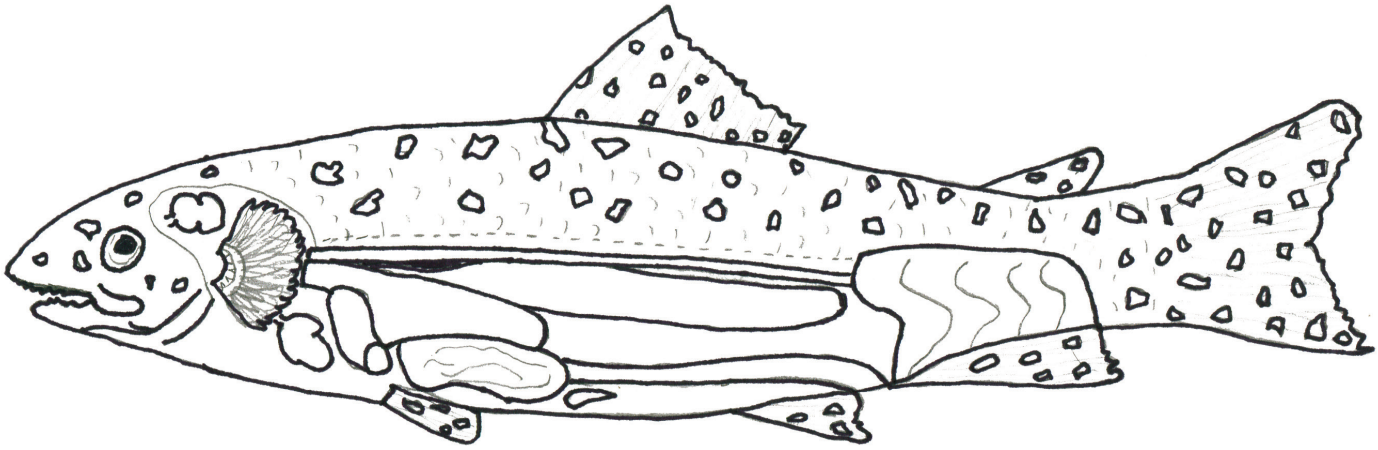


arms	eyes	gills	intestines	mouth	scales	swim bladder
bones	fingers	hair	legs	muscels	skin	teeth
brain	fins	heart	lungs	nose	stomach	toes

Trout Body Parts



Trout Body Parts



_____ This covers the outside of the trout. It has scales that protect the fish. Color it green.

_____ These help camouflage the trout against rocks. Color them black.

_____ These get oxygen out of the water. Color them bright pink.

_____ This pumps blood through the body. Color it red.

_____ This is the control center for a trout. It controls all vital functions. Color it light pink.

_____ This cleans the blood. Color it purple.

_____ This helps a fish move up and down in the water. Color it gray.

_____ This is where digestion starts. Color it light brown.

_____ This makes bile which helps with digestion. Color it blue.

_____ This acts like a small intestine. Color it yellow.

_____ This stores bile. Color it light green.

_____ This absorbs nutrients. Color it dark brown.

_____ This makes and stores blood. Color it light blue.

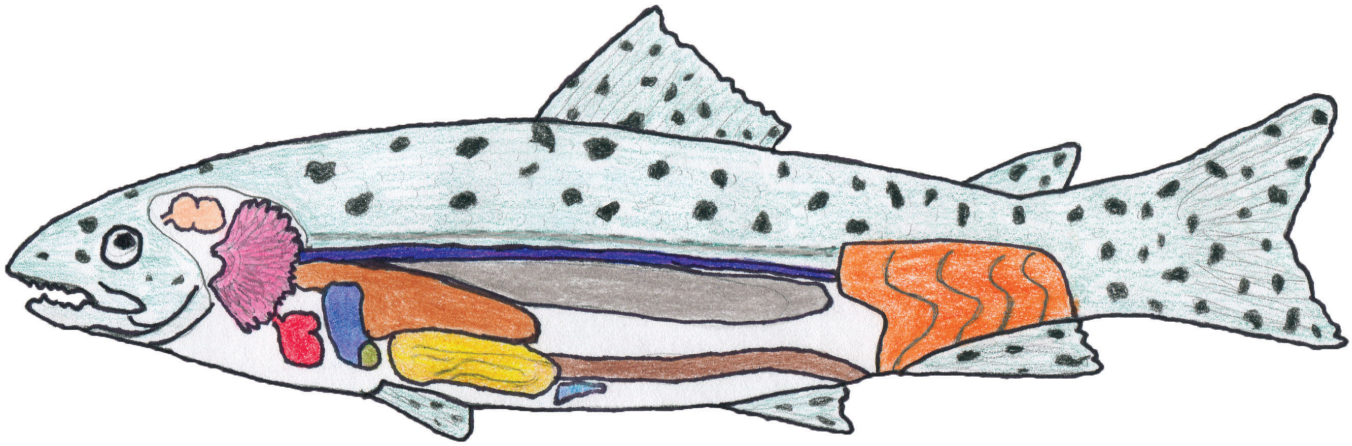
_____ These are found under skin. They move and bend a trout's body. Color them orange.

_____ This feels vibrations in the water. Color it gray.

Word Bank

brain	gall bladder	gills	heart	intestine
kidney	lateral line	liver	muscles	pyloric caeca
skin	spleen	spots	stomach	swim bladder

Trout Body Parts Key



skin _____ This covers the outside of the trout. It has scales that protect the fish. Color it green.

spots _____ These help camouflage the trout against rocks. Color them black.

gills _____ These get oxygen out of the water. Color them bright pink.

heart _____ This pumps blood through the body. Color it red.

brain _____ This is the control center for a trout. It controls all vital functions. Color it light pink.

kidney _____ This cleans the blood. Color it purple.

swim bladder This helps a fish move up and down in the water. Color it gray.

stomach _____ This is where digestion starts. Color it light brown.

liver _____ This makes bile which helps with digestion. Color it blue.

pyloric caeca This acts like a small intestine. Color it yellow.

gall bladder This stores bile. Color it light green.

intestine _____ This absorbs nutrients. Color it dark brown.

spleen _____ This makes and stores blood. Color it light blue.

muscles _____ These are found under skin. They move and bend a trout's body. Color them orange.

lateral line This feels vibrations in the water. Color it gray.

Word Bank

brain	gall bladder	gills	heart	intestine
kidney	lateral line	liver	muscles	pyloric caeca
skin	spleen	spots	stomach	swim bladder

Trout Dissection

Grade Level
4-12

Subject Areas
Science

Time
45-90 minutes

Vocabulary
adipose fin, anal fin, bile, caudal fin, circulatory system, circuli, cycloid scale, digestion, digestive system, dissect, dorsal fin, excretory system, fin ray, gallbladder, gill arch, gill filament, gill raker, gills, kidneys, lateral line, liver, nares, nervous system, operculum, osmoregulation, pectoral fin, pelvic fin, pyloric caeca, reproduction, respiration, scales, skeletal system, spleen, swim bladder, vent, vertebrate

Summary

Students dissect a trout and observe its external and internal anatomy.

Objectives

Students will...

- explore the internal and external anatomy of a trout
- explain the function of fish organs and body parts
- compare a trout's anatomy to that of a human

Materials

- fresh whole trout, 1 for every group of 2 to 4 students
  - Your TIC mentor may have ideas on how to obtain trout or contact a local hatchery for donations.
- Trout Dissection PowerPoint, included on USB drive - This PowerPoint may also be used to do a "virtual dissection" if you cannot or choose not to do an actual trout dissection.
- *Fish Anatomy* sheet, one per student
- *Trout Anatomy Reference Sheet,* one per student if needed
- dissecting scissors, work best
- scalpels or very sharp, thin, flexible knife
- tweezers or forceps
- newspapers
- paper towels
- magnifying glasses
- microscope, optional
- latex gloves
- *Trout Anatomy Crossword,* one per student

Background

The term anatomy refers to the structure of living things or any of their parts. Generally, each cell, tissue and organ of a living being has a specific function. For example, our opposable thumb is a digit that allows the hand to refine its grip and hold objects it may not be able to do otherwise.

External Anatomy

Coloring

Despite all of a trout's amazing adaptations to aquatic life, perhaps its most notable feature is its coloring.

Rainbow trout are so-called because of their red lateral stripe. These trout (of the *Oncorhynchus* genus) have black spots against a light background. A trout's appearance will vary from stream to stream, as water temperature and diet both affect its coloration.

Scales

Trout look so smooth that you might think they do not even have scales. Trout have a specific type of scale known as a cycloid scale. These scales are quite thin and partially embedded in the skin in an overlapping pattern and are only found on fish for which speed and reduced friction are essential. Thin scales provide an advantage in regulating buoyancy, because they are light. The thinness increases speed, but does not shield the trout from predators. A trout's scales are oval and have growth rings (circuli) that are similar to a tree's annual rings and are deposited throughout the year.

Fins

Fins are appendages used by fish to move, steer, stop and maintain position. Most fins are composed of fin rays covered by skin. The fin rays provide support and are necessary for fin movement. Trout have three unpaired fins: dorsal fin, anal fin and caudal fin. The dorsal and anal fins are essential in helping the fish stay upright. The caudal fin is the 'tail' of the fish and thrusts the fish through the water. It also acts as a rudder to steer the fish. Trout also have two paired fins: pectoral fins behind the gills and pelvic fins below and behind the pectoral fins. The pectoral fins act as brakes and help with side-to-side movement. The pelvic fins help with up and down movement. Trout also possess an adipose fin which lacks fin rays. It is believed to help reduce drag and improve swimming efficiency. This fin is often cut off by hatcheries as a means of distinguishing hatchery raised salmon from wild populations.

Mouth

The mouth is an important tool for feeling objects. The trout's mouth is covered in teeth. Teeth are even found on the roof of the mouth and on the tongue! All of these teeth are not used for chewing but are instead used for grabbing prey. By looking down the mouth of a trout, you can get a great view of the gills.

Gills

Trout take in oxygen and give off carbon dioxide, just like humans. However, they have gills to extract oxygen from water and to eliminate carbon dioxide and other gasses back into the water. Opercula are hard plates that cover the fragile gills on each side of the head. Trout take in water through the mouth and as water runs along the gills, the opercula open to allow the water to pass out of the fish. Gills are composed of four gill arches; each arch has both gill rakers and gill filaments. The gill filaments are where the exchanging of gasses occurs. Water with oxygen in it passes over the thin skin of the gill filaments and into the blood stream. Carbon dioxide passes out of the blood and into the water. Gill rakers are bony projections which point forward and inward from the gill arches. They strain out unwanted particles from the water to prevent injury and help strain out potential food, such as plankton.

Sensory Organs

Lateral Line

Have you ever wondered how a school of fish manages to move together so smoothly and quickly? The lateral line allows each fish to instantly sense a change in water pressure and stay in-line with the rest of the school. The lateral line is a series of sensory pores along the midline of each side of a fish. Trout use this feature to detect movement and vibrations in the water. The lateral line also allows them to sense objects in their path and sense certain chemicals in the water, including pheromones (special chemicals given off to attract a mate). Scales along the lateral line are unlike any other scales on the fish. They have small channels that allow water to flow along the sensory structures of the organ. Trout have one lateral line on each side of the body, unlike some other species of fish that have two.

Vision

With eyes on the sides of their head, trout can see in front, on the sides and most of the way behind them. Triangular shaped pupils also help them to see in front, to the side and behind their bodies. Trout do not have eye lids but have a thicker cornea than we do. Trout have large pupils which allow light to enter the eyes. Their pupils do not constrict with an increase in ambient light, which is probably why trout tend to stay away from sunny areas. It is believed that fish can see colors. Fish retinas contain both rods which help see in dim light and cones which help detect color. Additionally, it seems fish are more attracted to brightly colored lures than those that are dull in color. The optic lobes of a fish's brain are relatively large in comparison to the rest of the brain, proving how vital sight is to the fish and its survival.

Smell

Nares are the olfactory organs located in the snout of the trout. The nares are covered with flaps that guide water into the nasal sac, which contains the smell receptors. Sense of smell is important for migratory species. Migratory fish become imprinted on the smell of the stream where they were born. They follow smells to find their way home to spawn.

Ears

While trout don't have external ears, they do have internal ears. It is believed that because sound moves so quickly through water fish do not need an external opening to "catch" sounds like humans. The inner ear is composed of chambers that contain small pieces of bone. As the trout moves through the water, the bones move and hit against nerve endings, sending messages to the brain. The otolith is a free-floating oval-shaped bone in the ear often used to accurately age fish. Growth rings can be clearly distinguished on these bones similar to rings on scales. A trout's inner ear is also an organ of equilibrium, helping the fish keep its balance and stay upright.

Internal Anatomy

Skeletal and Muscular Systems

The skeletal and muscular systems are closely linked, providing physical support and overall shape to trout. Muscular contractions, made possible by the backbone's support, make the body bend for swimming and turning and enable the fish to put on the sporadic bursts of speed often needed to catch its food. Muscles constitute 40% of a fish's weight. Similarly, an average human adult male is made up of 40-50% of skeletal muscle, and an average adult female is made up of 30-40%.

Circulatory System

A trout's heart is located at the base of the throat in front of the abdominal cavity. The trout has a single pass circulatory system in which blood goes from the heart to the gills and then to the rest of the body. This differs from our circulatory system, called a dual pass circulatory system. Our circulatory system sends blood to the heart twice in one pass through the body – from the heart to the lungs, back to the heart, and then to the rest of the body. Unlike warm-blooded animals, fish lack bone marrow. Fish make blood cells in the kidney and the spleen.

Swim Bladder

Energy expenditure is kept to a minimum by maintaining neutral buoyancy, which trout do by means of the swim bladder. The swim bladder is a long, thin sac located underneath and parallel to the kidney. Trout inflate the swim bladder by taking in air through the mouth and forcing it through a duct into the bladder. Conversely, they can deflate the swim bladder by 'burping' out air. This allows the fish to sink into deeper waters.

Digestive System

Trout have a simple digestive system, beginning with their mouth. A trout's mouth is covered with short, pointed teeth to help it hold larger prey (not to chew). The teeth are slanted toward the throat to prevent any prey from escaping. Food passes from the mouth through the esophagus and to the J-shaped stomach. The stomach is broken down into two regions: the cardiac and pyloric regions. The cardiac region, near the heart at the top of the stomach, releases enzymes and acid to aid in digestion. The pyloric region, at the back of the stomach, grinds and pushes the food into the intestine. At the junction of the stomach and intestine, there are hollow, finger-like projections called pyloric caeca. It is similar in function to our small intestine. This is the primary place that digestion and absorption take place. The liver is a large, dark red or brown organ located in front of the stomach. The liver produces bile, a green fluid released into the intestine via the bile duct, to neutralize stomach acids. The gallbladder, a round dark-purple or greenish sac, sits atop the liver and stores bile.

Nervous System

As in most vertebrates, the trout's nervous system is made up of the brain, spinal column, and nerves. The trout's brain is encased in a bony skull. The brain can be further broken down into different lobes. The olfactory and optic lobes of the brain process information from the nares and eyes. The cerebellum controls muscle movement, and the medulla oblongata controls vital processes, such as heart rate and respiration. Just as in humans, nerves send impulses to the brain, which reacts to the stimuli.

Excretory System

The byproducts of metabolism and digestion are removed from the body by both the excretory system and structures of the respiratory system. The excretory system works to excrete urine while ammonia is excreted via the respiratory system. It is diffused from the gill filaments during respiration.

The kidney is the main excretory organ, although it also serves in the processes of osmoregulation (see below) and blood formation. It develops in the trout embryo as a set of paired structures, which unite in the adult trout to become one obvious organ, dark-brown to purple-black in color. It is located beneath the vertebral column in the abdominal cavity. Because the trout kidney is primitive, it is incapable of excreting nitrogenous wastes like ammonia. Instead, a part of these compounds is deposited under the skin of the fish in the form of guanine. It is this guanine that reflects light and renders the fish silvery.

Osmoregulation

Osmoregulation is the regulation or balance of bodily fluids and water so that internal fluids do not become too diluted or too concentrated. Why is this so important to trout? Trout are constantly absorbing water through the gills and skin. Additionally, salts are always leaving their bodies due to simple diffusion from a high concentration (in the trout's body) to a low concentration (the stream). To achieve a balance, trout rid their body of excess water by producing large quantities of dilute urine. To fight the loss of salt, a trout takes in sodium and chloride through the gills and from food through the wall of the gut. Osmoregulation is essential to anadromous fish, such as salmon and steelhead, that migrate between freshwater and saltwater.

Reproductive Structures

Increase in day length and rising water temperatures are two important factors that influence the full development of the reproductive structures. Rainbow trout can attain sexual maturity in one year, but usually require two or three. The gonads, or reproductive organs (testes and ovaries), can be identified easily in adult trout. Both ovaries and testes are paired structures suspended from the back (dorsal side) of a trout by a thin membrane. The male reproductive glands are off-white in color and smooth in texture, consisting of tubules that contain semen. In females, the ovaries produce ova, which are extruded through a pore in front of the urinary opening. If you have received a trout to dissect from your local hatchery, your fish is most likely sterile and will not have any reproductive organs.

Advance Preparation

Prepare work stations where two to four students can work together. Cover work stations with newspaper. Place fish, dissection tools, tweezers, magnifying glass, gloves and fish anatomy diagrams at each station. If you only have one trout, choose a location where all students can view the dissection clearly. Cover the surface with newspaper and prepare all the materials in a convenient area. Display the diagram of a fish's external and internal anatomy on the board or hand out copies of the diagrams for the students.

Procedure

Use the *Trout Dissection PowerPoint* found on the USB drive to help guide students through the dissection or use the PowerPoint for a virtual dissection.

Slide 1: Observe the whole fish.

- **Shape:** Have students describe the fish's overall shape and how this is beneficial to the trout.
    - Trout are torpedo-shaped and streamlined to help them swim fast.

Slide 2: Observe the whole fish. Fish are generally divided into three main sections: head, trunk, tail.

- **Slime:** Have students feel the fish's skin and discuss what purpose the slime serves.
    - It protects fish from fungus, parasites and diseases. It has some antibacterial properties.
    - Slime is also an anti-abrasive, helping fish slip over rocks and lubricant, enabling ease of movement through water.
- **Color Pattern:** Discuss the function of coloration and the advantages of being dark on top and light on the belly. Why does the fish have spots?
    - The dark on top camouflages the trout with the stream bed from predators above the water (such as eagles or osprey). The color of its belly camouflages it from predators below the fish (such as otters).
    - Spots help camouflage it among the rocks.
    - Young trout have vertical stripes (parr marks) when they are a couple inches long. Eventually the vertical stripes fade and spots appear.

Slide 3: Fins: Look at the placement of the fins. Imagine the fish swimming in the water. How does it move? How are the fins used? Note the range of movement of each fin – pectorals can rotate 180° while other fins are not as flexible.

- **Fin Rays:** Only fins with bony rays can move. The rays are attached to muscle in the fish. Allow students to feel the bony rays that support the fins.
- **Identify each fin:**
    - **Dorsal**: The dorsal fin helps to keep the fish upright when turning abruptly and helps in steering.
    - **Pectoral**: Pectoral fins help balance the fish, keep it level and prevent it from rolling from side to side. They also help the fish with maneuverability, steering and controlling depth.
    - **Pelvic**: Pelvic fins help balance the fish, keep it level and prevent it from rolling from side to side. They also help the fish maneuver through the water.
    - **Anal**: The anal fin helps to stabilize the fish like the keel on a boat. It also helps to steer and prevent the fish from rolling over in sharp turns.
    - **Caudal**: The caudal fin provides the power to move the fish forward and acts as a rudder to steer.
    - **Adipose**: The function of the adipose fin is being studied by biologists. It is believed to help prevent drag and improve swimming efficiency.

Slide 4: External Anatomy

- **Scales:** Use a magnifying glass to see how the scales are arranged. Why do fish have scales? Do fish have the same number of scales their whole lives?
    - Scales are not very thick, but they offer protection for the fish, kind of like a thin suit of armor.
    - Trout have cycloid scales. They have the same number of scales their whole life. They build growth rings on their scales similar to the rings of a tree.
- **Lateral Line:** Observe the lateral line. Discuss its purpose and how it works.
    - The lateral line is a sensory organ (series of pores or holes) running along the midline of the fish on each side.
    - It is used to detect vibrations in the water, water pressure, avoid objects, and sense certain chemicals in the water, including pheromones or special chemicals given off to attract a mate.
- **Operculum:** The operculum is a bony plate which protects the gills. Opercula is plural.

Slide 5: External Anatomy – Nare and Teeth

- **Nare or Nostril:** Locate the nares. They are closed sacs which contain smell receptors or nerves in the lining of the sac. Water enters the sac and chemicals (smells) are detected by sensitive nerves. Sense of smell is important to trout.
    - Trout and salmon use their sense of smell to navigate to their natal streams to spawn.
    - Smell may also help fish find food and avoid predators.
- **Teeth:** Have students feel the teeth along the gums and on the roof of the mouth. Ask students

what function the teeth perform. Are they used for chewing?

- Teeth are used for grasping and holding prey, not chewing.

Slide 6: Mouth Have the students pick the fish up and look at the open mouth. Note the color of the gums. Rainbow and steelhead will have light colored gums. Make a note on how wide the mouth can open and have the students comment on why this is so.

- **Tongue:** Have the students feel the trout's tongue. Is it similar to our tongues?
  - The tongue has teeth on it to help grasp prey and to help swallow prey.
- **Esophagus:** Food passes through the esophagus to the stomach.
- **Gill Arches and Gill Rakers:** Point out the gill arches and rakers.
  - **Gill Arches –** Use a probe to separate the arches and explore how they are arranged. Gill arches support the gill filaments.
  - **Gill Rakers –** Bony projections along the inside curve of the gill arches. Strain particles out of the water to keep the gills from being injured and help strain out potential food, like plankton.

Slide 7: Eye

- **No Eyelid:** Note there is no eyelid. Have the students observe the tough, clear membrane that covers the eye.
- **Eye Movement:** Rotate the eye in the eye socket with your finger and notice the range of movement. Trout can move each eye independently.

Slide 8: Eye Remove an eye by cutting the tissue behind it, holding it in the bony socket.

- **Eye size:** Note the size of the eye. What does this tell us?
  - Tells us how important vision is to trout.
- **Pupil:** Note the triangular-shaped pupil. This lets as much light as possible enter the eye.

Slide 9: Lens Slice into the eye and remove the lens. You may have to squeeze the eye a bit to locate the lens. The lens is a small, hard ball in the center of the eye. Why do the students think it is round?

- The round lens allows the fish to see in all directions at the same time.
- Humans have a lens that is fairly flat or dish-shaped. Our eyes are capable of changing the curvature of the lens to focus at varying distances —flatter for long-range focusing and more curved for shorter range distances.

Slide 10: Expose Gill Tissue Place the fish on its side. Lift the operculum and look at the gills. Cut the operculum away from the base, exposing the gills.

Slide 11: Gills Point out the gill arches, gill rakers and gill filaments.

- **Gill filaments:** Observe the large surface area provided by the gill filaments and the thin tissue which allows blood vessels to come into contact with oxygen in the water. Compare and contrast gills with lungs.

Slide 12: Expose internal organs

- Carefully cut the fish open using scissors. Cut from the gills under the lateral line, down to just past the vent. Cut the flap of flesh from the belly of the fish.

Slide 13: Internal Anatomy Before moving any organs, let the students observe how all the organs fit together. Look for the thin transparent membrane that encloses the organs. Point out the location of the organs.

Slide 14: Swim Bladder Look for the swim bladder. It is made of very thin tissue and is located in the upper body cavity, below the kidneys. It will be less developed in small fish and may be difficult to find. It may not be inflated or may have been damaged while opening the body cavity. Point to its location and discuss its function.

Slide 15: Kidneys Place the fish on its back and locate the kidneys just under the backbone. It will appear there is one kidney, but there are actually two kidneys fused together. They are thin, dark in color and run the whole length of the body cavity. Discuss with the students how kidneys function to clean the blood stream and make blood. Unlike mammals, fish do not have bone marrow to produce blood cells. They make blood cells in the kidney and spleen.

Slide 16: Digestion Note the location of the digestive tract before disturbing the organs. Look for fat deposits in the body cavity and discuss the importance of fat reserves, especially for migrating fish.

Slide 17: Path of Digestion Investigate the digestive tract by starting in the mouth and following the route that food would take.

- **Esophagus:** Put a probe in the esophagus to show the beginning of the route. Follow the path of digestion with your finger to the stomach.
- **Cardiac Stomach:** This is where digestion begins.

- **Pyloric Stomach:** This area of the stomach is made of different tissue than the cardiac stomach.
- **Intestines:** The intestines provide the last chance to extract nutrients from food. Notice the network of blood vessels which are used for nutrient exchange.
- **Vent:** Waste is eliminated out of the body at the vent.

Slide 18: Cardiac Stomach Remove the cardiac stomach and carefully cut it open. Discuss the folds and rolls of tissue in the lining of the stomach. What purpose do they serve?

- The folds increase surface area for digestive enzymes. Strong muscles in the sides of the stomach push food toward the pyloric region of the stomach.

Slide 19: Pyloric Stomach: The pyloric region grinds and pushes food into the intestines. The pyloric caeca are the finger-like projections found at the junction of the stomach and intestines. This is the primary place where digestion and absorption take place. Discuss how much the pyloric caeca projections increase the area for absorbing nutrients, sugars and proteins.

Slide 20: Liver The liver is in front of the stomach. Discuss the liver's role in digestion. It manufactures bile which digests fat.

Slide 21: Gall Bladder The gall bladder is connected to the liver and stores bile.

Slide 22: Spleen The spleen is found under the stomach area. It is a reddish-purple organ that makes and stores blood.

Slide 23: Heart and Gills You may have to move the liver to the side to locate the heart. Why are the heart and gills located so closely to each other?

- The closeness of the heart and gills is no accident. Blood pressure is best near the heart, the pump. Blood absorbs oxygen from the gills then is sent to the rest of the body.

Slide 24: Heart Trout have a single pass circulatory system. Blood goes from the heart to the gills and then to the rest of the body. There are three main parts of the heart.

- **Bulbus arteriosus:** Main artery leading from the heart.
- **Atrium:** Receives the blood.
- **Ventricle:** Pumps the blood to the gills and body.

Slide 25: Inside of Heart Cut the heart in half to see the chambers. This must be done carefully with a sharp scalpel.

Slide 26: Expose the Brain This can be tricky to do. Hold the fish head upright and cut across the back of the head (Draw an imaginary line across the fish's back to connect the opercula.) Cut down a little bit at a time until the light-pink spinal cord is exposed. Use the spinal cord as a guide to find the skull. Carefully cut the top of the skull and pull back the sides with your fingers. The brain is light-pink. Carefully remove the brain if you can.

Slide 27: Brain The brain is the control center for the fish. There are three parts readily seen.

- **Medulla Oblongata:** Controls vital functions such as respiration and heartbeat.
- **Cerebellum:** Controls higher functions such as muscle movements to chase prey.
- **Olfactory and Optic Lobes:** Process information from nares and eyes.

Evaluation

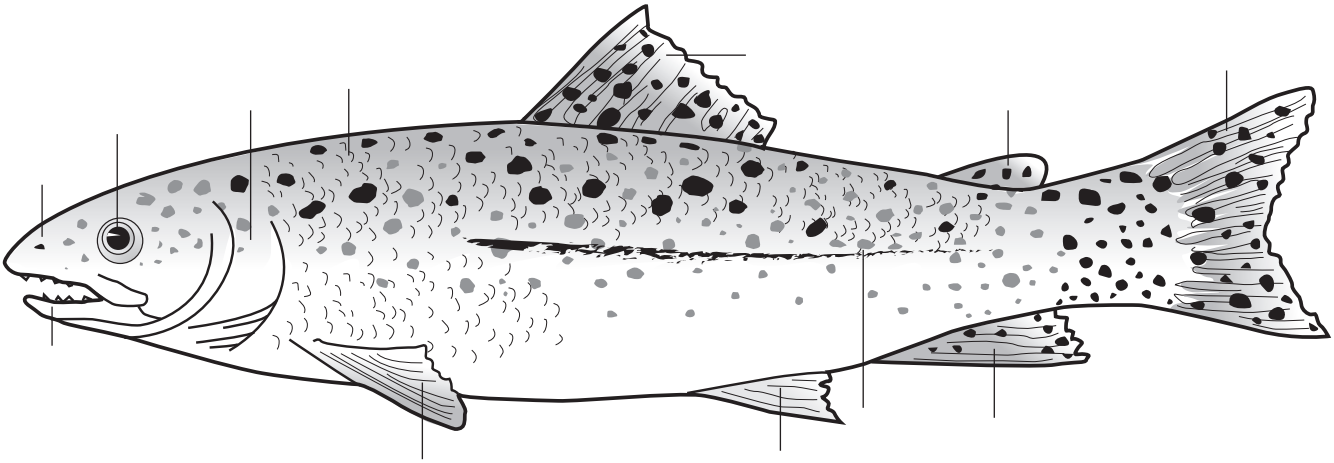
- Discuss with students how the trout's body parts and functions compare to a human's. Create a chart comparing organ purpose in each organism. Reference the *Fish Anatomy Reference Sheet* as needed.
- Have students label the organs on the *Fish Anatomy Worksheet* and include the diagram in their journals for future reference.
- Complete the *Trout Anatomy Crossword.*

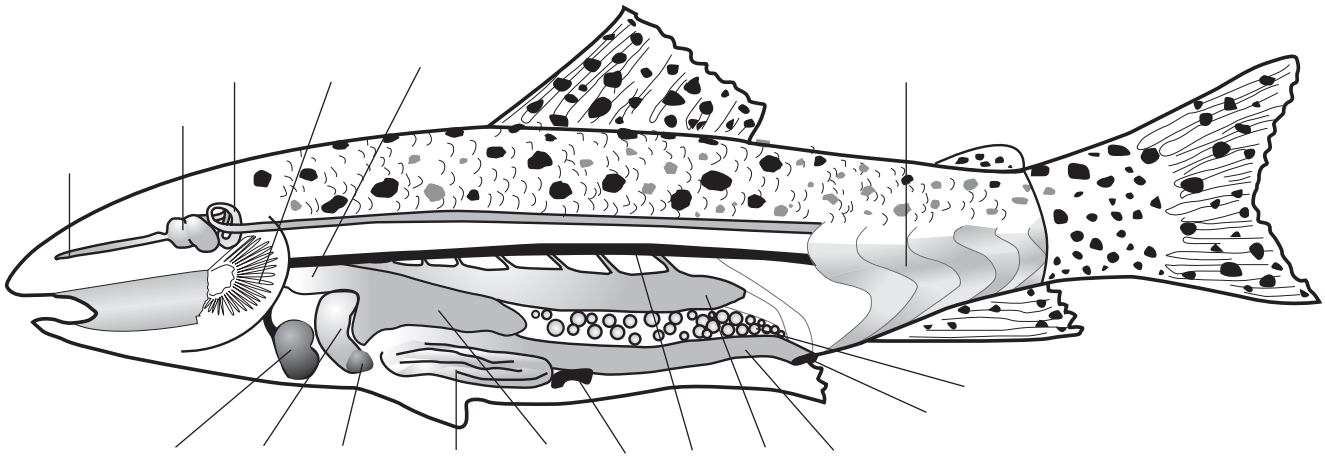
Trout Anatomy Reference Sheet

	Part	What?	Where?	Why?
External Anatomy	Slime	Clear coating	All over body	To protect from fungus and parasites; to lubricate and help speed through water
	Scales	Small, round, thin pieces of bone-like material	All over body	To provide armor-like protection
	Lateral line	Series of sensory pores	Running along each side, from operculum to tail	To sense water movement and chemicals in water
	Dorsal fin	Rayed fin	Along back	To keep fish upright when turning, help with steering
	Adipose fin	Small, fleshy fin	Between dorsal and caudal fins	Believed to help prevent drag and improve swimming efficiency
	Caudal fin	Rayed fin	At tail of fish	To power through the water and act as a rudder
	Anal fin	Rayed fin	On underside, last fin before the tail	To keep from rolling onto side, adds stability like the keel of a boat
	Pectoral fins	Pair of rayed fins	Directly behind the gills	Balance fish and keep level, help maneuver, steer and control depth
	Pelvic fins	Pair of rayed fins	Behind and below pectoral fins	Balance fish and keep level, help steer
	Fin rays	Bony projections	In all fins except the adipose	To provide support and help fins move
	Eye	Spherical, gel-like organ	On both sides of the head	To see – find food and avoid predators
	Nares	Holes/nostrils	At tip of snout	To smell; to help return home to spawn
	Teeth	Tiny, sharp projections made of bone and dentin	On top and bottom of mouth	To grasp and hold prey
	Gills	Organ comprised of 4 gill arches, with filaments and rakers	On both sides of the body, behind the head and under the operculum	To extract oxygen from water and eliminate carbon dioxide back into water
	Gill filament	Soft finger-like tissue	On gill arches, extending toward tail of fish	To exchange gasses
	Gill raker	Bony projections	On gill arches, pointing toward the head of fish	To aid in feeding (collect plankton) and strain out particles that may injure the gills
	Operculum	Hard, cartilage plate	Over the gills, behind the head	To protect the soft gills
Internal Anatomy	**Part**	**What?**	**Where?**	**Why?**
	Swim bladder	Long, thin, clear membrane	Underneath kidney, running parallel to it	To hold air and keep the fish buoyant
	Fat deposits	White tissue	Around stomach area	To provide stored energy when needed
	Kidney	Thin, long, dark red organ	Under back bone, along length of body	To filter wastes from the blood, help with osmoregulation
	Cardiac region of the stomach	Long, top stem of the J-shaped organ, light in color	Behind the heart and below the swim bladder	To begin digestion by releasing enzymes and acids
	Pyloric region of the stomach	'Hook' part of the J-shaped organ, light in color	Behind the heart and below the swim bladder	To grind food and push it into the intestine
	Pyloric caeca	Finger-like tissue	Along the pyloric region of the stomach	To increase surface area and absorb nutrients from food
	Intestine	Long, thin organ	Following the stomach	To absorb the last bit of nutrients and lead wastes to vent
	Spleen	Dark, bean-like organ	By the end of the stomach	To produce and store blood
	Liver	Large, dark red organ	In front of the stomach	To manufacture bile (needed to break down fat)
	Gall bladder	Small, dark, greenish sac	Attached to side of liver	To store bile
	Heart	Small, triangular, red organ	At the base of the throat, close to gills	To pump blood throughout the body

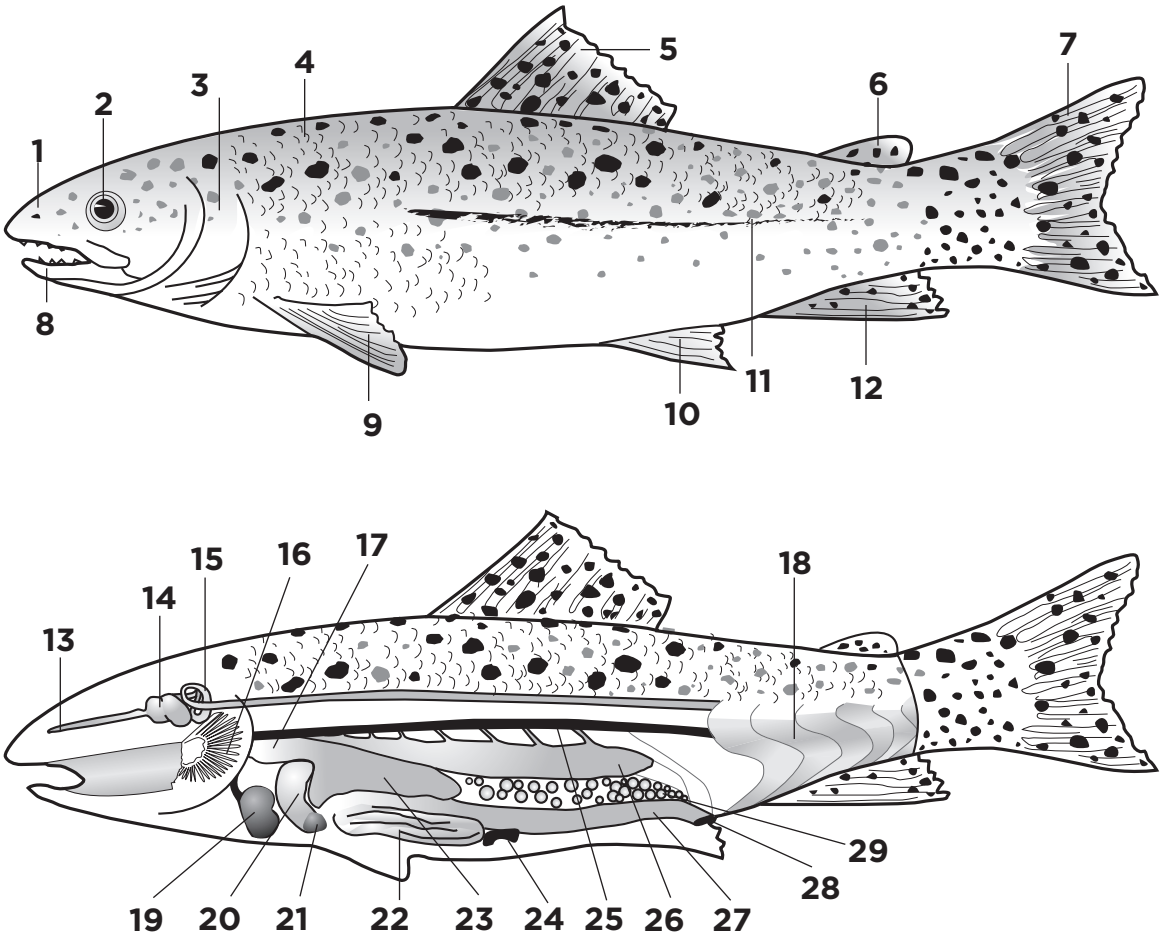
Name: _____

FISH ANATOMY





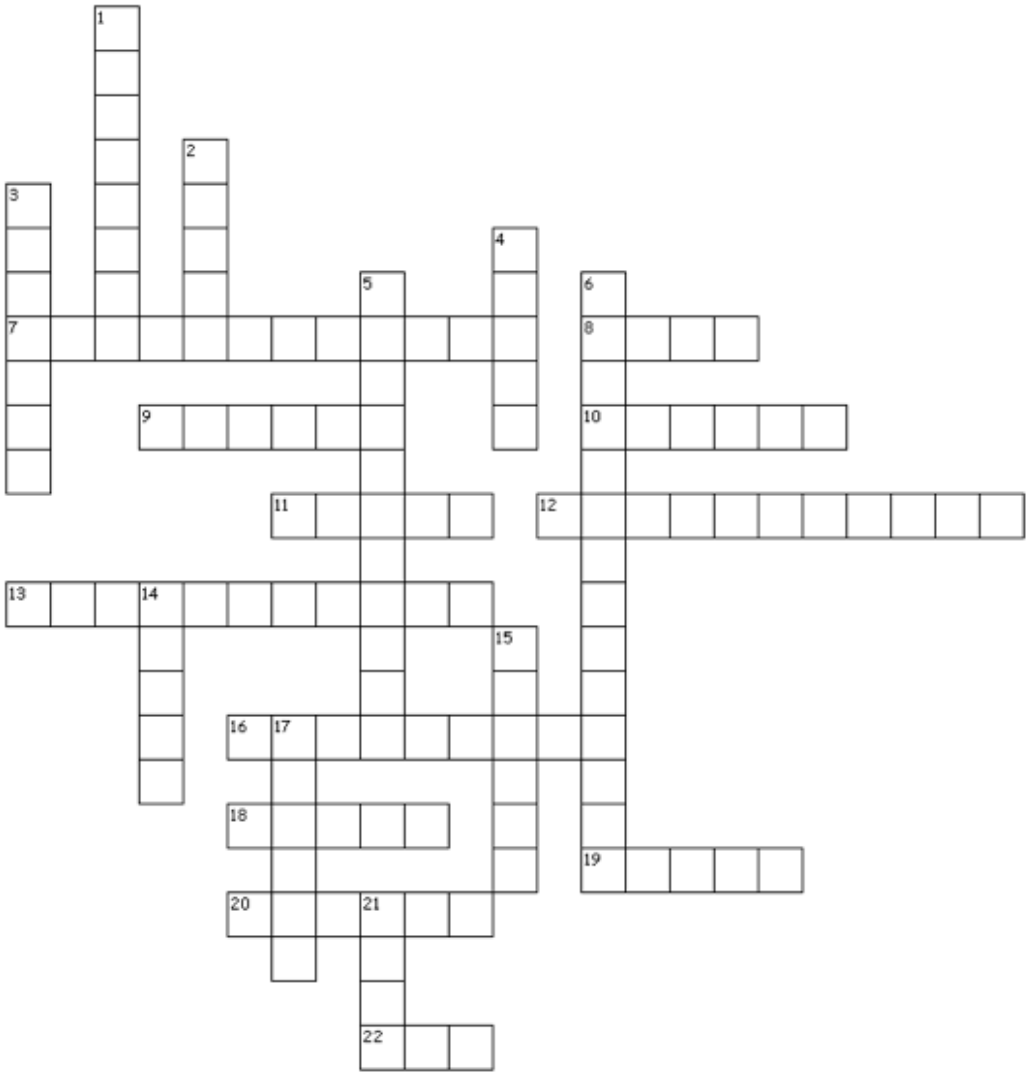
FISH ANATOMY ANSWER KEY



1. Nare
2. Eye
3. Operculum
4. Scales
5. Dorsal fin
6. Adipose fin
7. Caudal fin
8. Mouth
9. Pectoral fin
10. Pelvic fin
11. Lateral line
12. Anal fin
13. Olfactory organs
14. Brain
15. Inner ear
16. Gills
17. Esophagus
18. Body muscles
19. Heart
20. Liver
21. Gall bladder
22. Pyloric caeca
23. Stomach
24. Spleen
25. Kidney
26. Swim bladder
27. Intestine
28. Vent
29. Gonads

Name:_____

Trout Anatomy Crossword



Word Bank

Adipose
Anal
Brain
Caudal
Cardiac Stomach
Dorsal
Eye
Gall Bladder
Gills
Heart
Kidney
Lateral Line
Liver
Mouth
Nare
Operculum
Pectoral
Pelvic
Pyloric Caeca
Slime
Spleen
Swim Bladder

Across

7. This is most like a human's small intestine.
8. The fin that helps stabilize the fish like a keel on a boat.
9. This is the fin that acts as a rudder to steer the fish.
10. The fin on the fish's back that helps prevent the fish from rolling.
11. These are used to extract oxygen from water.
12. The organ that allows fish to sense movements in water.
13. This organ enables the fish to float.
16. The hard covering that protects the gills.
18. This protects the fish from infection.
19. This pumps blood through the fish's body.
20. This organ cleans the blood.
22. This has a clear membrane to protect it.

Down

1. This is the pair of fins that are most forward on the fish's body.
2. This organ makes bile to help in digesting fat.
3. This is the only fin without rays.
4. The control center for a fish.
5. This organ stores bile.
6. Where digestion begins.
14. This is what trout use to hold their prey.
15. This is where blood is produced and stored.
17. This is the pair of fins on the bottom of the fish used for balance.
21. This enables the fish to smell.

Trout Anatomy Crossword Answers

Across

7. **pyloric caeca** This is most like a human's small intestine.

8. **anal** The fin that helps stabilize the fish like a keel on a boat.

9. **caudal** This is the fin that acts as a rudder to steer the fish.

10. **dorsal** The fin on the fish's back that helps prevent the fish from rolling.

11. **gills** These are used to extract oxygen from water.

12. **lateral line** The organ that allows fish to sense movements in water.

13. **swim bladder** This organ enables the fish to float.

16. **operculum** The hard covering that protects the gills.

18. **slime** This protects the fish from infection.

19. **heart** This pumps blood through the fish's body.

20. **kidney** This organ cleans the blood.

22. **eye** This has a clear membrane to protect it.

Down

1. **pectoral** This is the pair of fins that are most forward on the fish's body.

2. **liver** This organ makes bile to help in digesting fat.

3. **adipose** This is the only fin without rays.

4. **brain** The control center for a fish.

5. **gall bladder** This organ stores bile.

6. **cardiac stomach** Where digestion begins.

14. **mouth** This is what trout use to hold their prey.

15. **spleen** This is where blood is produced and stored.

17. **pelvic** This is the pair of fins on the bottom of the fish used for balance.

21. **nare** This enables the fish to smell.

Gyotaku

Grade Level
2-12

Subject Areas
Language Arts, Science, Visual Arts

Time
45 minutes

Vocabulary
adipose fin, anal fin, caudal fin, dorsal fin, eye, gyotaku, nares, operculum, pectoral fin, pelvic fin, scales

Summary

Students use an ancient Japanese art form to make prints of fish.

Objectives

Students will...

- simulate an art form established by Japanese fishermen centuries ago
- recognize and name the external parts of a fish

Materials

- fish - real, nongutted fish are preferable but rubber fish may also be used (Your local fish hatchery may be able to supply real fish for printing.)
- salt
- tempera or acrylic paint – whatever colors you want
- ceramic or paper clay (optional)
- paper towels
- brushes (1" sponge brushes to paint the body, smaller brushes for detail)
- markers
- newspaper to lay out over work space
- material for final prints – rice paper, butcher paper, regular printer paper, cloth

Background

Gyotaku (pronounced ghee-oh-tah-koo) literally translates to 'fish rubbing' and dates back to the early 1800s. Fishermen in Japan began this tradition to record their catch. Gyotaku allowed them to document the size and types of fish caught while still enabling them to sell or eat the fish. Also, certain fish in Japan are revered, and fishermen would take rubbings of these fish then release them back in the water. Prints were brought back and displayed in the homes of the fishermen either on walls or in journals. These prints were used as conversation pieces and to relate proud and heroic stories of the catch. Today, we have taxidermy mounts and cameras to record our catches. However, gyotaku is still practiced and has developed into a fine art form.

Advance Preparation

If the fish has been frozen, partially thaw it out (a fish completely thawed gets squishy). Place the fish on several paper towels and make sure it is well drained. Sprinkle table salt on the side of the fish. Let the salt stand for about four minutes. This helps to remove the slime. Wipe the salt from the fish with a rag or paper towels.

If your fish was not gutted, take small pieces of paper towel and insert them into the vent and under the gill plate. This will prevent any leaks from being transferred onto the paper or the cloth during the printing process.

If your fish is gutted, wad up sheets of paper towel and stuff them into the stomach cavity. This provides support while printing.

To make the fins stand out, you may want to prop them up with clay. The dorsal fin and, if the fish is big enough, the pectoral and pelvic fins may be propped up with a small amount of ceramic clay. Regular modeling clay contains plastic or oil residue and won't adhere to the fins. Place the clay behind the fin near its base and press it tightly against the fin. This action should cause the clay to flatten and the fin to splay out.

Procedure

1. Ask the students if they have ever heard some "fish tales" told by anglers. Anglers are known for telling exaggerated tales of the "huge" fish they caught. In Japan, fishermen recorded the actual size of the fish they caught (long before cameras) with an art known as gyotaku. Explain that gyotaku translates to "fish rubbing." Although it isn't necessary now (because of cameras and taxidermy), it is still a very popular art form. You may want to show examples of gyotaku prints made by professional artists. A Google search of "gyotaku" will provide many examples.

2. Place a clean sheet of newspaper out where you plan on working and place the fish on the paper. Starting with the head, paint down to the tail of the fish. A very thin layer of paint works best to show the details of the scales and fins. Brush the paint in the reverse direction, from the tail to the head to evenly spread out paint to avoid any paint clumps or smears. Don't forget the fins.

3. Place your paper on top of the fish. Gently press and rub the head of the fish, its mouth and gill plate. Don't rub too far under the fish or your print will come out distorted. Move toward the back and tail of the fish, pressing and rubbing gently as you move along. Make sure to get those fins!

4. Carefully remove the paper. Take a close look at your print. Notice the details.

5. Hang or lay out to dry.

6. Once dry, you may want to add some details with markers, such as outlining the fish or adding details to the eye.

7. Review the anatomy of the fish shown on the print. Have the students label the anatomy on their prints if desired.

Evaluation

1. If your classroom has studied art concepts, you may wish to grade the projects on criteria such as color, intensity, balance, completeness, etc.

2. Have your students write a fictional story to go along with their fish print, telling how the fish was caught and the steps or challenges to catching the fish. The story could also be from the fish's perspective and tell the fish's journey of being caught.

Extension

1. Print on T-shirts using fabric paint.

2. Compare gyotaku to other ancient Japanese art forms, such as ukiyo-e.

3. Have students paint a suitable habitat around their fish print.

Fish Fins: Form and Function

Grade Level
3-12

Subject Areas
Language Arts, Science, Visual Arts

Time
Fish Observations: 15-50 minutes

Making and Testing Models: 45-75 minutes

Vocabulary
adaptation, adipose fin, anal fin, caudal fin, dorsal fin, pectoral fin, pelvic fin

Summary

Students observe and record fin movements; design models to investigate how fins help stabilize fish; and write about their results and findings.

Objectives

Students will...

- observe how fish use fins to move and record their observations
- describe how fish use fins to move forward, backward, up, down, slow down, turn and stop
- design models to investigate how fins help to stabilize fish
- learn the names and functions of different fins

Materials

- class aquarium with fish
- TIC Journals or other paper for recording observations
- pencils/pens
- copies of *Fish Fins* sheet, one per student
- Fish Fins PowerPoint, included on USB drive
- permanent markers to draw on plastic
- one to three round plastic bottles with caps per student, such as one-liter or two-liter bottles
- flat plastic lids or sides cut from flat plastic bottles, such as milk jugs, for cutting out fin shapes, four or five per student
- sturdy scissors
- duct tape
- large tub of water or children's wading pool filled with water (or take students to a nearby pond or lake to test models)
- six-foot lengths of string for pulling model through water if testing models in pond or lake

Background

There is an amazing variety of fish species living in many different habitats, from trout living in cold mountain streams to parrot fish living in tropical oceans. Even though there is great diversity among fish species, some general characteristics can be made about fish as a group.

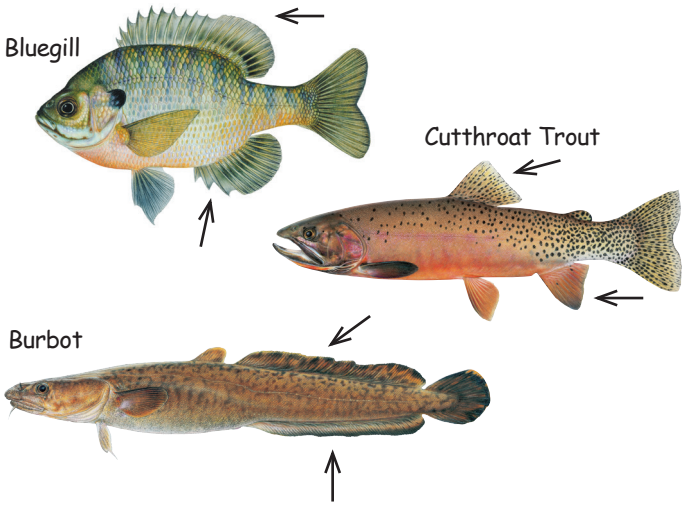
Generally, fish have fins and a long, streamlined or narrow body that help them to swim easily through water. The form, or shape, of a fish's body and body parts relates to their function, or how the parts work. Function also depends on form. This relationship exists in the natural world and also to things people invent and make. A duck's webbed feet help it to swim, and the streamlined shape of a submarine helps it move easily through the water.

By observing and studying the different body parts of a fish, one can learn how the fish's body functions, why the fish lives where it does, and how the fish is able to get food. Making models is one way to learn about structures, their functions and how they behave under certain conditions. Models can be used to investigate how different types of fish fins help fish survive in their habitats. Making observations using models is one way to look at the world like a scientist.

Types of Fins

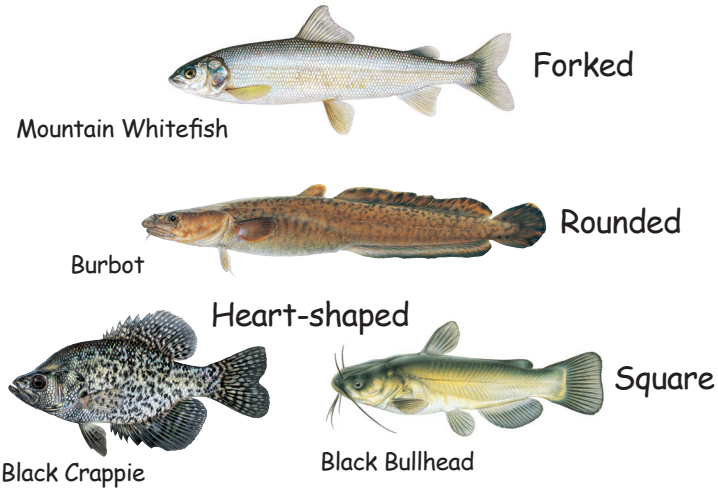
Dorsal and Anal Fins

The dorsal and anal fins help a fish turn and keep a fish upright when turning abruptly. The dorsal fin is located on the top of a fish along the back between the head and tail. A fish may have a single dorsal fin or two connected or unconnected fins. The anal fin is located on the underside of the fish in front of the tail fin by the anus or vent. The anal fin helps to stabilize a fish like the keel on the bottom of a boat. Deep-bodied or laterally compressed fishes, like bluegill, require more stability to keep upright in the water and have longer dorsal and anal fins. Burbots and eel-like fishes also have long dorsal and anal fins to assist in swimming.



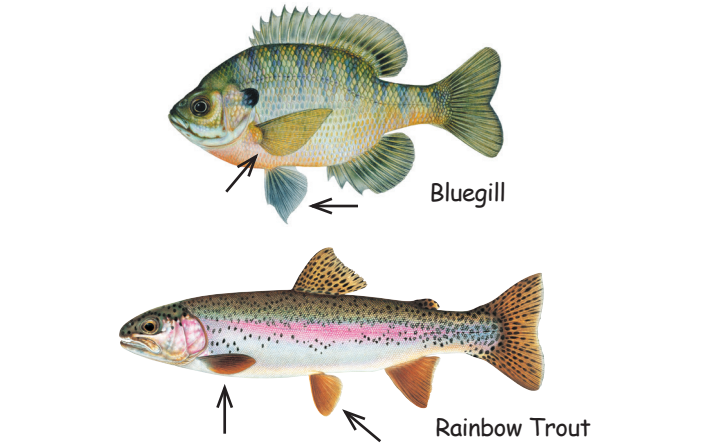
Caudal Fin

The caudal fin, or tail fin, is located at the end of a fish and provides the power to move a fish forward. It also acts like a rudder to help a fish steer. Caudal fins come in a variety of shapes – forked, heart-shaped, square or rounded. The shape corresponds to the cruising speed of the fish. Fish that spend most of their time cruising and searching for prey have forked caudal fins. A forked tail has less drag. When a fish locates a potential meal, a quick flick of the tail will give a sudden burst of speed. A fish with a rounded tail is going to be the least speedy.



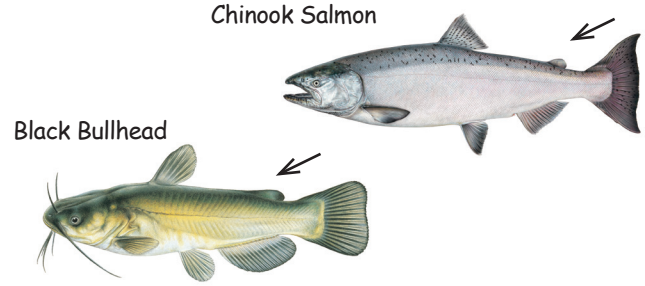
Pelvic and Pectoral Fins

Pelvic and pectoral fins are usually paired. Pelvic fins, located on the bottom of a 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. Pectoral fins are located on either side of the fish near the gills. These fins do everything that pelvic fins do and also help steer and control depth. Trout have pelvic and pectoral fins separated widely on their bodies and attached horizontally. Other fish, like bluegill or crappie, have pelvic and pectoral fins located closer together and vertical to one another. The pectoral fins are higher on the body close to the gill covers with the pelvic fins below the pectoral fins on the bottom of the fish. The fins are closer to the fish's center of gravity and often have a wrist-like function. The fins offer greater maneuverability traveling through plants. They also help the fish remain stationary to pick insects off plants.



Adipose Fin

Fish in the salmon and catfish families have an adipose fin between the dorsal and caudal fins. This fin is soft and fleshy, like an earlobe. The function of the adipose fin is being studied by biologists. It is thought that this fin helps reduce drag and improves swimming efficiency.



Procedure

Part One: Observing Fish

1. Tell the students they will be learning about the different fins on a fish. Each fin has a special function, or role, that helps a fish move through its habitat.

2. Explain to the students that they will be observing their TIC trout and recording how they move through the water in their TIC Journals (or writing observations down on a sheet of paper). They should think about the shapes and positions of the different fins as they watch how the fins work. Things to observe and record include:

   - Written observations about how the fish move up, down, forward, backward, turn, stop and remain still
   - Drawings and descriptions of the different fins
   - Explanations of what the different fins seem to do for the fish

3. In small groups, have students observe fish and record observations.

4. Once students have had an opportunity to observe the fish, ask the students about their observations. How do the fins help the fish? Define adaptation (a characteristic that helps an organism survive in its environment). Ask students to write a description of how the various fins they observed would be considered adaptations. (How fins function to help the fish survive.)

5. Show the class the Fish Fins PowerPoint and pass out the *Fish Fins* sheet. As a class, go over the different fins and their functions, adding information from the Background section as needed. Fill out the table on the sheet placing the appropriate number by each fin name.

6. Ask the students if they observed the fin functions described for each fin when they were observing the trout in the aquarium. Was it easy to tell how each fin was helping the fish to move? Why or why not? Have the students look back at their recorded observations and drawings and label the fins in their drawings.

Part Two: Models

1. Review the *Fish Fins* sheet with students.

2. Explain to the students that they will be making models out of plastic bottles to test how different fin shapes help fish move through water. Scientists make models to study different structures. 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. Students can work in groups or individually to create models.

3. Pass out one or two plastic bottles and flat plastic lids to create fins to each student. Have the students place their bottles, with the caps on, in a tub of water one at a time and blow air on the bottle. How does the bottle react? Have students observe the shape of their "fish body" (plastic bottle) and think about the fin shapes, sizes and locations that would help a fish with this shape stabilize itself and move through water. Have students reference their observations of the TIC fish and *Fish Fins* sheet as needed.

4. Have the students draw on a piece of paper two different anal fin shapes to try on their "fish bodies." The fins should be as realistic in size and shape to a real fin as possible. Cut the fins out and use as a template to draw the fins on a piece of flat plastic with a permanent marker. Cut the fins out with scissors and using duct tape secure each fin to the plastic bottles in the anal fin location.

5. As the anal fins are secured, have the students bring their models to the tub of water. Have students place one model in the water at a time and blow on it or make small waves to see how the model reacts. Gently push the model and let it glide to see what happens. Have students record their observations. Repeat with the other models. Which fin shape seemed to work the best? Have students speculate why certain shapes may function better than others. The bottle may tip to one side or the other. Ask students what would give tip-prone models more stability. They may say they need two more fins, one on each side of the model, or one more fin facing another direction.

6. Have the students modify their models by adding a caudal fin to act as a rudder. Have them draw a caudal fin shape on paper to use as a template and cut out of plastic. They can choose to attach their fins straight or at an angle facing left or right with duct tape. How will the different fin shapes and orientations affect the model's movements? Have the students bring their models to the tub of water and partially fill the bottles with water so the tail is underwater. Blow on the models and manipulate the water. Students should draw their models in their journals or notebooks with the anal and caudal fins they designed, recording their observations and explanations for what they observe.

7. Empty the models and have students design and attach pectoral fins as they did with the other fins. Ask the students to consider the fin size needed and how the fins should be oriented on the model – vertically, horizontally or angled. Once fins are attached, again have students partially fill bottles with water so fins are underwater and observe the models' movement in the water. Did the placement of the fins affect movement? Have students draw and record observations.

8. In groups, have the students review the observations they recorded and decide which fin designs were most stable and helped their fish models move most efficiently. They can then incorporate the best fin designs to make final models to test in a nearby pond. If this is not possible, students can test their models in a tub or pool. This time, students may include dorsal and pelvic fins if they choose.

9. If testing models at a pond or larger body of water, attach a six-foot length of string to the bottle after partially filling with water to submerge – not sink- the model so all fins are under the water. Test each model by holding the model by the string and placing it in the current of a stream or pulling it through the shallow water of a pond. Once again, have students record their observations.

10. Back in the classroom, have students draw their final model designs, label the fins and write the function the fins perform.

Evaluation

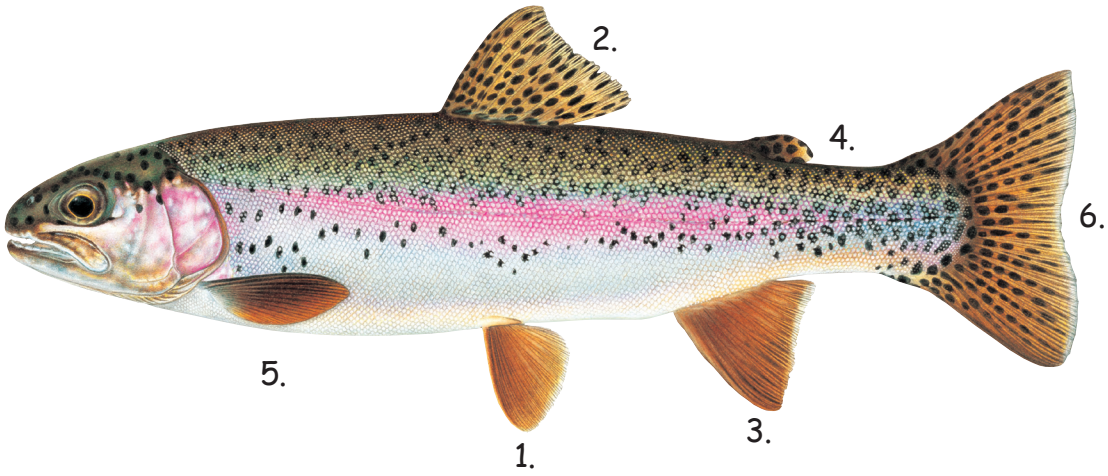
1. Have student groups present their findings and results on how their models performed in the water. Have them explain why their fins functioned effectively, or how they would change the shape or location of the fins to improve how the model moves in the water.

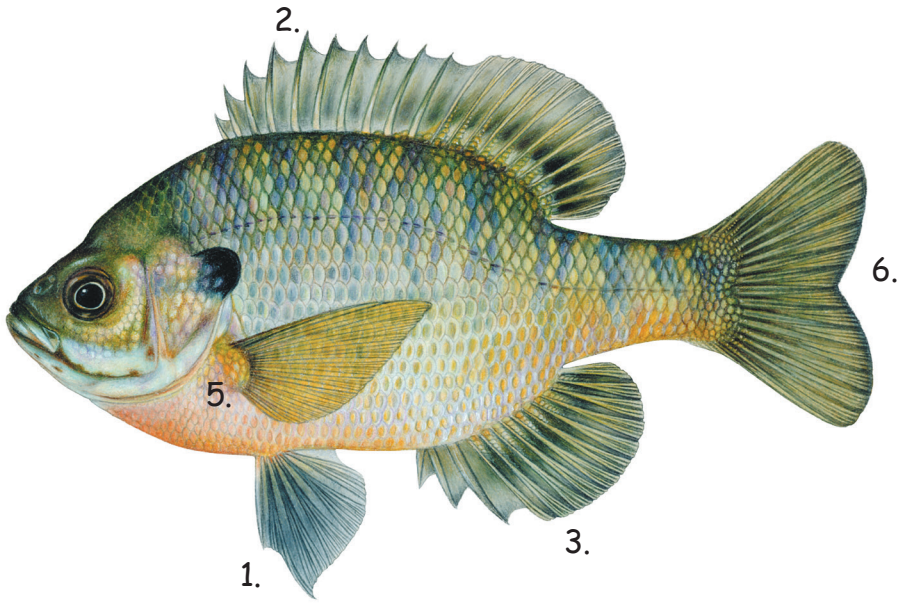
2. Have students write about their experiences with this lesson. Ask students to reflect on their observations of the TIC fish and their models. Which aspects of their fin designs were effective? Did their models imitate the functions of real fish fins? What didn't work? What could have worked better? Students should consider fin size, shape, placement on the model, and the concept that different fins work together to stabilize the model. Have students use the names of the fin types in their descriptions.

Answers to Fish Fins

Number	Fins	Function
2	Dorsal Fin	Stability, defense that helps fish look bigger, helps in steering
4	Adipose Fin (salmon and catfish families)	Reduces drag and improves swimming efficiency
6	Caudal Fin	Steering like a rudder and propelling forward like a motor
3	Anal Fin	Stability, help steer and prevent rolling over in sharp turns
1	Pelvic Fins	Balance, resting and maneuverability
5	Pectoral Fins	Maneuverability, going up, down, backward, forward and remaining still, steering

Fish Fins





Number	Fins	Function
	Dorsal Fin	Stability, defense that helps fish look bigger, helps in steering
	Adipose Fin (salmon and catfish families)	Reduces drag and improves swimming efficiency
	Caudal Fin	Steering like a rudder and propelling forward like a motor
	Anal Fin	Stability, help steer and prevent rolling over in sharp turns
	Pelvic Fins	Balance, resting and maneuverability
	Pectoral Fins	Maneuverability, going up, down, backward, forward and remaining still, steering

Fashion a Fish

Grade Level
3-12

Subject Areas
Science, Visual Arts

Time
30-45 minutes

Vocabulary
adapt, adaptation, behavioral adaptation, camouflage, characteristic, coloration, habitat, species, structural adaptation

Summary

Students design fish with unique forms, shapes and behaviors to discover the benefits of these adaptations.

Objectives

Students will...

- describe adaptations fish have to their environments
- describe how adaptations can help fish survive in their habitats
- interpret the importance of adaptations in animals

Materials

- one copy of adaptation cards (additional copies with a class of more than 30); cut and separate the cards into groups of four cards each: one coloration, one mouth type, one body shape, and one reproduction in each group
- paper or poster board
- markers, colored pencils or paint

Background

All animals are the product of countless adaptations that occurred over time. Adaptations are features that increase the animals' likelihood of surviving in their habitat. When a habitat changes, either slowly or catastrophically, animals must adapt to those habitat changes to survive. As those 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 different fish can live together and flourish. Some species have adapted to such a narrow range of habitat conditions that they are extremely vulnerable to change. These species are usually more susceptible than other animals to death or extinction. In this activity, students design a fish based upon certain adaptations.

Procedure

1. Begin a discussion by asking the class to define what the word adaptation means. An adaptation is a special feature of an organism that increases its chance of survival in its habitat. How do species adapt? Those individuals that are best equipped for life in a specific habitat are more likely to survive to the age where they can reproduce. Therefore, their genes and characteristics are more likely to be carried on to the next generation.

2. Assign students to find a picture or make a drawing of a species of animal that has a special adaptation. For example: a picture of a giraffe with a long neck for reaching vegetation in tall trees, or an owl with large eyes that gather light to aid with night vision.

3. Conduct a class discussion on the value of different kinds of animal adaptations. As part of the discussion, ask the students to identify different kinds of adaptations in humans.

4. Collect the students' pictures or drawings of adaptations. Categorize them into the following groups:
   - protective coloration and camouflage
   - body shape or form
   - mouth type or feeding behavior
   - reproduction or behavior
   - other (one or more categories the students establish, in addition to the four above that will be needed for the rest of the activity)

5. Break up the classroom into five groups. Pass one complete set of cards to each group of students. There might be five groups with four to six students in each group.

6. Review the adaptations by asking each group what they think the advantages are to the adaptations they were given. Record a list of the advantages to each adaptation on the board.

7. Ask the students to "fashion a fish" from the characteristics on the cards they received. The fish will be fictitious and may not look like a "real" fish. Each group should:
   - create an art form that represents their fish
   - name the fish
   - describe and draw the habitat for their fish

8. Ask each group to report on the attributes of the fish they have designed, including identifying and describing its adaptations. Ask the students to describe how this kind of fish is adapted for survival.

9. Ask the students to make inferences about the importance of adaptations in fish and other animals.

Evaluation

1. Grade the students on their presentations of their drawings to the class and their explanations of the adaptions they incorporated. Is the habitat they drew their fish in realistic for the adaptations they were asked to incorporate in the fish?

2. Have the students invent an animal that would be adapted to live in their community or a different and exotic habitat of their choice. Consider mouth, shape, coloration, reproduction, food, shelter, and other characteristics. Draw and describe the animal. Older grades may write a natural history of the animal – also describing social interactions, life cycle, and general life style.

Extension

1. Take an adaptation card from any category and find a real fish with that adaptation.

2. Look at examples of actual fish. Describe the fish and speculate on its habitat by examining its coloration, body shape and mouth.

Adapted from Project WILD Aquatic Activity Guide copyright by the Council for Environmental Education.

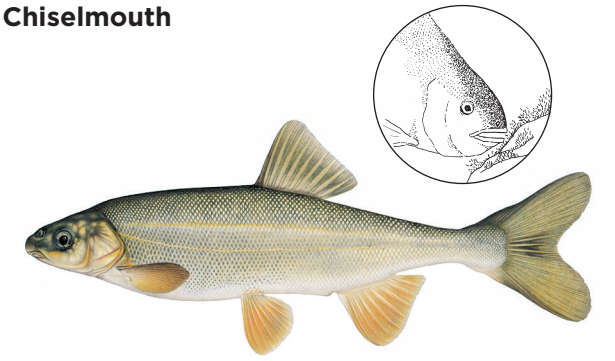
Adaptation	Advantage	Examples
Mouth		
Sucker-shaped mouth	Helps to feed on very small plants and animals on bottom	Sturgeon, sucker, carp
Elongated upper jaw	Helps to feed on prey it looks down on	Channel catfish
Hard plate on lower jaw	Helps to scrape algae off of rocks and the bottom	Chiselmouth
Duckbill jaws	Helps to firmly grasp prey	Northern pike, muskellunge
Extremely large jaws	Helps to completely surround prey	Largemouth bass, grouper
Body Shape		
Torpedo shaped	Increases the speed of the fish	Muskellunge, trout, salmon, tuna
Flat bellied	Allows fish to lay on bottom	Sculpin, catfish, sucker
Snake-like	Streamlines the fish for long distances	Pacific lamprey
Vertical disk	Allows the fish to move easily between vertical plants and feed above or below	Pumpkinseed, crappie, bluegill
Large, spiny dorsal fin	Makes fish look larger, prevents predator attack from behind	Yellow perch
Coloration		
Light-colored belly	Camouflages so that predators have difficulty seeing it from below	Sockeye salmon, perch, stugeon
Dark upper side	Camouflages so that predators have difficulty seeing it from above	Bluegill, crappie, flounder
Vertical stripes	Allows the fish to hide in vegetation	Tiger muskellunge, pickerel, bluegill
Spotted	Helps the fish hide in rocks and on the bottom	Rainbow trout, cutthroat trout
Mottled coloration	Helps the fish hide in rocks and on the bottom	Black crappie, sculpin, burbot
Reproduction		
Eggs deposited in nest on bottom	Hides eggs from predators, keeps them oxygenated	Bull trout, salmon, most minnows
Defends spawning territory	Eggs are protected by adults	Longnose dace, bass
Cavity spawners	Eggs are hidden from predators	Bullhead catfish
Eggs attached to vegetation	Eggs remain stable until hatching	Carp, perch, northern pike
Migrate to spawn in groups	Helps mix genes to maintain diversity in population	Burbot, grouper

Fish Adaptation Cards

Mouth/Feeding:
sucker shaped mouth
Sturgeon

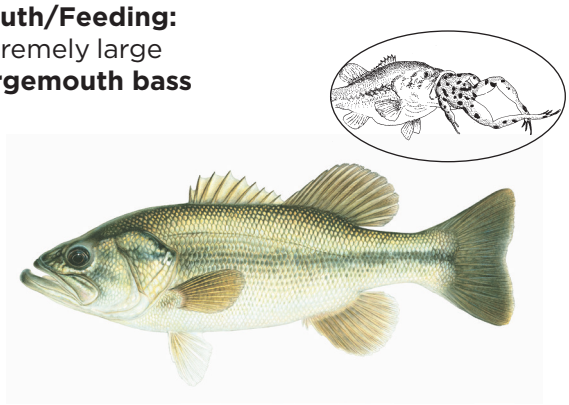
Mouth/Feeding:
elongated upper jaw
Channel catfish

Mouth/Feeding: hard plate on lower jaw
Chiselmouth



Mouth/Feeding:
duck-billed jaws
Northern pike

Mouth/Feeding:
extremely large
Largemouth bass



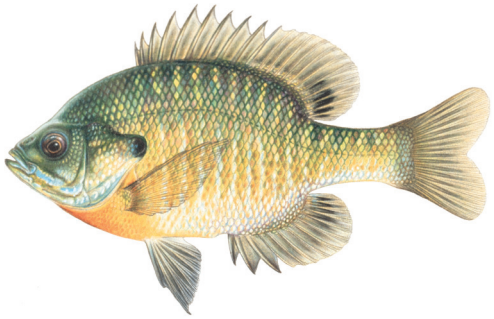
Body shape:
torpedo shaped
Rainbow trout

Body shape:
flat bellied
Sculpin

Body shape:
snake-like
Pacific Lamprey

Fish Adaptation Cards

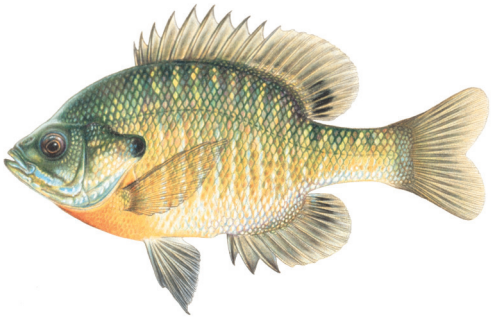
Body shape:
vertical disk
Bluegill



Body shape:
spiny dorsal fin
Yellow perch

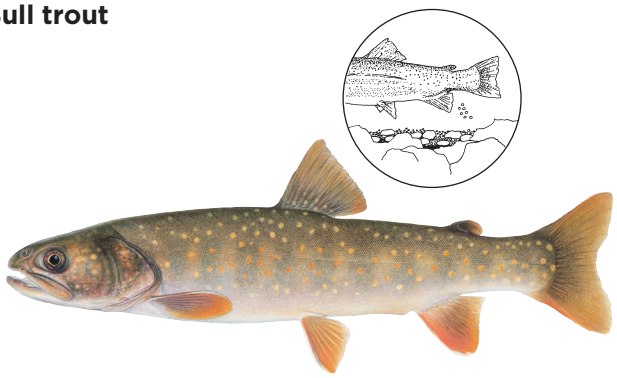
Coloration:
light-colored belly
Salmon

Coloration:
Darker on top
Bluegill

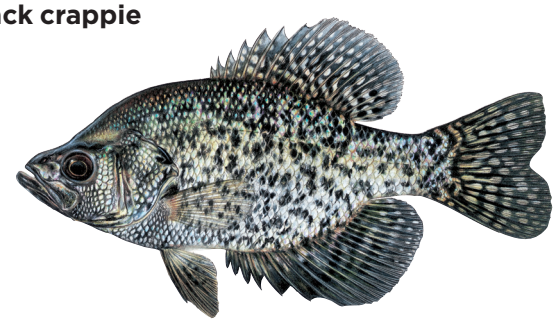


Coloration:
vertical stripes
Tiger muskellunge

Reproduction: eggs deposited in bottom nests
Bull trout



Coloration:
mottled
Black crappie

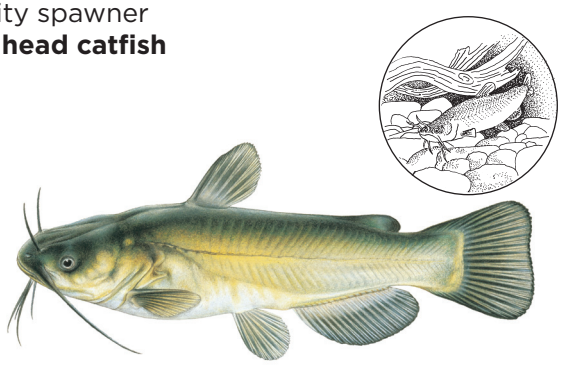


Coloration:
spotted
Rainbow trout

Fish Adaptation Cards

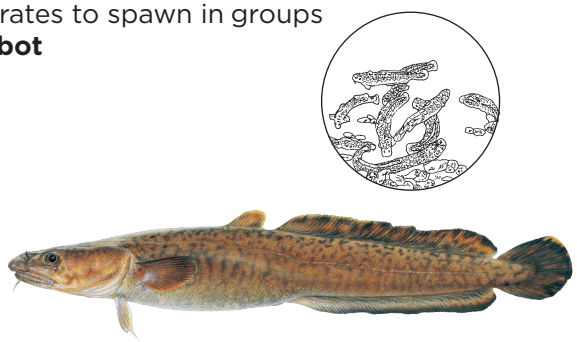
Reproduction:
defends spawning territory
Longnose dace

Reproduction:
cavity spawner
Bullhead catfish



Reproduction:
eggs deposited on vegetation
Northern pike

Reproduction:
migrates to spawn in groups
Burbot



Protective Coloration

Summary

Students learn about protective coloration by decorating cookies so they blend in with a wrapping paper background.

Objectives

Students will...

- demonstrate their knowledge of camouflage by decorating cookies to hide against a background
- illustrate the importance of camouflage in the survival of an individual

Materials

- wrapping paper of different colors and patterns
- sugar cookies, ideally fish-shaped
- white frosting or supply tinted frosting in various colors
- food coloring to match colors found in the wrapping paper or primary colors (red, yellow, blue) for students to mix frosting colors themselves
- plastic spoons/knives
- paper plates and napkins

Background

Most animals have developed body colors and markings that improve their chances of survival. This adaptive mechanism, known as protective coloration, varies from species to species. There are a few types of protective coloration:

- Cryptic coloration – Also known as camouflage, this is coloration where an organism matches its background, hiding it from predators and/or prey.
- Disruptive coloration – This is coloration in which colors and patterns disrupt body shape and outline, making it difficult to pick out individuals in a crowd, such as zebras.
- Aposematic coloration – Also known as warning coloration, this is when an animal has conspicuous coloration or makings to warn off predators, such as the orange and black makings on the monarch butterfly or stripes on a skunk.
- Mimicry – This is when an organism resembles another organism for protection, such as a gopher snake looking and acting like a rattlesnake.

When an animal is camouflaged its colors are very similar to that of its habitat, helping to conceal the animal either from its predators or prey. For example, a sculpin's mottled coloring of brown and black helps camouflage it against the rocky bottoms of streams. Although protective coloration is not infallible, it does increase chances for survival of the species.

Grade Level
2-12

Subject Areas
Language Arts, Science, Visual Arts

Time
30-60 minutes

Vocabulary
adaptation, aposematic coloration, camouflage, cryptic coloration, disruptive coloration, mimicry, protective coloration

Advance Preparation

Cut out squares of wrapping paper for the students to use as habitat. Bake or purchase fish-shaped sugar cookies. Mix colors into frosting if supplying colored frosting to students.

Procedure

1. Start a discussion about adaptations with the students. Adaptations are special features that help an animal survive in its habitat. The colors or pattern of colors on an animal are often an important adaptation.

2. Ask students to define camouflage. Camouflage is protective coloring that helps to hide an animal. Have students give examples of species that are camouflaged. If two of the species mentioned swapped habitats, would they still be camouflaged? Possibly not. Camouflage is usually specific to the animal's habitat. However, some animals are generalists and may be camouflaged in varying habitats. Gray squirrels, for example, could be camouflaged in a number of different forest types. Depending on the level of your students, discuss other forms of protective coloration.

3. Pass out a piece of wrapping paper, a cookie, a paper plate, plastic knife and napkin to each student. The wrapping paper represents the habitat for the students' "fish."

4. Using the paper plate as a pallet, have the students blend white frosting with the food coloring to make colors that will camouflage their fish against the wrapping paper habitat and frost their cookies. For younger students, you may want to supply colored frosting.

Evaluation

1. Have the students define camouflage and tell why it is helpful.

    - Camouflage is a type of coloration, blending the animal into its own habitat. It helps hide the animal from predators as well as prey.

2. Have the students write about moving their "fish" to another habitat. Is the fish still camouflaged? How might the coloration affect their fish if its habitat is altered? Is its special coloration general to fit into many habitats or more specialized? Some animals are 'specialists' and only are camouflaged in a very distinct environment. Some animals are 'generalists' and can fit in a number of different habitats. How might this affect the long term survival of a species?

Extension

1. Have students decorate cookies with other types of protective coloration, including disruptive coloration, aposematic coloration, and mimicry.

2. Research the story behind the light and dark-colored peppered moths of England, a classic example of natural selection. Population studies have shown that prior to the Industrial Revolution of England, the vast majority of peppered moths were light-colored. These moths were camouflaged against the light-colored trees and lichens they rested upon. However, during the Industrial Revolution there was a shift in population sizes. The dark-colored moths began to outnumber the light-colored moths. Scientists believe the shift was due to increased pollution that killed lichens and blackened trees with soot. The dark-colored moths were better able to hide on the darkened trees while the light-colored moths became more susceptible to predators.

Activity provided by Kris Albin-Stone.

Dichotomous Keys

Summary

Students learn about order and classification by creating their own dichotomous key and navigate a dichotomous key of fish found in Idaho.

Objectives

Students will...

- build a flow chart classification key for six pieces of candy (or shoes)
- translate the flow chart to write a dichotomous key
- review fish anatomy
- follow a dichotomous key for fish in Idaho
- differentiate between similar fish species
- hypothesize the functions of certain forms and adaptations

Materials

Part One: Creating a Dichotomous Key

- six different types of candy to key, such as Twizzlers, jelly beans, Raisinettes, caramels, Reese's peanut butter cups and Andes mints
- one additional type of candy to try to key out with the created dichotomous key

OR

- one shoe from six different students
- scales and rulers to measure the size and weight of different candies, optional

Part Two: Using a Dichotomous Key

- copies of the *Dichotomous Key for Common Fishes of Idaho*, one per student
- color copies of the fish to identify; cut along lines keeping the letter associated with the fish picture; enough sets for each group of 2 to 4 students
- enlarged pictures of fish to display in front of class, optional

Background

Scientific classification is a method by which scientists group and categorize species of organisms. Modern classification has its roots in the work of Carl Linnaeus, who grouped species according to shared physical characteristics. A hierarchal system with eight divisions is used to classify all of the organisms on Earth. From broadest to narrowest, the levels of classification are: domain, kingdom, phylum, class, order, family, genus, and species.

Grade Level
6-12

Subject Areas
Science

Time
Part One: 30 minutes

Part Two: 45 minutes

Vocabulary
adipose fin, anal fin, barbel, binomial nomenclature, caudal fin, classification, dichotomous, dorsal fin, dorsal spines, pectoral fin, pelvic fin, species, taxonomy

With millions of species on our planet, scientists rely on a type of identification key, called a dichotomous key, to identify items in the natural world. From reptiles to rocks, flowers to fish, the format of a dichotomous key is always the same.

The word dichotomous originates from Greek. The prefix 'di' means two; the root word originates from 'temnein' which means to cut. Two choices are given at each step in the form of a couplet, eventually leading to the correct answer. For example:

1. a. Flower has 3 petals.....Go to 2
   b. Flower has 4 petals.....Go to 4

2. a. Petals' edges are smooth .....Trillium
   b. Petals' edges are fringed .....Go to 3

By reading the two statements of each couplet, you progress through the key from typically broad characteristics to narrower characteristics until only a single choice remains.

Part One: Creating a Dichotomous Key Procedure

1. Begin by asking your students how botanists identify different types of trees, especially similar trees, like pine trees. Explain that they use dichotomous keys and explain how dichotomous keys work. Scientists use dichotomous keys to identify different items in the natural world – from rocks, to insects and flowers. Tell your students they will build a dichotomous key together.

2. Have your students imagine that they are visitors to a foreign land or country. The local people offer the students different candies that they have never seen before. How can they identify and compare the candy, so they have a better understanding of what the candy is like? They could use a key to help them identify and compare the different candies.

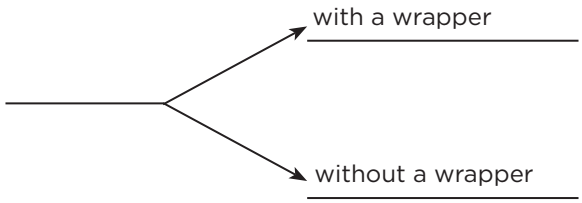
3. Pass out an example of each candy type to the students or groups of students for their observation. If using shoes, ask students to volunteer a shoe for you to display in the front of the classroom.

4. Tell the students they are to divide all the candy into two separate groups. The groups don't have to have an equal number of candy pieces. The students have to agree on some obvious characteristic that will distinguish them. Example characteristics:

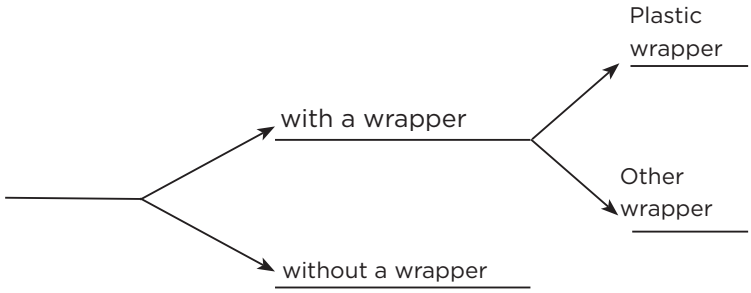
   - Group 1 is with a wrapper, Group 2 is without a wrapper
   - Group 1 is chocolate coated, Group 2 is without chocolate coating
   - Group 1 weighs less than 2 ounces, Group 2 weighs more than 2 ounces

5. After an agreement is reached, record the agreement on the board and have a student from each group keep track of the agreements on a sheet of paper.

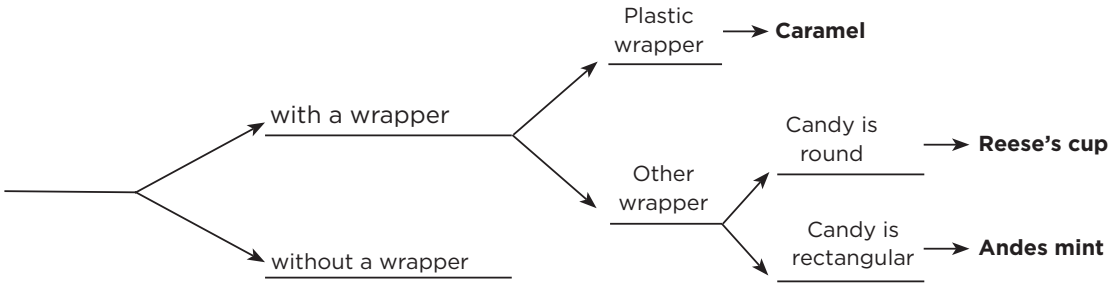
6. Draw two parallel, horizontal lines some distance apart on the board. Label the lines with the agreed upon characteristics.



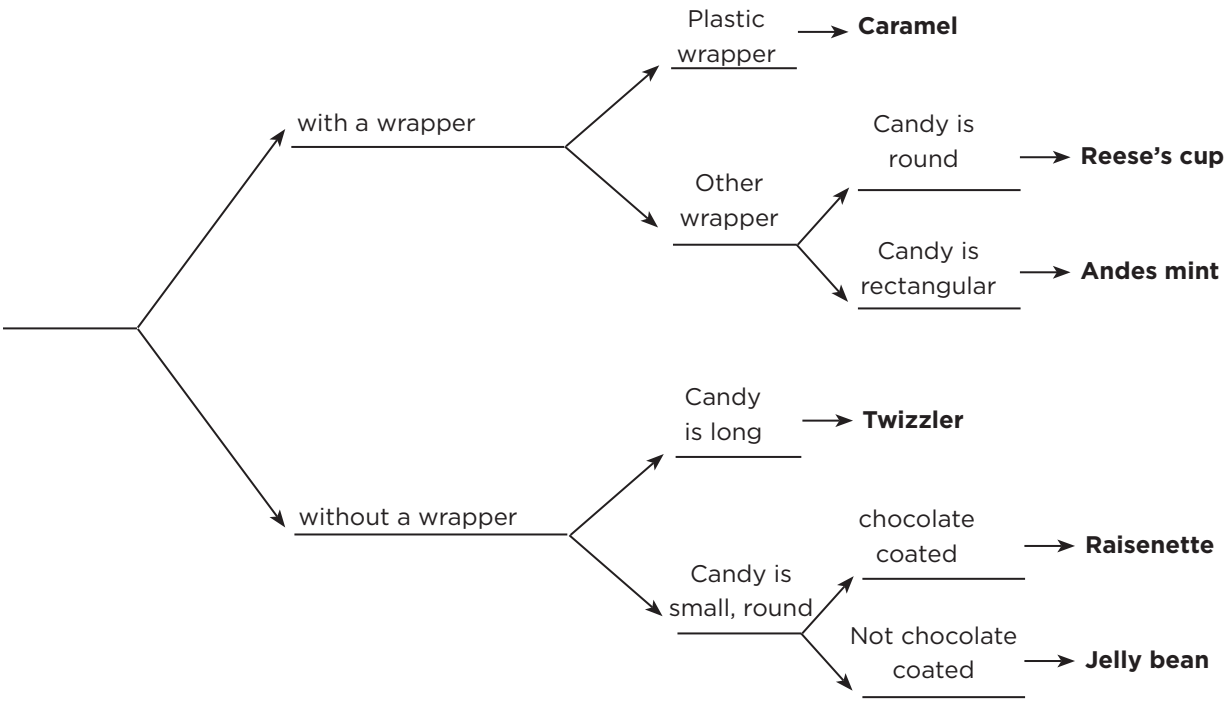
7. Push aside Group 2 for the moment to focus on keying Group 1. Students must again divide Group 1 into two distinct categories. After agreement is reached, add this information to the chalkboard sketch.



8. Continue the process of dividing the candy into two distinct groups and adding the information to the sketch until each candy has been identified.

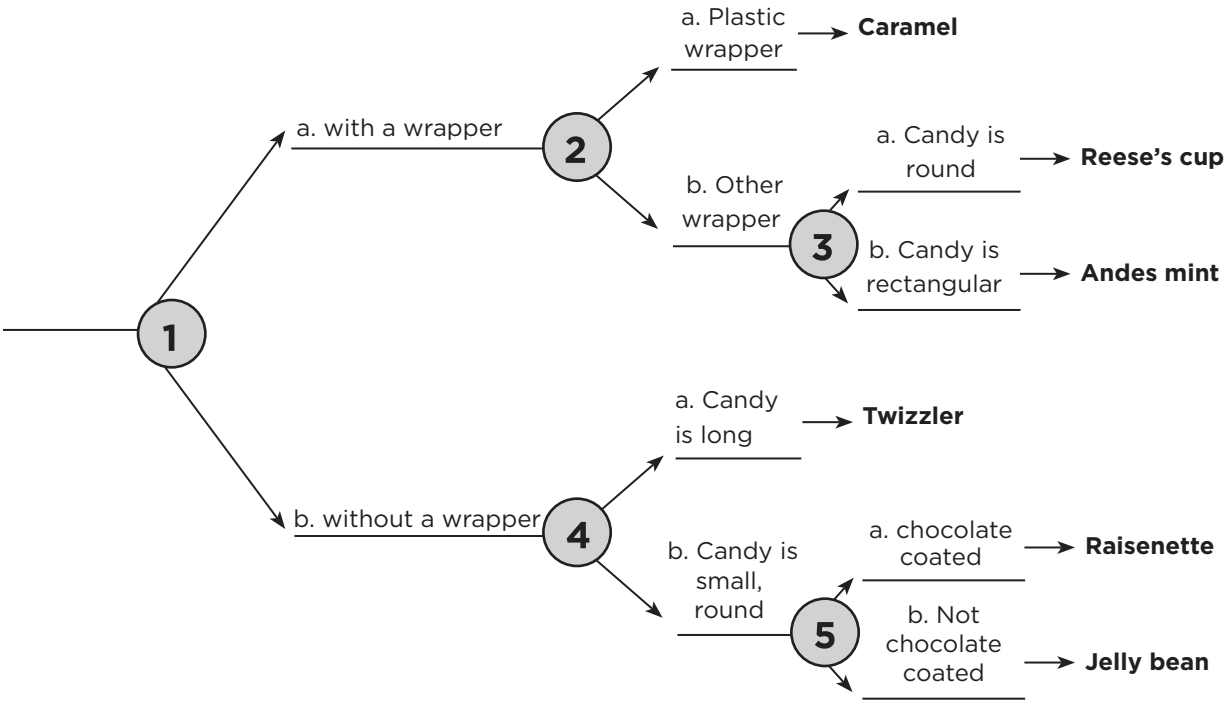


9. Do the same for the second group that was initially pushed aside.



10. The students have successfully created a dichotomous key! Most scientific keys, however, are written down as a compact list of statements. You must now translate this flow chart to a formal key. At each point where two arrows divide, place a number. In front of the two statements at each number, label the choices a. and b.

11. Now write down those numbers and letters followed by the description in a listed format. Add the directions to the next step and label it *Dichotomous Key for Candy.* Have the students use the key they just made.



Dichotomous Key for Candy

1. a. Candy has a wrapper .....Go to 2
   b. Candy is without a wrapper .....Go to 4

2. a. Candy has a plastic wrapper .....Caramel
   b. Candy has other wrapper.....Go to 3

3. a. Candy is round.....Reese's cup
   b. Candy is rectangular .....Andes mint

4. a. Candy is long.....Twizzler
   b. Candy is small and round .....Go to 5

5. a. Candy is chocolate coated.....Raisinette
   b. Candy is not chocolate coated ..Jelly bean

12. Add an additional candy to the key you have made. Can the students identify the new candy? The students should discover that the key works only for identification of those items used in its' original construction.

13. Can only scientists use dichotomous keys? No! Lots of people interested in the natural world use dichotomous keys to identify items they encounter while enjoying the outdoors.

Part Two: Use a Dichotomous Key Procedure

1. Students should be familiar with a fish's anatomy, especially fin names, before beginning part two of the lesson. Review the anatomy of a fish as needed.

2. Break the class up into groups of two to four students per group. Pass out dichotomous keys and fish cards to each group. Have the students work through the key to identify the fish on the cards. Students write the corresponding letter on the fish card next to the name of the fish species on the key. Switch cards if needed so every group identifies all the fish.

3. To use this activity for a grade, collect the fish keys with answers from each student.

4. Regroup and review the fish and their identities. Go through the steps of identifying any tricky fish. What fish were difficult to key? Why? What fish were easy to key? Why?

Evaluation

Collect and grade the *Dichotomous Key for Common Fishes of Idaho.*

Key to Fish Cards

A	channel catfish
B	northern pike
C	white sturgeon
D	Chinook salmon
E	bull trout
F	rainbow trout
G	largemouth bass
H	cutthroat trout
J	Pacific lamprey
K	mottled sculpin
L	bluegill

Extension

1. Have students create their own dichotomous keys for five different items of their choice. Encourage students to become creative with the items they key.

2. Have a discussion about the different adaptations on the fish that were keyed. Why do the fish all look so different? As the fish have evolved, each species has developed unique structures and body shapes suited for survival in a particular microhabitat.

   - Compare the mouth of the sturgeon to the mouth of the northern pike. What does this tell us about what/where it eats? (Sturgeon eat along the bottom, northern pike eat prey along the surface of the water.)
   - Compare the body shape and skin of a trout to that of a sturgeon. What clue does this offer about the speed of the fish? (Trout are known for their speed – often necessary for survival. Sturgeon have a thick skin offering protection.)
   - Look at the barbels on the catfish. What purpose might these serve? What might this tell us about where it lives? (Barbels are sensors – catfish are often found in dark, murky water where sight is impaired.)
   - Why would a fish like the bluegill need a spiny dorsal fin? (If a predator comes up behind the bluegill to swallow it, the bluegill can extend its spines to prevent the predator from swallowing it.)
   - Is the salmon always that color? (No, male salmon can become red when spawning. It is believed this helps attract a mate.) This is why colors aren't always the best clue to identifying a species.
   - Encourage any other thoughts on differences/adaptations.

Name:

Dichotomous Key for Common Fishes of Idaho

1. a. Species has barbels (feelers around mouth) ..... Go to 2

   b. Species does not have barbels ..... Go to 3

2. a. Species has spikey plates along its back ..... **White sturgeon**_____

   b. Species does not have spikey plates along back ..... **Channel catfish**_____

3. a. Species has spiny dorsal and/or anal fins ..... Go to 9

   b. Species does not have spiny dorsal and/or anal fins ..... Go to 4

4. a. Species has pectoral and pelvic fins ..... Go to 5

   b. Species does not have pectoral and pelvic fins ..... **Pacific lamprey**_____

5. a. Species has black spots ..... Go to 6

   b. Species has lightly colored spots ..... Go to 8

6. a. Species' caudal fin is black-tipped ..... **Chinook salmon**_____

   b. Species' caudal fin is yellow with black spots ..... Go to 7

7. a. Species has red on lower jaw ..... **Cutthroat trout**_____

   b. Species has does not have red on lower jaw ..... **Rainbow trout**_____

8. a. Species has oblong, oval-shaped spots on body; spots on fins ..... **Northern pike**_____

   b. Species has circular spots on body; no spots on fins ..... **Bull trout**_____

9. a. Species has an obvious stripe(s) ..... Go to 10

   b. Species is blotchy; no obvious stripe(s) ..... **Mottled sculpin**_____

10. a. Species has horizontal stripe ..... **Largemouth bass**_____

    b. Species has vertical stripes ..... **Bluegill**_____

Fish Identification Cards

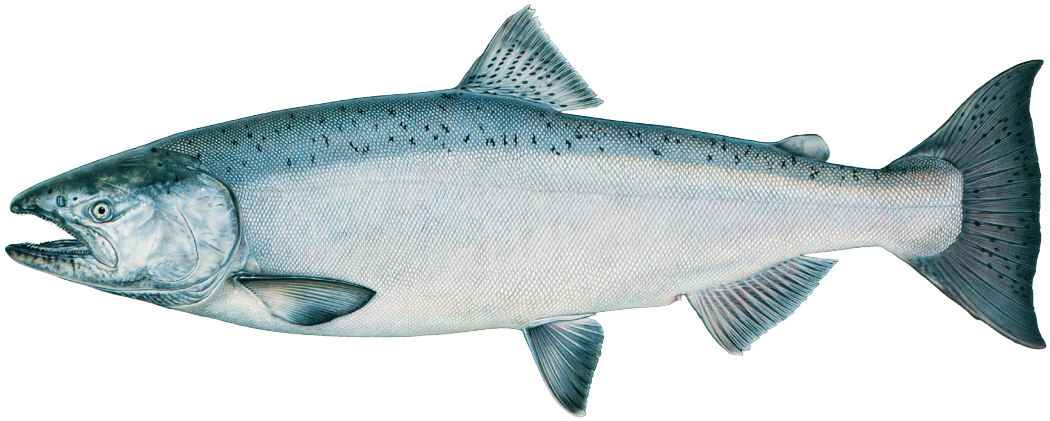
Illustrations by Joseph Tomelleri

A

B

C

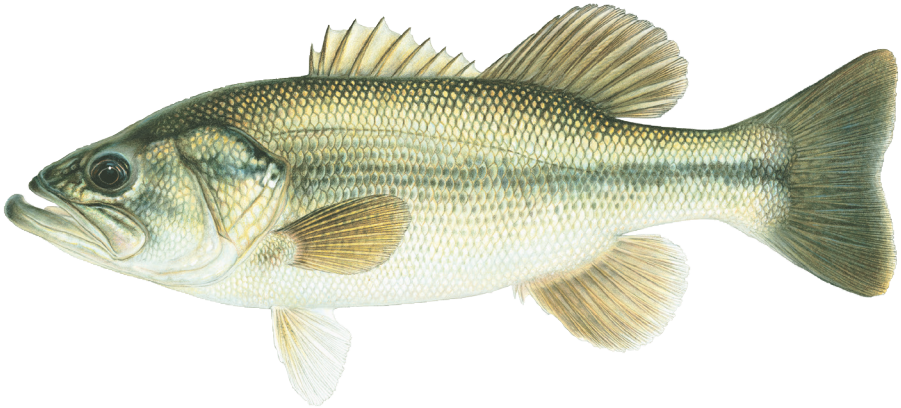
D



E

F

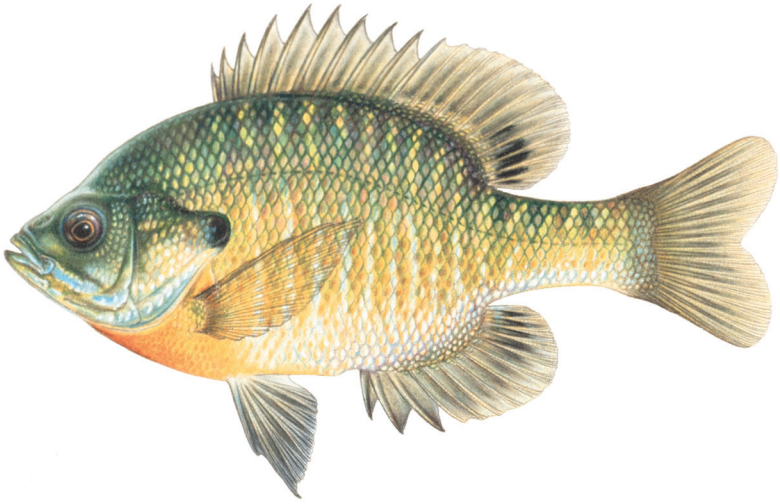
G



H

J

K



L

Luck of the Draw
Upper Grades

Summary

Students experience the process of meiosis and construct a trout with traits randomly selected from parent fish.

Objectives

Students will...

- model chromosome segregation during meiosis
- compare the genotypes and phenotypes of the offspring produced by the same parents
- analyze the expected and predicted outcomes of the offspring produced

Materials

- copies of *Chromosome Masters (Dominant) , Chromosome Masters (Recessive)* and *Gender Chromosomes Masters (male and female)*– each student gets 18 chromosomes
  - copy the recessive, dominant, and gender chromosomes onto pink (female) and blue (male) paper. Make enough copies on pink paper for half of the class and enough on blue for the other half. Cut out and sort chromosomes. Place a set of 8 recessive chromosomes, a set of 8 dominant chromosomes, and 2 gender chromosomes (X and X for females, X and Y for males) in envelopes.
- envelopes to hold chromosomes, one per student
- two copies of *Parent Trout,* copied on gray paper
- copies of trout bodies and traits (the following numbers are for a class of 30 students)
  - 16 – 20 copies of *Smooth Back Shape Master,* print equal numbers on gray and tan paper
  - 16 – 20 copies of *Rounded Back Shape Master* , print equal numbers on gray and tan paper
  - 10 – 20 copies of *Tails Master* , print equal numbers on gray and tan paper
  - 10 – 20 copies of *Dorsal and Anal Fins Master* , print equal numbers on gray and tan paper
- pink, blue, yellow and green markers
- glue sticks
- scissors
- copies of *Trout Traits, Individual Offspring Traits,* and *Classroom Totals* tables for each student
- bulletin board covered with blue paper to represent a stream to display fish, if desired

Grade Level
7-12

Subject Areas
Language Arts, Math, Science

Time
60-90 minutes

Vocabulary
allele, characteristic, chromosome, diploid, DNA, dominant allele, egg, fertilization, gene, genetics, genotype, heterozygous, homozygous, meiosis, mitosis, parr marks, phenotype, Punnett square, recessive allele, reproduction, spawn, sperm, trait, triploid

Background

All living things look and act the way they do because of traits they inherited from their parents. Traits are passed along from generation to generation by genes through the process of sexual reproduction. Genes are hooked together to form chromosomes. Chromosomes are found in the nucleus of every cell.

Chromosomes duplicate and divide during routine cell division or mitosis. The new 'daughter' cell inherits the same genetic coding as the parent cell. For example, in this exercise trout have 18 chromosomes. (In reality, rainbow trout have 58 chromosomes. We reduced this number to simplify the activity.) In order for a trout to grow, its cells must undergo mitosis. When this process occurs, the daughter cell will inherit 18 chromosomes identical to the parent's.

When an organism needs to create reproductive cells (such as an egg or sperm) a different type of cell division, meiosis, takes place. Meiosis creates daughter cells with only one half of the chromosomes found in the original parent cell. For example, when a parent trout cell undergoes meiosis, the daughter cell (sperm or egg) only has 9 chromosomes. In sexual reproduction, when the egg cell and sperm cell join, their chromosomes combine so that the new organism has 18 chromosomes. If meiosis did not occur, the chromosome number for a species would double each generation!

Variations in the way an organism looks (its phenotype) are due to variations in the organism's set of genes (its genotype) found on the chromosomes. Different genes, such as yellow or green, for the same trait (eye color) are known as alleles. There is an allele coding for yellow eyes and one coding for green eyes. In this lesson, all traits have two alleles, one dominant and one recessive. Dominant alleles mask other alleles for the same trait and will be physically observable. Recessive alleles are only physically observed when paired with another copy of the same recessive allele. For example, if the allele for yellow eyes is dominant over the allele for green eyes, a

trout that inherits one yellow allele from one parent and one green allele from the other parent will have yellow eyes. Only a trout that inherits the allele for green eyes from both parents will actually exhibit green eyes.

Famed scientist Gregor Mendel discovered that traits are inherited in certain numerical ratios. According to Mendel's laws, by drawing a Punnett square you can predict the likelihood of an offspring's phenotype and genotype for each trait. A Punnett square compares all the possible combinations of alleles from the mother with those from the father, as shown in Table 1.

Paternal genotype \ Maternal genotype	B	b
B	BB	Bb
b	Bb	bb

Table 1

In this exercise both parent trout are heterozygous for each trait, meaning they have both a dominant and a recessive allele for each trait. Table 1 shows both parents' genotypes (Bb) outside the box. The potential genotypes of the offspring are show inside the box. The probability of an individual offspring having the genotype BB is 25% (1 in 4), Bb is 50% (2 in 4), and bb is 25% (1 in 4). Of those offspring, however, roughly 75% (3 in 4) will exhibit the dominant allele (offspring carrying the BB genotype and those with the Bb genotype). Only 25% of the offspring (1 in 4) have the probability of showing the recessive allele.

Procedure

1. Have the copies of the trout body parts, glue sticks, markers, and scissors available to the class.

2. Before beginning the activity, the students should be familiar with the names of fish fins.

3. Discuss examples of human heredity. Humans get traits, such as eye color, hair color, and ear lobe shape, from their parents. Remind students that the same concepts of heredity apply to all organisms.

4. Discuss how all offspring receive half of their genes from their mother and the other half from their father. Some genes are dominant. They are always expressed or seen in the offspring and are indicated by a capital letter (such as Y). Other genes are recessive and are indicated by a lower case letter (y). Recessive genes are only expressed when an offspring gets a recessive gene from each parent.

5. Imagine two of your classroom's trout surviving and maturing over the next three years. The fish will be ready to spawn (mate). (NOTE: Your trout are most likely sterile and will not reproduce.) Your classroom's fish will spawn and produce a number of offspring—as will be shown through this exercise.

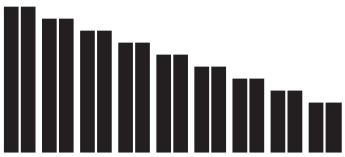
6. Post the pictures of your parent fish. Both parents look the same, but each parent fish is heterozygous (has a dominant and a recessive gene) for each trait. Even though the parents look the same, they may have offspring that look differently.

7. Review the eight traits that the spawning trout carry —both their different genotypes (set of genes) and phenotypes (how they look) are listed in the table *Trout Traits*. Also, go over the gender chromosomes —males carry an X and a Y chromosome while females carry two X chromosomes.

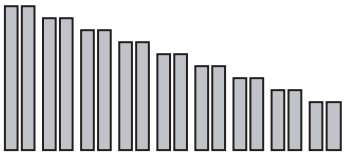
8. Students are paired with a partner. Each pair of students gets two envelopes of chromosomes—one envelope with chromosomes from the female parent (pink) and one from the male parent (blue).

9. Students arrange both the male and female chromosomes face down in pairs by length. The letter symbol for each trait should not be visible. Keep the male and female chromosomes separate at this step.

18 female chromosomes



18 male chromosomes

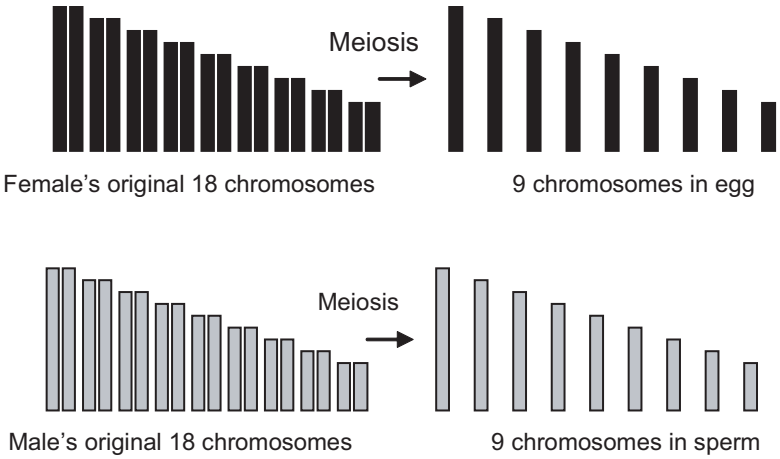


10. Without looking at the printed side, each student randomly picks one chromosome from each of the nine groups and places it face down. Put the chromosome not selected back in the envelope.

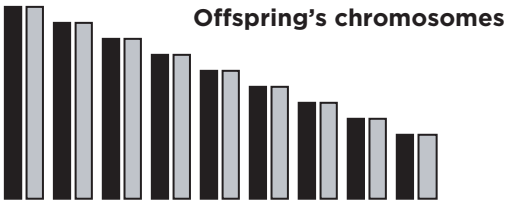
    - To do this, it may be easiest to have the student pick up the two chromosomes for the trait, shuffle them for 30 seconds, and then pick one.

11. When completed, each female parent and male parent should have nine chromosomes.

    - What process does this represent? meiosis



12. Still keeping the chromosomes face down, combine the female and male chromosomes together and pair them by length. This step represents fertilization and restores the original chromosome number for this species of fish.



13. Now, have the students flip the chromosomes face up. Based on the combined chromosomes, have the students fill out the offspring's genotypes on the Individual Offspring Characteristics table. Students refer to the Trout Traits table to find the resulting phenotype the fry has for each genotype.

14. Students then make a fish based upon the genes received from the parents. Using the gray or tan masters, have the students assemble their fish based upon their offspring's traits. Students cut out each shape (leaving the outside black line) and glue the pieces together. To identify the offspring's sex, outline the shape of the fish with either a pink or blue marker. Have the students color the eye with the appropriate (yellow or green) marker.

15. Students put their names on the back of the fish and place it on the blue bulletin board that represents the stream.

16. Direct the class's attention to the "school" of trout on the bulletin board. Observe the varying traits the offspring exhibit. Have students report their genotype information to complete the "No. of fry with genotype" column on the Classroom Totals chart. Students complete the rest of the chart.

Evaluation

Students independently complete the rest of the *Classroom Totals* table for collection and a grade. Have the students write a paragraph explaining whether or not the classroom's results were close to those expected according to Mendel's laws. Can they give possible reasons why the results are different than expected? (i.e. BB is 25% (1 in 4), Bb is 50% (2 in 4), and bb is 25% (1 in 4). Of those offspring, 75% (3 in 4) will exhibit the dominant allele -offspring carrying the BB and Bb genotype. Only 25% of the offspring (1 in 4) have the probability of showing the recessive allele.)

Extension

Students complete the activity again, this time using the offspring (F1 generation) as parents. How do the traits of the F2 generation compare to the F1 generation and the original parents?

Explain to your students that many of the rainbow trout raised in hatcheries are sterile. Fisheries biologists do not want the hatchery trout to interbreed with wild trout. The hatchery trout are sterilized by subjecting the eggs to pressure. At this developmental stage, the eggs are undergoing very rapid growth, or mitosis. This pressure causes an error in mitosis, and the resulting eggs have three copies of chromosomes instead of two. Have students research or brainstorm the reason why these fish, with three copies of chromosomes, are sterile.

Activity adapted from *Luck of the Draw,* written by Oregon Department of Fish and Wildlife. Thanks to Kris Albin- Stone for allowing use of her adaptations to the activity.

Name: _____

Trout Traits

Characteristic	Dominant Trait Phenotypes	Recessive Trait Phenotypes	Mother's Genotype	Father's Genotype	Possible Offspring Genotypes	
Back Shape	Smooth back (B)	Rounded back (b)	Bb	Bb	BB, Bb	bb
Body Color	Gray body (G)	Tan body (g)	Gg	Gg	GG, Gg	gg
Tail Shape	Forked tail (F)	Squared tail (f)	Ff	Ff	FF, Ff	ff
Tail Spotting	Spotted (N)	No spots (n)	Nn	Nn	NN, Nn	nn
Parr Marks	Has parr marks (P)	No parr marks (p)	Pp	Pp	PP, Pp	pp
Dorsal fin rays	6 dorsal rays (R)	3 dorsal rays (r)	Rr	Rr	RR, Rr	rr
Anal fin shape	Elongated anal fin (E)	Short anal fin (e)	Ee	Ee	EE, Ee	ee
Eye color	Yellow (Y)	Green (y)	Yy	Yy	YY, Yy	yy
Gender			XX	XY	XX, XY	

Individual Offspring Characteristics

Trait	Genotype	Phenotype
Back shape		
Body color		
Tail shape		
Tail spotting		
Parr marks		
Dorsal fin rays		
Anal fin shape		
Eye color		
Gender		

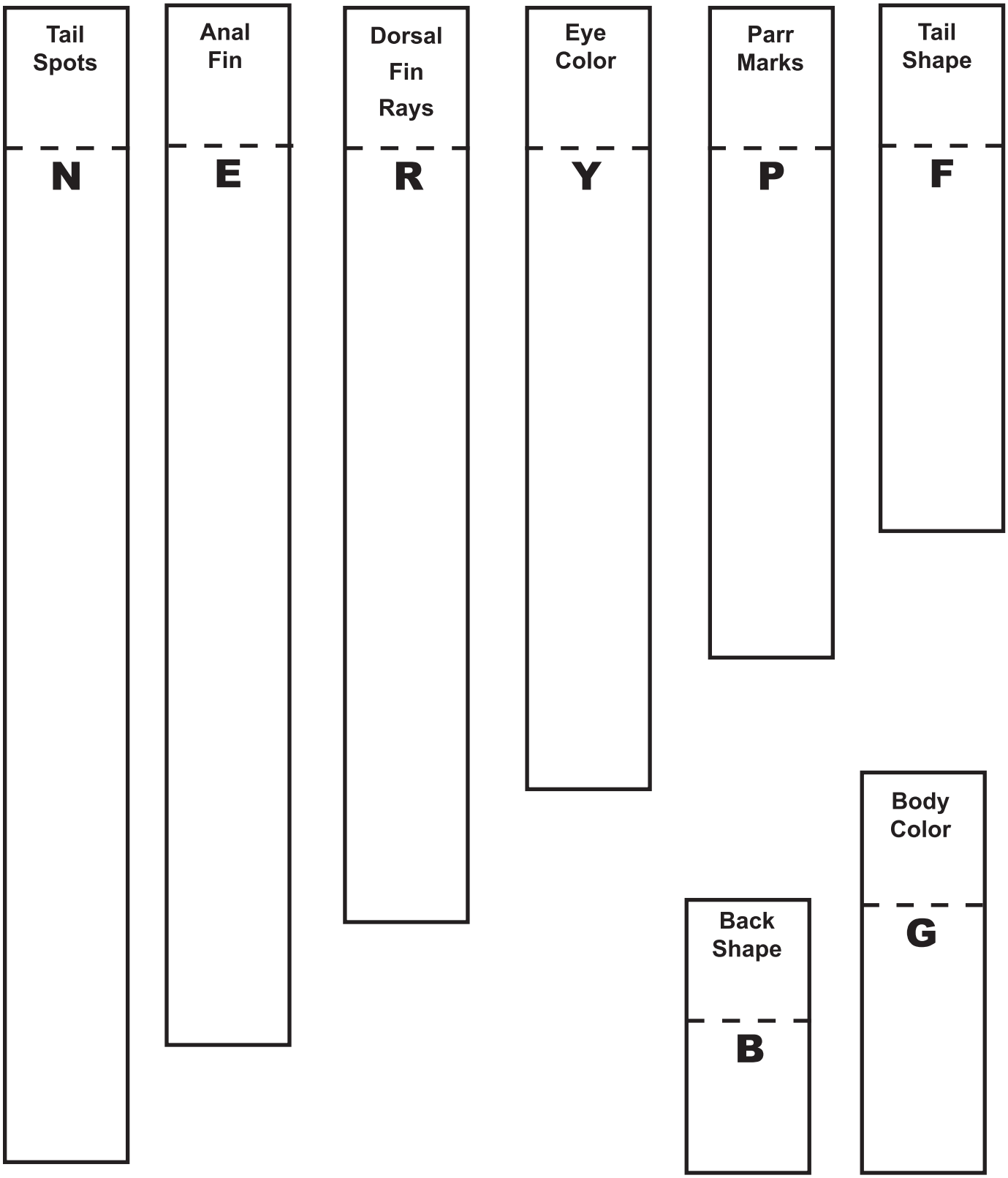
Name: _____

Classroom Totals

Trait	Phenotype	Genotype	No. of fry with genotype	% of class total	No. of fry with phenotype	% of class total
Back shape	Smooth	BB				
		Bb				
	Rounded	bb				
Body color	Gray	GG				
		Gg				
	Tan	gg				
Tail Shape	Forked	FF				
		Ff				
	Square	ff				
Tail spot-ting	Spots	NN				
		Nn				
	No spots	nn				
Parr marks	Yes	PP				
		Pp				
	No	pp				
Dorsal fin rays	6 rays	RR				
		Rr				
	3 rays	rr				
Anal fin shape	Elongated	EE				
		Ee				
	Short	ee				
Eye color	Yellow	YY				
		Yy				
	Green	yy				
Gender	Male	XY				
	Female	XX				

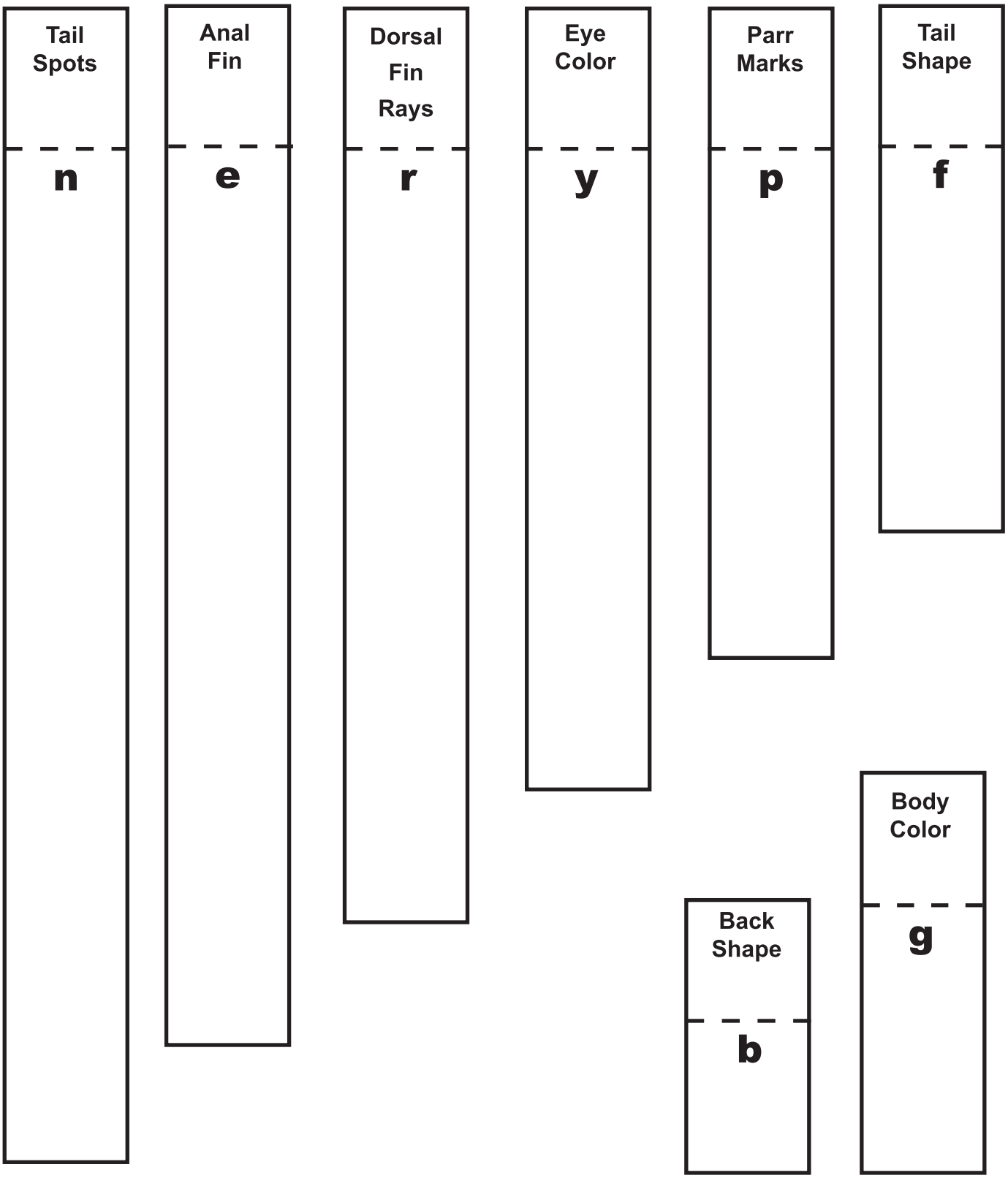
Chromosome Masters (Dominant)

This page of chromosomes represents the dominant form of each trait. Make two copies of this page for each student group — one for the male parent and one for the female parent. Use pink paper for the female's dominant genes and blue paper for the male's dominant genes.

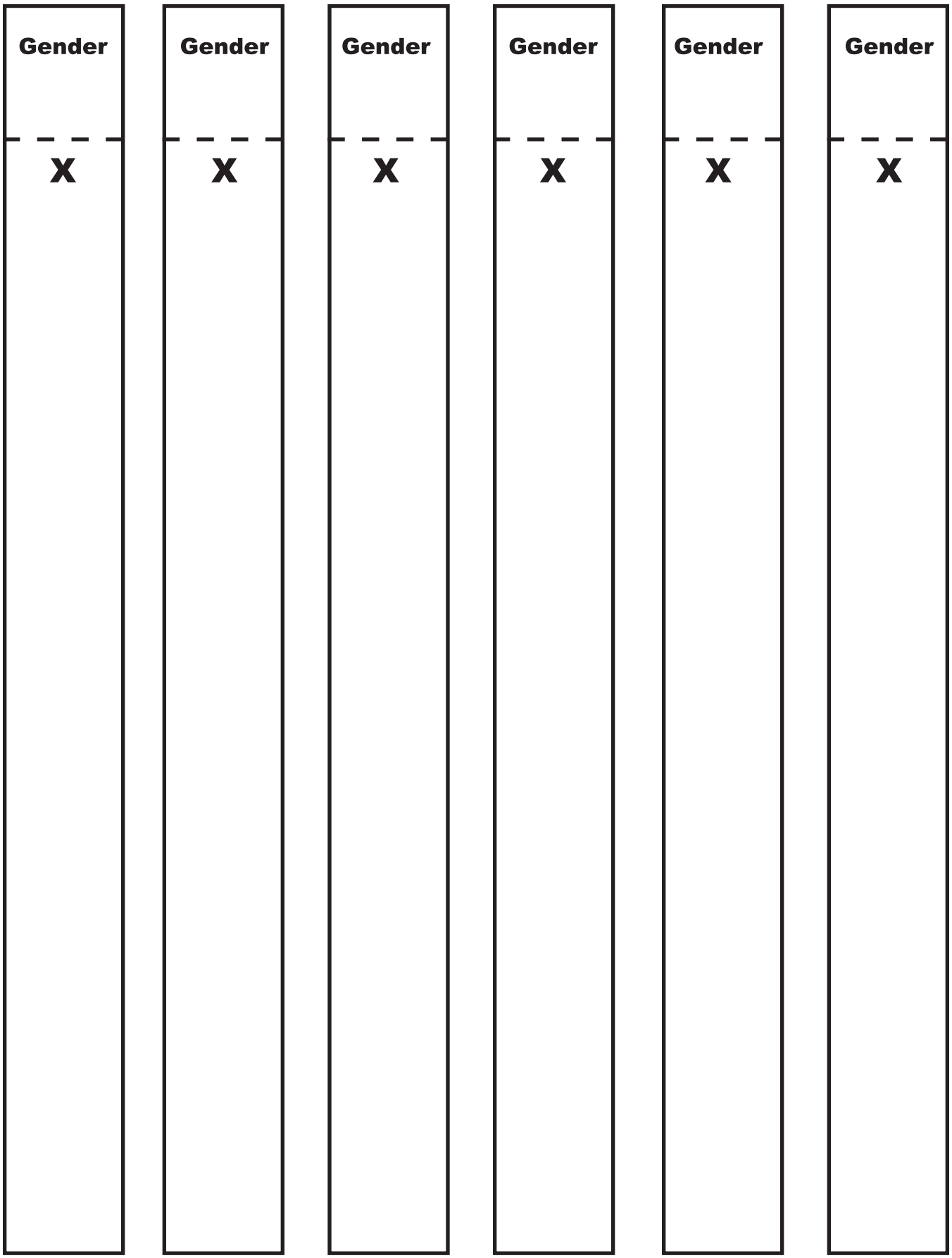


Chromosome Masters (Recessive)

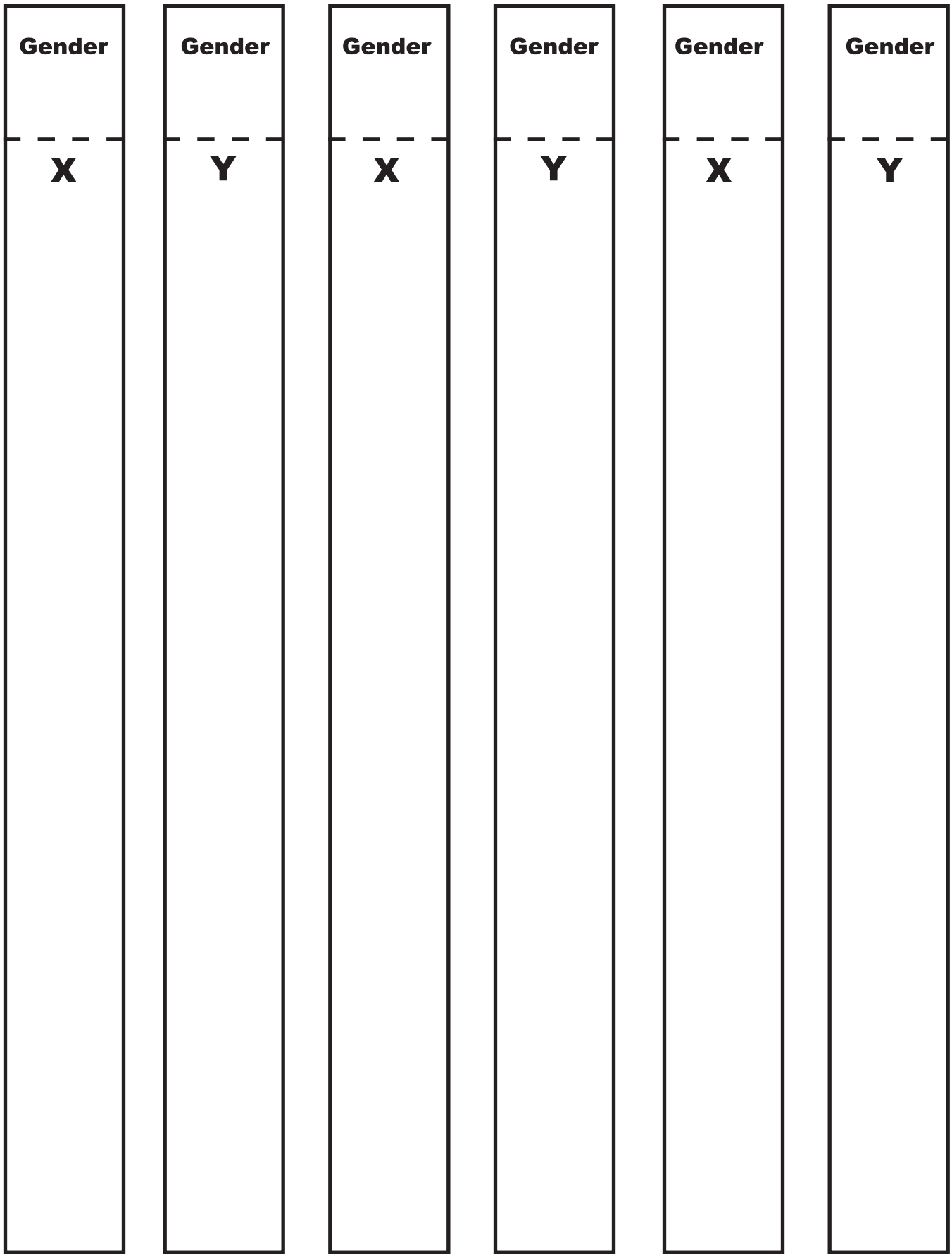
This page of chromosomes represents the recessive form of each trait. Make two copies of this page for each student group — one for the male parent and one for the female parent. Use pink paper for the female's recessive genes (same color as her dominant genes) and blue paper for the male's recessive genes (same color as his dominant genes).



Gender Chromosomes Master (female)

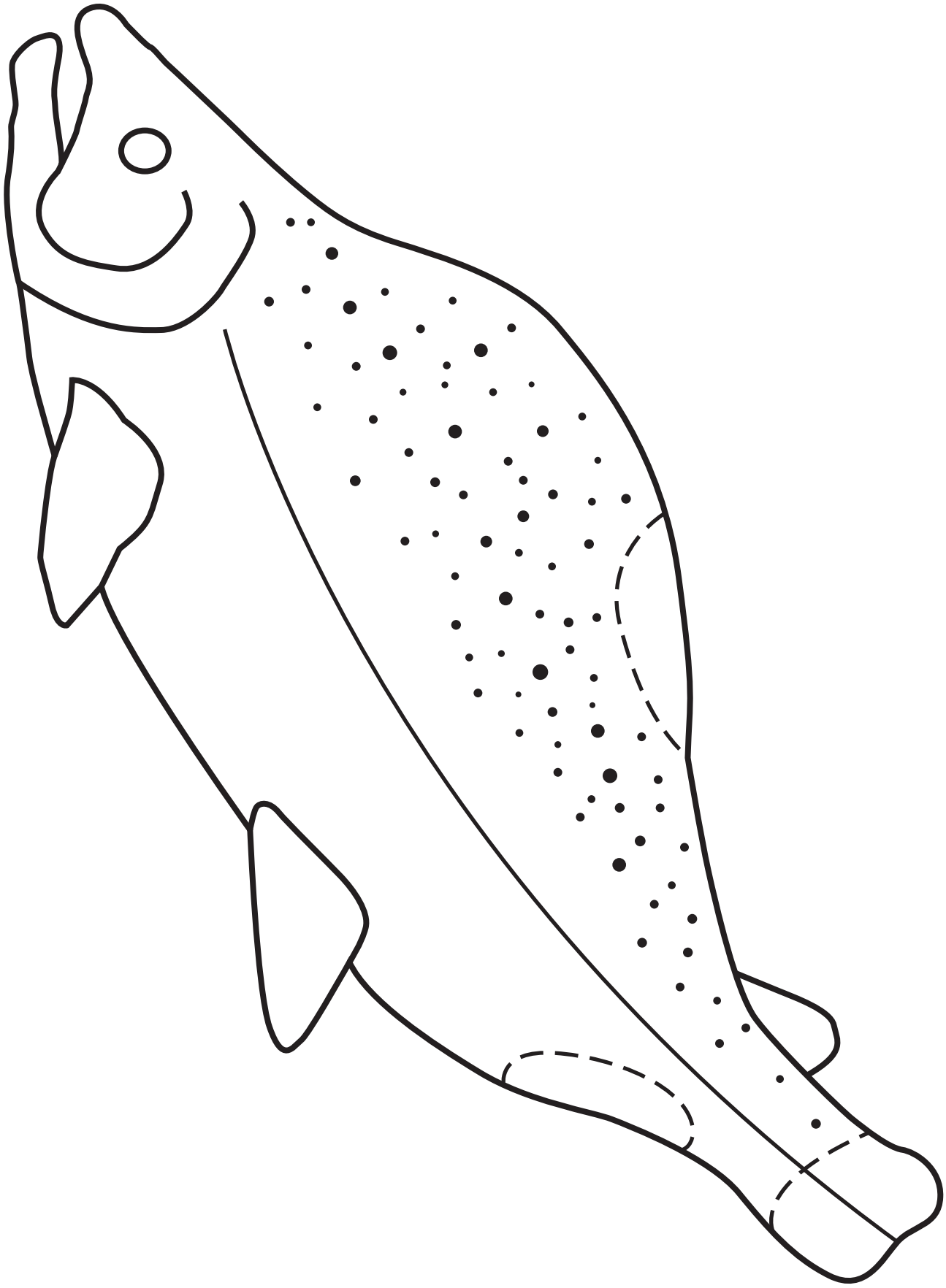


Gender Chromosomes Master (male)



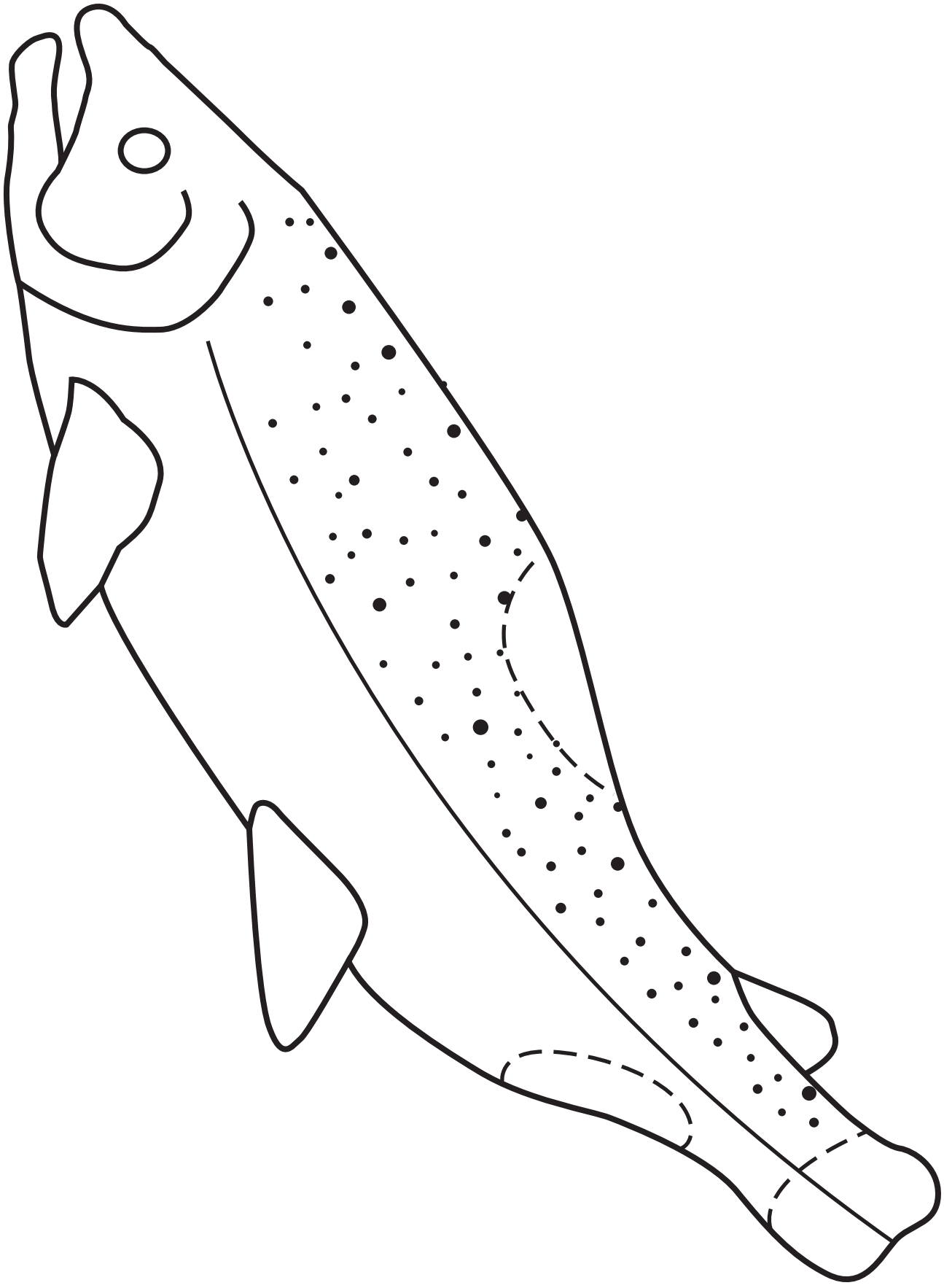
Rounded Back Shape Master

(Print equal numbers of gray and tan pages of this master for each class.)



Smooth Back Shape Master

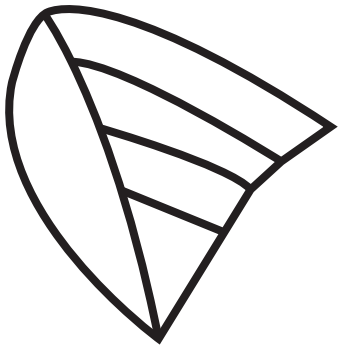
(Print equal numbers of gray and tan pages of this master for each class.)



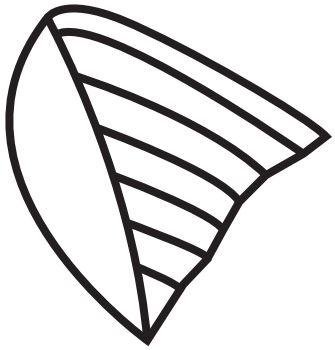
Dorsal and Anal Fins Master

(Print equal numbers of gray and tan pages of this master for each class.)

Dorsal fin with 3 rays

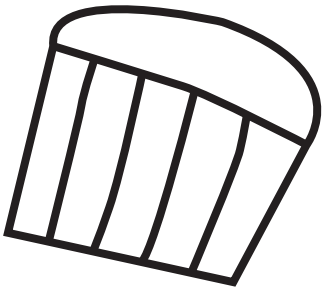


Dorsal fin with 6 rays



Elongated anal fin

Short anal fin

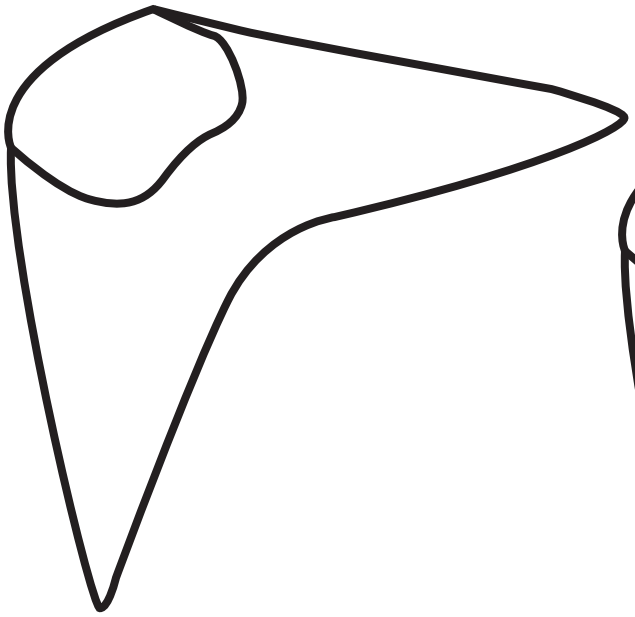


Parr Marks

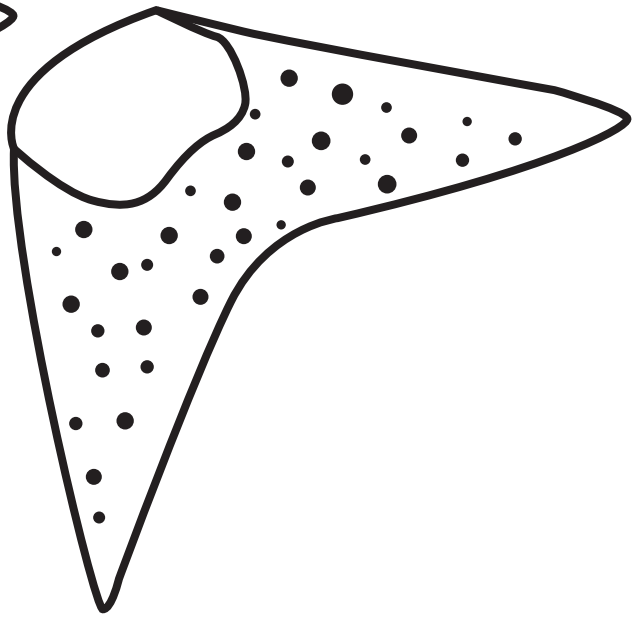
Tails Master

(Print equal numbers of gray and tan pages of this master for each class.)

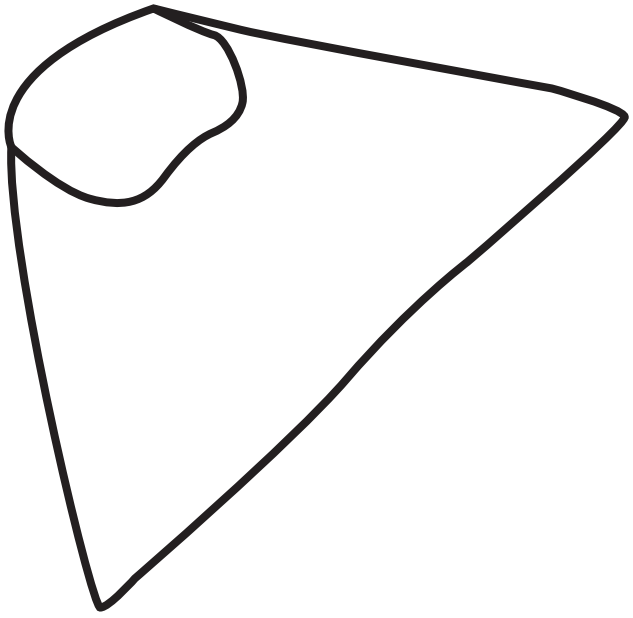
Forked tail without spots



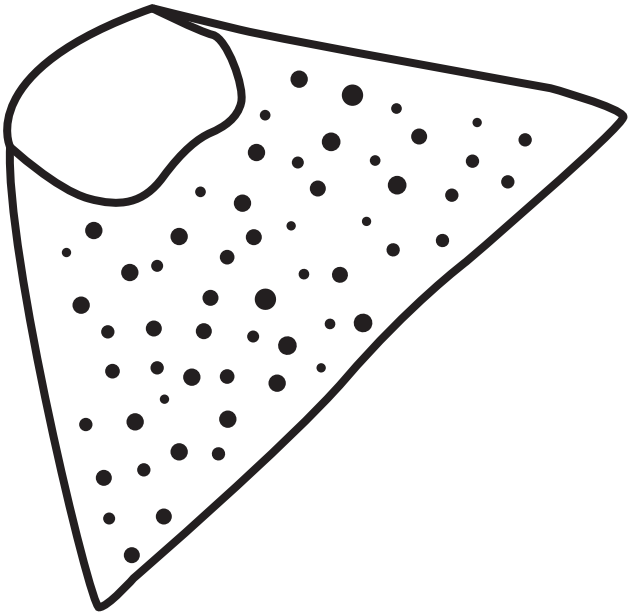
Forked tail with spots



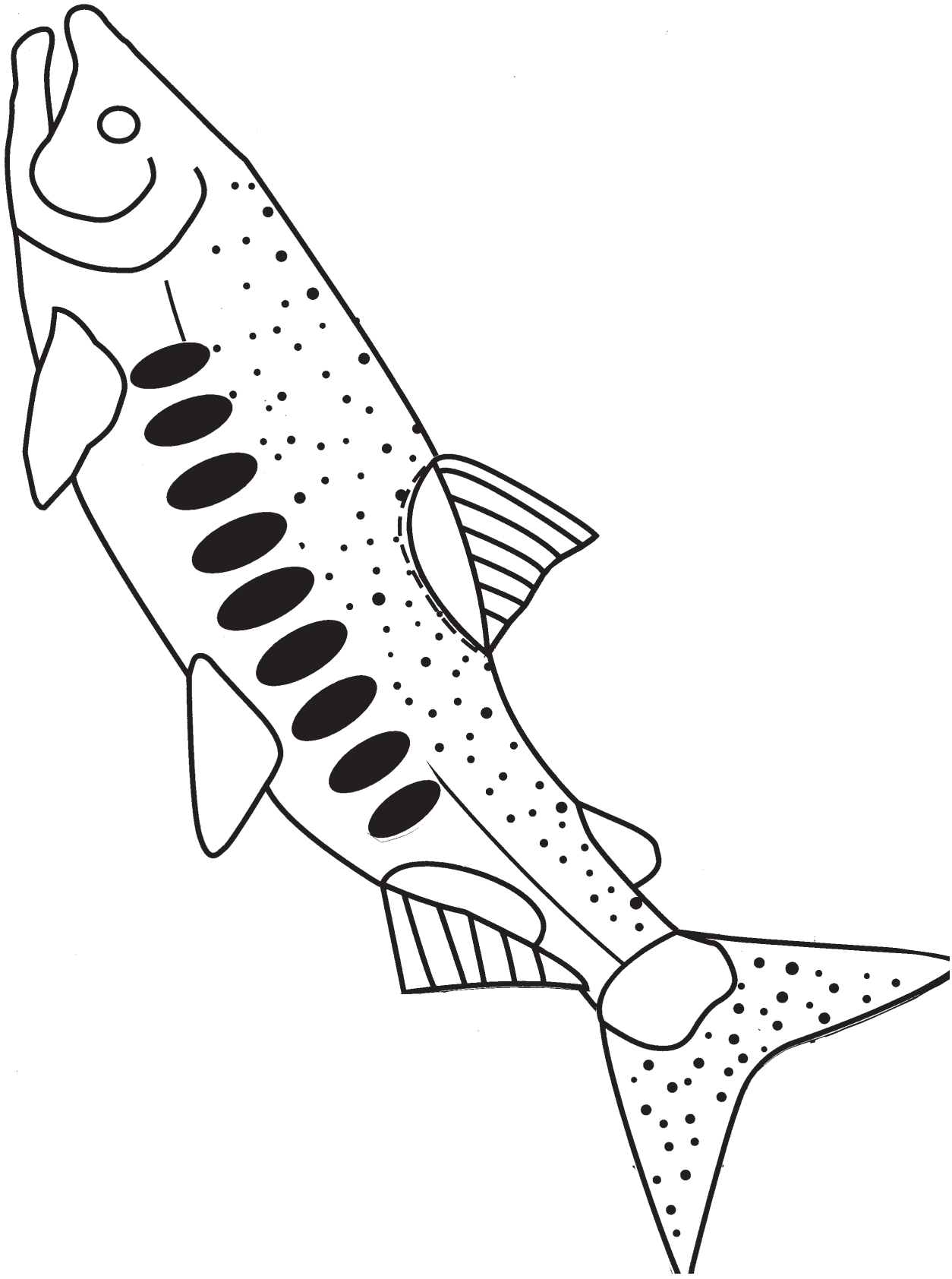
Square tail without spots



Square tail with spots



Parent Trout



Luck of the Draw Lower Grades

Summary

Students experience the process of constructing a trout from traits selected from parent fish.

Objectives

Students will...

- recognize all living things inherit traits from their parents, half from their mother and half from their father
- construct fish with traits randomly picked from parent fish traits

Materials

- copies of *Luck of the Draw Student Worksheet*, one per student
- copies of each of the following, about 20-25 each for a class of 30 students:
  - *Smooth Back Shape Master*
  - *Rounded Back Shape Master*
  - *Tails Master*
  - *Dorsal and Anal Fins Master*
- examples of what the parent fish look like copied on gray paper or colored gray
- 12 Popsicle sticks to draw parent gene types; write the following letters on the ends of the sticks – one letter per stick (You may want to make more than one set to speed up the drawing process.)
  - G, g, B, b, F, f, N, n, R, r, E, e
- envelopes with the following labels and Popsicles sticks placed within the envelopes
  - Body Color: G and g sticks
  - Back Shape: B and b sticks
  - Tail Shape: F and f sticks
  - Tail Spotting: N and n sticks
  - Dorsal Fin Rays: R and r sticks
  - Anal Fin Shape: E and e sticks
- scissors
- glue
- gray and tan colored crayons
- bulletin board covered with blue paper to represent a stream to display fish, if desired

Grade Level
2-6

Subject Areas
Science

Time
30-45 minutes

Vocabulary
allele, chromosome, dominant allele, gene, genotype, meiosis, mitosis, phenotype, recessive allele, traits

Background

All living things look and act the way they do because of traits they inherited from their parents. Traits are passed along from generation to generation by genes through the process of sexual reproduction. Genes are hooked together to form chromosomes. Chromosomes are found in the nucleus of every cell.

Chromosomes duplicate and divide during routine cell division or mitosis. The new 'daughter' cell inherits the same genetic coding as the parent cell. For example, in this exercise trout have 12 chromosomes. (In reality, rainbow trout have 58 chromosomes. We reduced this number to simplify the activity.) In order for a trout to grow, its cells must undergo mitosis. When this process occurs, the daughter cell will inherit 12 chromosomes identical to the parent's.

When an organism needs to create reproductive cells (such as an egg or sperm) a different type of cell division, meiosis, takes place. Meiosis creates daughter cells with only one half of the chromosomes found in the original parent cell. For example, when a parent trout cell undergoes meiosis, the daughter cell (sperm or egg) only has 6 chromosomes. In sexual reproduction, when the egg cell and sperm cell join, their chromosomes combine so that the new organism has 12 chromosomes. If meiosis did not occur, the chromosome number for a species would double each generation!

Variations in the way an organism looks (its phenotype) are due to variations in the organism's set of genes (its genotype) found on the chromosomes. Different genes, such as yellow or green, for the same trait (eye color) are known as alleles. There is an allele coding for yellow eyes and one coding for green eyes. In this lesson, all traits have two alleles, one dominant and one recessive. Dominant alleles mask other alleles for the same trait and will be physically observable. Recessive alleles are only physically observed when paired with another copy of the same recessive allele. For example, if the allele for yellow eyes is dominant over the allele for green eyes, a trout that inherits one yellow allele from one parent and one green allele from the other parent will have yellow eyes. Only a trout that inherits the allele for green eyes from both parents will actually exhibit green eyes.

Procedure

1. If students are unfamiliar with the name of fish fins, go over the names with the students.

2. Discuss examples of human heredity (i.e., eye color, hair color, ear lobes, etc.). Remind students that the same concept of heredity applies to all organisms. Only the traits and their expressions are different.

3. Discuss that all offspring receive half their genes, which make up traits, from their mother and half from their father. Some genes are dominant. They are always expressed or seen in the offspring and are indicated by a capital letter (B). Other genes are recessive and are indicated by a lower case letter (b). Recessive genes are only expressed when the offspring gets a recessive gene from each parent. For example, let's say H is the symbol for brown hair and h is the symbol for blonde hair. A baby will get one H or h from the mother and one from the father. If the baby gets the HH combination, the baby will have brown hair. If the baby gets the Hh combination, the baby will again have brown hair because the dominant H is always expressed. If the baby gets the hh combination, the baby will have blonde hair. It needs both recessive genes for that trait to show.

4. Tell the students that they will make a fish based upon genes received from its parents. Post examples of the parents. Both parents look the same, but each parent fish has a dominant (capital letter) and recessive (lower case letter) gene for each trait. Even though the parents look the same, they may have offspring that do not look like them.

5. Demonstrate the activity by showing the students the *Luck of the Draw Student Worksheet* and envelopes labeled with traits and Popsicle sticks representing the parent genes. Pick one trait envelope and draw a "gene" (stick) from the envelope to represent the mother's contribution. Circle the appropriate letter on the *Luck of the Draw Student Worksheet.* Place the stick back in the envelope and mix the sticks up. Draw again from the envelope to represent the father's gene contribution and circle the appropriate letter. Write the combined letters in the appropriate space and circle the gene combination for your fish. Now circle the trait type associated with your gene combination. This trait will be "seen" in the fish.

6. Hand out the *Luck of the Draw Student Worksheet*. Have the students pick one trait and draw for genes as you demonstrated. Have the students share envelopes until they have all trait types determined.

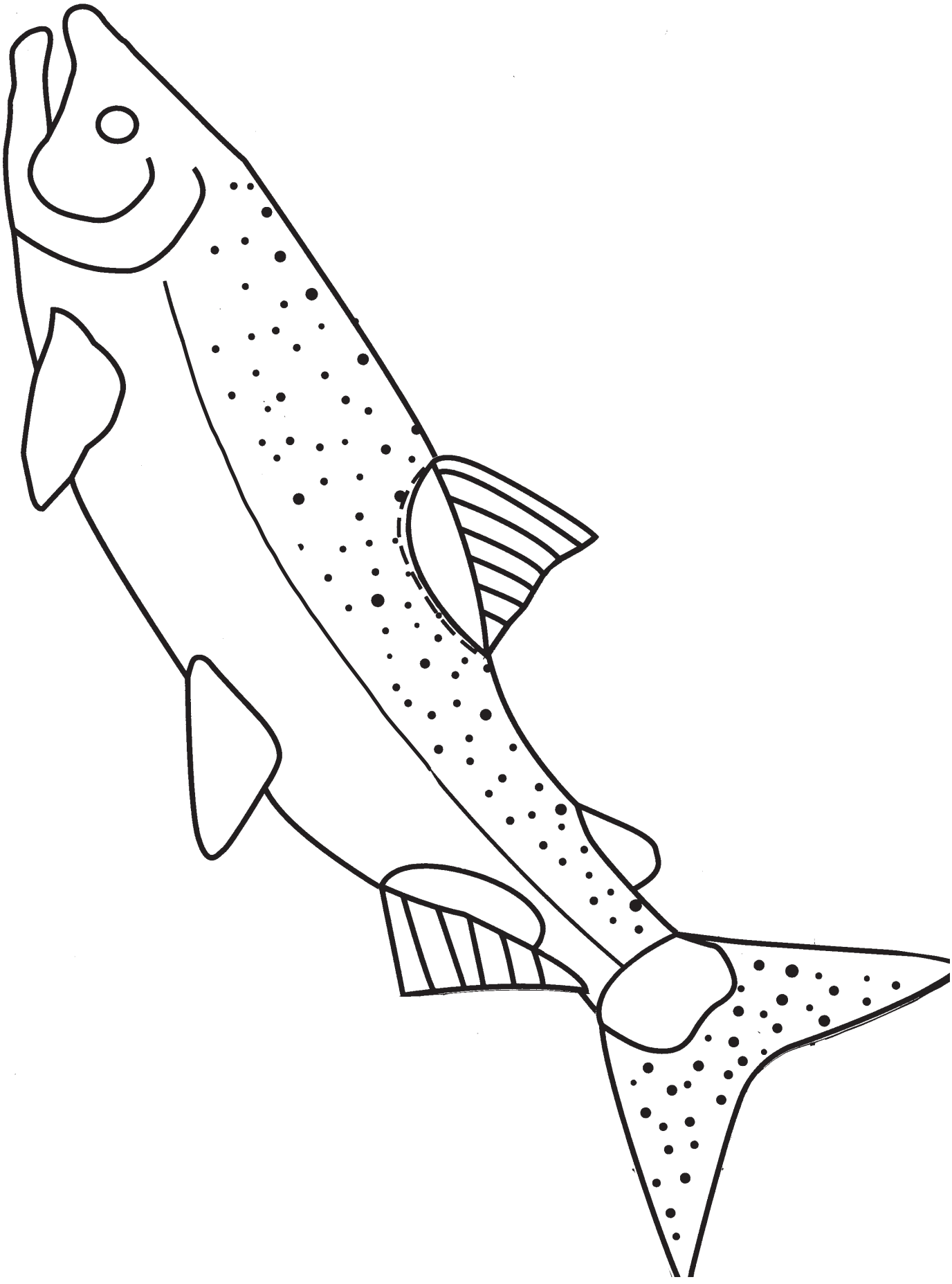
7. Place the copies of the *Smooth Back Shape Master, Rounded Back Shape Master, Tails Master,* and *Dorsal and Anal Fins Master* out for students. Have the students assemble their fish based upon the traits they circled and color the fish gray or tan based on their fish's trait type.

8. Display the fish on a bulletin board covered with blue construction paper. Discuss how the offspring fish look when compared to the parent fish. Relate this back to how all organisms are different because of the traits they inherit from their parents. How many different combinations occurred from the same parents?

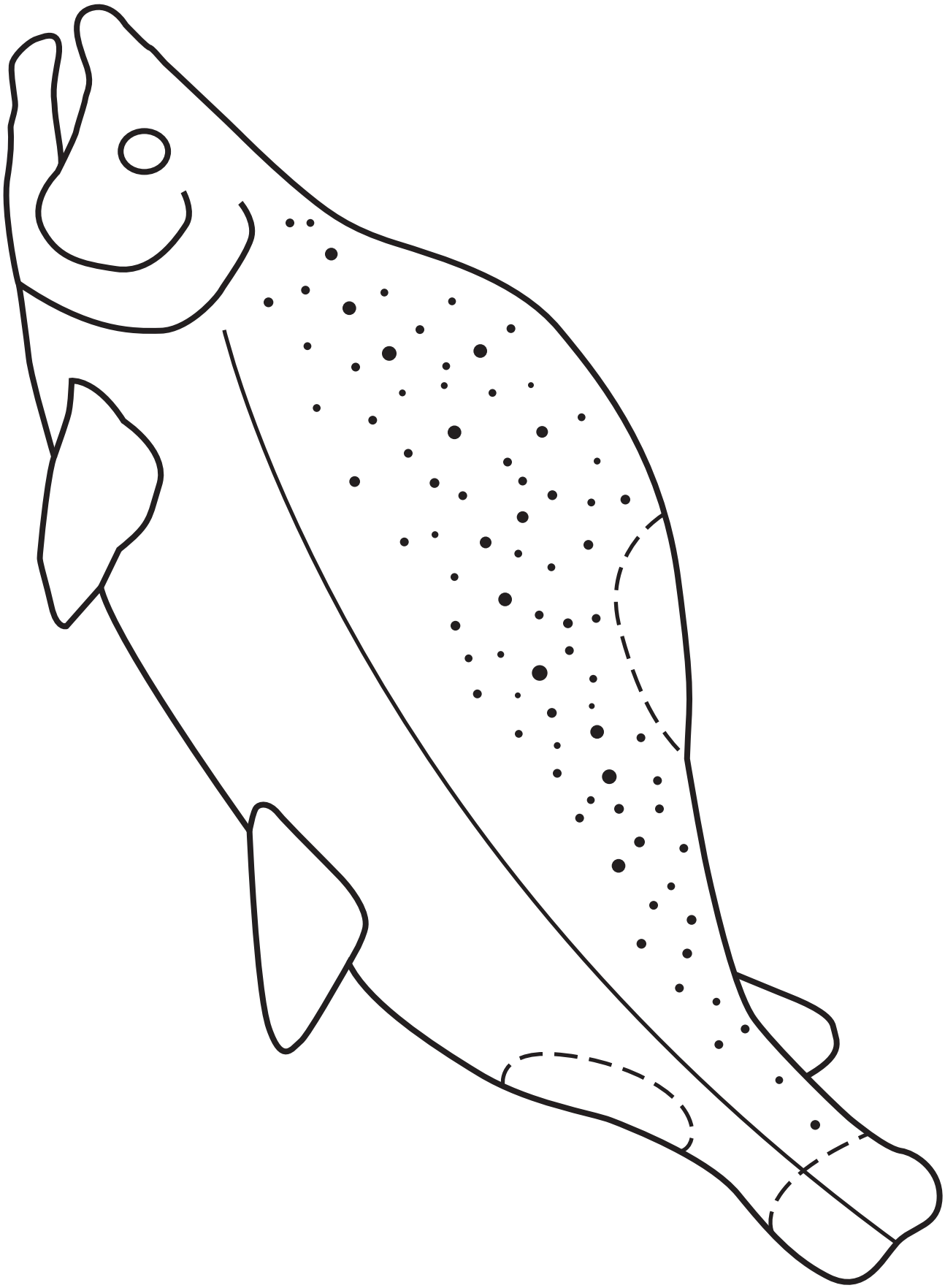
Luck of the Draw Student Worksheet

Trait	Mother Gene Contribution	Father Gene Contribution	My Fish's Combination From Parents	Gene Combination for Trait Types (Genotypes)	Trait Types (Phenotypes)
Body Color	G g	G g		GG or Gg	Gray Body
				gg	Tan Body
Back Shape	B b	B b		BB or Bb	Smooth Back
				bb	Rounded Back
Tail Shape	F f	F f		FF or Ff	Forked Tail
				ff	Squared Tail
Tail Spotting	N n	N n		NN or Nn	Spotted Tail
				nn	No Spots on Tail
Dorsal Fin Rays	R r	R r		RR or Rr	6 Dorsal Rays
				rr	3 Dorsal Rays
Anal Fin Shape	E e	E e		EE or Ee	Long Anal Fin
				ee	Short Anal Fin

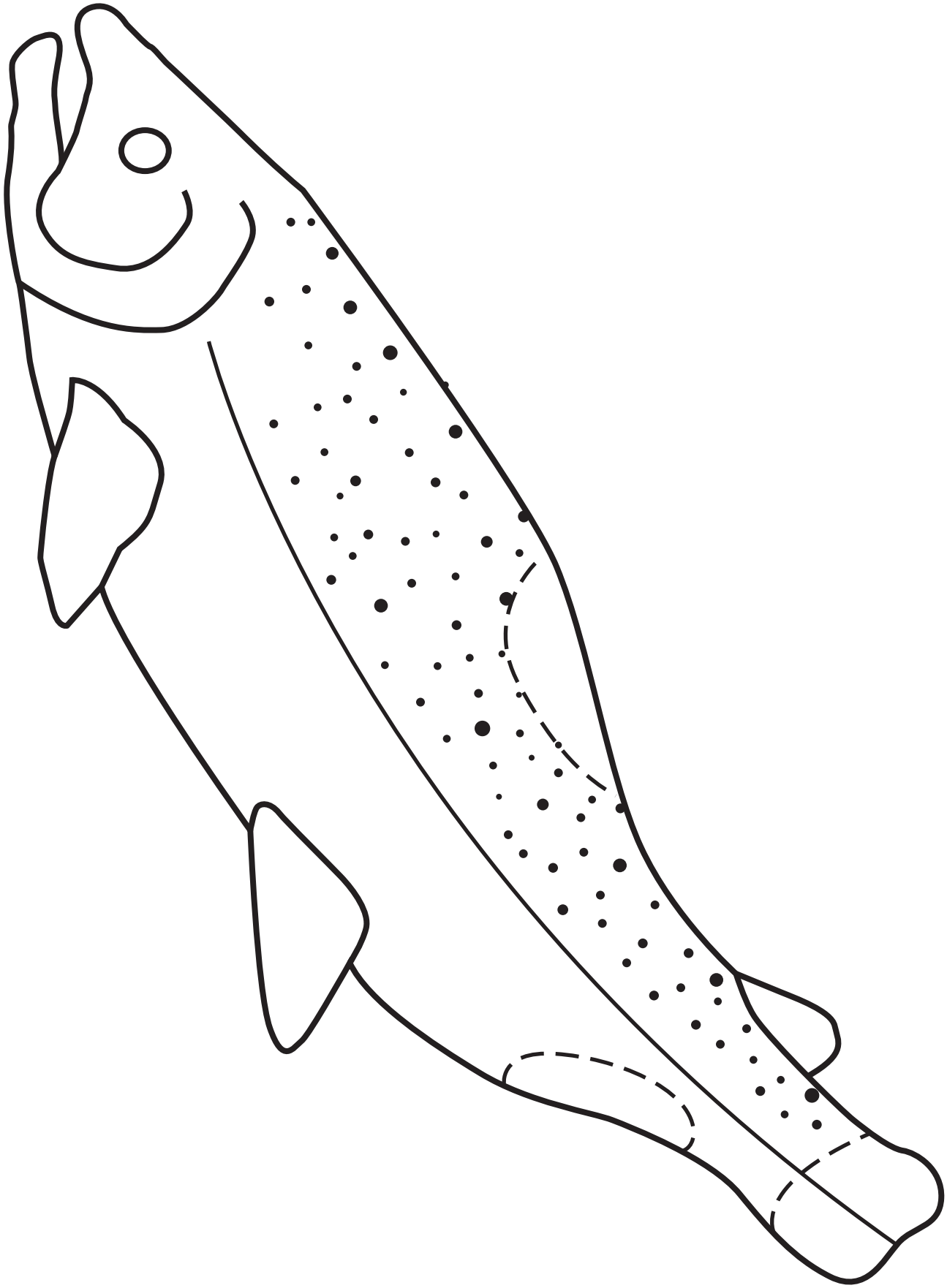
Parent Trout



Rounded Back Shape Master

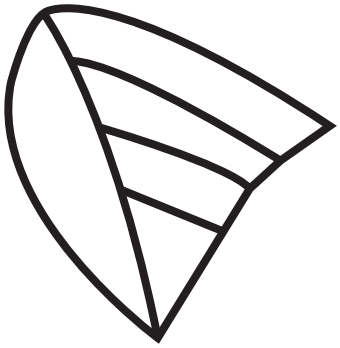


Smooth Back Shape Master

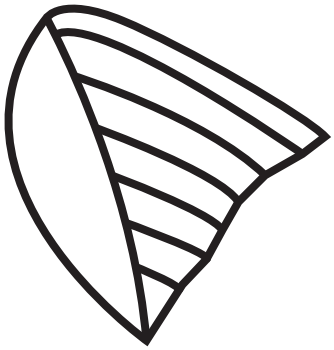


Dorsal and Anal Fins Master

Dorsal fin with 3 rays

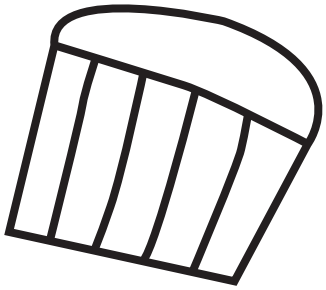


Dorsal fin with 6 rays



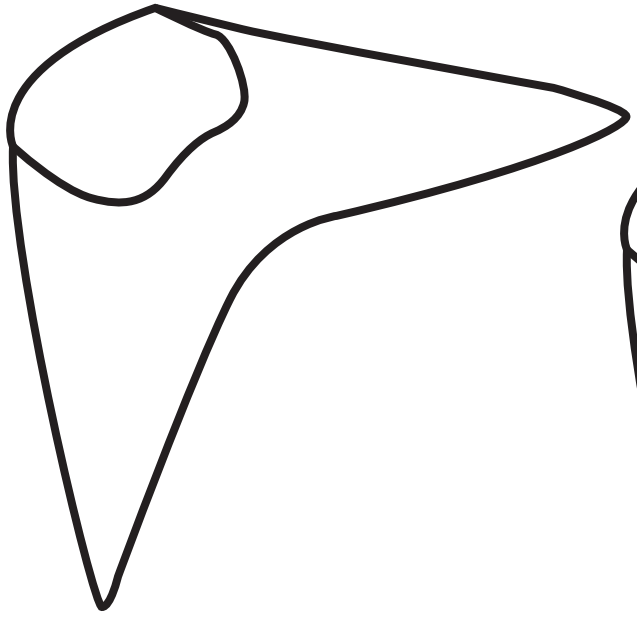
Elongated anal fin

Short anal fin

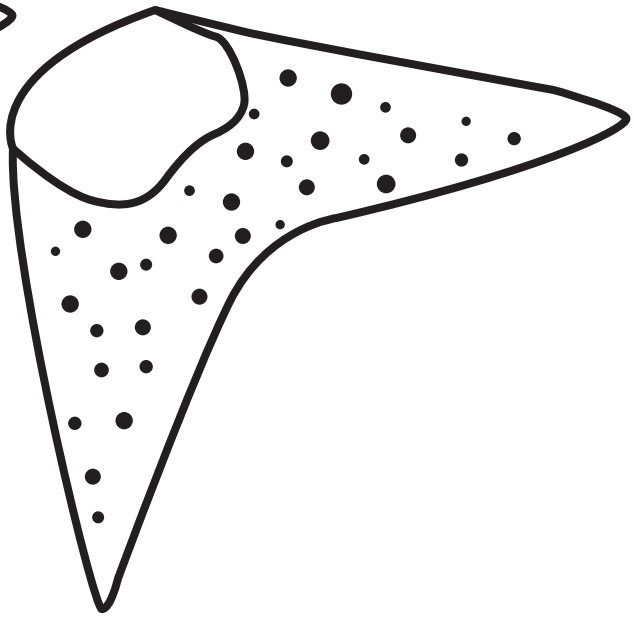


Tails Master

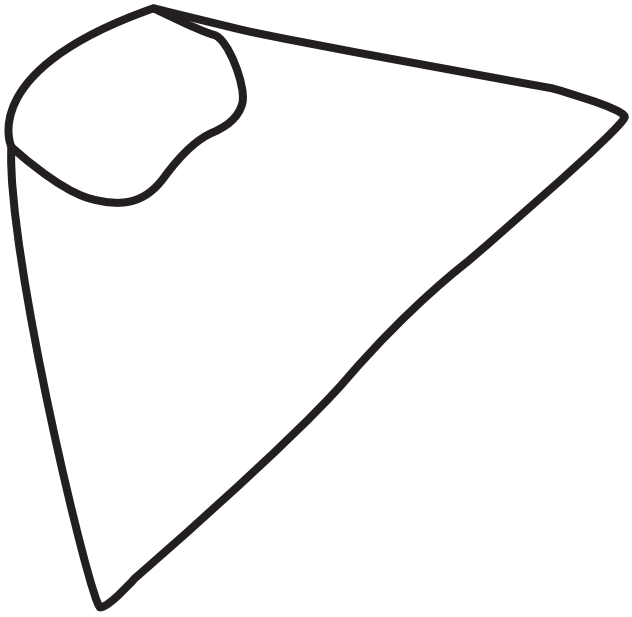
Forked tail without spots



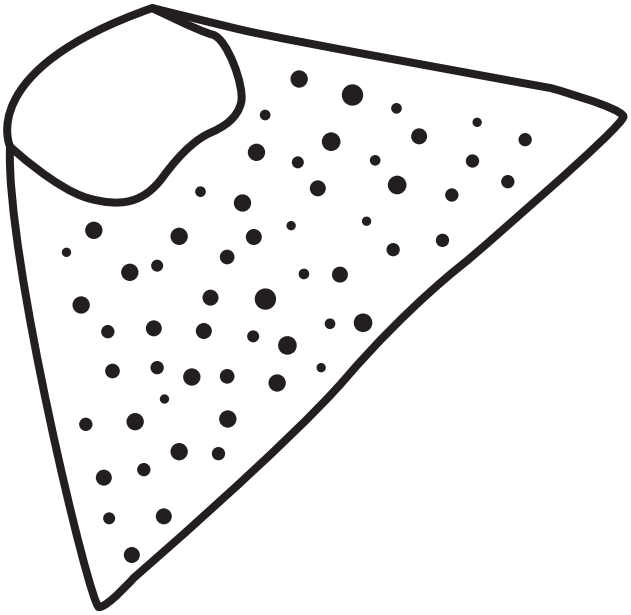
Forked tail with spots



Square tail without spots



Square tail with spots



Habitat Health Assessment

Grade Level
4-12

Subject Areas
Language Arts, Math, Science

Time
Part One: 45 minutes

Part Two: 30 minutes

Vocabulary
aquatic, benthic, channelization, dissolved oxygen, ecosystem, environment, erosion, habitat, invertebrate, larva, macroinvertebrate, nymph, pH, pollution, pool, riffle, riparian zone, sediment, silt, substrate, tolerance, turbidity

Summary

Students visually and biologically assess the health of a stream.

Objectives

Students will...

- identify physical characteristics of a stream and rate them based on what a healthy stream should look like
- collect and identify macroinvertebrates
- decide whether the habitat is suitable for trout
- hypothesize why these types of assessments are important

Materials

Part One:

- copies of *Visual Survey* worksheet, one for each student or group of students
- clipboards to write on
- thermometer (to measure air and water)
- water quality kit (to measure pH)

Part Two:

- copies of *Biological Survey* worksheet
- copies of *Macroinvertebrate Identification* sheet
- waders; if water is not too cold, shorts and water shoes may be fine
- kick net(s)
- magnifying glasses
- 4 – 5 ice cube trays
- pipettes or plastic spoons to handle macroinvertebrates

Background

Habitat is a place that provides a species with what it needs to survive: food, water, shelter, and space in a suitable arrangement. In other words, habitat is a home. For people, habitat might stretch from their house (where they have water, shelter and space) to the supermarket (where they buy food). All the places people go to get what they need to survive can be considered part of their habitat.

When it comes to finding a home, trout are some of the pickiest species of fish in the country. The ideal trout habitat is a fast-flowing stream with cold, clear and clean water. The stream or river should meander and offer a variety of depths over gravel and rocks, with both fast-moving and slower water. Diversity is very important in a habitat, because it provides varying microhabitats (small, specialized habitats). For example, trout may seek deep pockets of water when water levels are low. Conversely, trout may seek riffles when temperatures are warm and dissolved oxygen levels decrease.

One way biologists look at the health of a stream is by conducting a visual survey. This involves looking at sections of the stream that are representative of different conditions. The class will conduct a visual survey of a stream or creek to assess if it is a suitable habitat for trout. To assess the stream, students must be familiar with the various parts of a stream. So what makes up a healthy stream habitat?

Water quality is a critical element of a stream's health. Trout need cool, clean, oxygen-rich water. The optimal temperature depends on species, but generally trout prefer water that is around 50 to 60 degrees Fahrenheit. As water temperatures rise, dissolved oxygen levels decrease. Warm water may cause eggs to hatch before the spring food supply is available. Additionally, as water temperatures rise, the amount of oxygen in the water decreases. Dissolved oxygen is the amount of oxygen mixed within the water and can be measured with most water quality kits. Trout need water that is rich in oxygen. Water becomes more oxygenated as it bubbles over rocks and boulders, and it is able to hold oxygen better at lower temperatures. pH stands for power of hydrogen and is a measure of the acidity or alkalinity of a solution. Solutions with a pH under 7 are considered acidic and those with a pH over 7 are considered basic. If the pH of the water varies out of the 6.5 to 8.5 range, it can affect the internal muscles and organs of the fish. Finally, trout need water that is free of pollution. Heavy metals and organic contaminants, found in storm water runoff, sewage and industrial wastewater, are harmful to trout. While nitrogen and phosphorus are important nutrients when present in low concentrations, high levels can cause excess algal growth. This becomes a problem

when the algae die and the decomposition process depletes dissolved oxygen in the water.

The **riparian zone** is the transitional area between a body of water and the surrounding lands. In other words, it is the green zone between the edge of the stream and the land around it. A healthy riparian zone is one of the most important elements for a healthy stream ecosystem. Ideally, the land along the stream is covered with lush shrubs, plants and grasses, and a thick canopy of overhanging trees. The riparian zone offers many benefits to trout.

- Root systems protect banks from erosion, thereby limiting the amount of silt that can damage eggs in the stream.
- The vegetation also stabilizes water levels by alternately soaking up rainfall and releasing moisture.
- Thick summer foliage over the stream keeps the water shaded and cool.
- Fallen trees in the stream provide habitat, trapping gravel to create perfect spawning sites. Additionally, slow-flowing pools are formed by these trees, providing rearing areas.
- Leaf litter provides food for many aquatic insects.
- In colder climates, streamside vegetation can keep the water slightly warmer for young fish.
- The plants and their roots reduce the amount of pollutants that reach the stream via surface runoff.

Riffles are portions of a stream that are shallow and fast. They often have bedrock, cobble stones, and sometimes boulders, which are essential elements for trout survival. Riffles are necessary for many reasons.

- They break up the flow of water and allow oxygen to mix with it. This increases dissolved oxygen in the stream and also cleanses trout eggs of silt and waste.
- They provide a habitat and breeding ground for the aquatic insects on which trout feed.
- The broken water surface helps to hide trout from predators.
- They protect young trout with hiding spaces between boulders and within whitewater areas.

Pools are areas of deeper and slower water that are generally formed around stream bends or obstructions such as logs, root wads or boulders. Pools are equally as important as riffles.

- They allow fish to rest and provide feeding areas.
- They slow water so that organic materials can settle, decompose, and produce carbon dioxide and other nutrients needed by plants.

Biologists consider a one-to-one pool to riffle ratio as part of a healthy spawning stream.

Scientists can also assess the health of a stream by conducting a biological survey. This involves the collection of insects and crustaceans that live in the stream. These organisms are referred to as benthic macroinvertebrates (or simply macros); benthic means bottom-dwelling, macro means large enough to see with the naked eye and invertebrate means they have no backbone. These animals live on rocks, logs, sediment, debris and aquatic plants during some period in their life. Macros include crustaceans such as crayfish, mollusks such as clams and snails, aquatic worms and the immature forms of aquatic insects such as stonefly and mayfly nymphs.

Macros are great indicators of water quality because...

- They differ in their sensitivity to stress in the waterway. Some are very sensitive to pollutants in the water. Others are less sensitive to pollution and can be found in almost any stream.
- They usually live in the same area of a stream for most of their lives. Sampling macros is a good indication of what the water quality has been like for the past few months. If the water quality is generally poor, or if a polluting event occurred within the past several months, it will be reflected in the macroinvertebrate population.
- They are easily collected in many streams and rivers and do not require any expensive equipment.

Macroinvertebrates are generally broken up into three categories: pollution intolerant, moderately pollution tolerant and pollution tolerant. Depending upon the type and number of macros found, the water quality can be rated as excellent, good, fair or poor. A stream with excellent water quality should support a diversity of invertebrates from all three pollution tolerance groups.

Part One: Visual Assessment

Procedure

1. Explain to the students that they will be visually assessing a stream to determine if it is a suitable habitat for trout. What do they think it means to visually assess or survey an area? Visually assessing a stream involves making a judgment on the quality of the stream by looking at certain characteristics. Hand out the *Visual Survey* worksheet. Review all the characteristics they will assess, why they are important, and how the final score of the stream will be found.
2. Pass out *Visual Survey* worksheets and clipboards.
3. Take the initial measurements together (temperature, pH, and any others you see fit) as a class.

4. To measure temperature, let a thermometer sit in the water for about five minutes.

5. To measure pH use a water quality test kit and follow the directions included.

6. Experiment with other tests if possible. Other parameters include: dissolved oxygen, turbidity, coliform, nitrates/ nitrites.

7. Define the stream walk boundaries; make sure students understand that staying within the boundaries protects both them and wildlife.

8. Break up students into groups. Depending on the grade level and time available, assign each group to one characteristic on the worksheet or have each group assess all of the characteristics.

9. Allow students time to walk around within the boundaries and observe the characteristics of the stream.

10. Regroup and have everyone share their scores of the assigned characteristic. If each group evaluated all the characteristics, find an average or agreed upon score for each characteristic. Determine the stream score together.

11. Would they want to release their trout here? Do they think this is an accurate way of assessing a stream? What faults might there be in assessing a stream this way?

Part Two: Biological Assessment

Procedure

1. Explain to the students that they will be biologically assessing a stream to determine if it is a suitable habitat for trout. How do you biologically survey a stream? This type of survey involves the collection of benthic macroinvertebrates – insects and crustaceans that live in the stream. Break down and explain the meaning of the name benthic macroinvertebrate. Benthic means bottom-dwelling, macro means it can be seen by the naked eye, and invertebrate means without a backbone. Review why biologists like to collect these organisms as indicators of water quality.

    - Macroinvertebrates differ in their sensitivity to stress in the waterway. Some are very sensitive to pollutants in the water; some are less sensitive.
    - Macroinvertebrates usually live in the same area of a stream for most of their lives and reflect the history of the water quality for a few months. If the water quality is generally poor, or if a polluting event occurred within the past several months, it will be reflected in the macroinvertebrate population.
    - Macroinvertebrates are an easy and cheap way to determine water quality – almost anyone can assess water quality by sampling macroinvertebrates and no expensive equipment is involved.

2. Depending on the availability of waders and kick nets, either small groups can go one at a time to collect samples or groups can all go out on their own.

3. Demonstrate how to collect macroinvertebrates. If possible, select a shallow area (knee high) with gravel/cobble bottom and fairly fast current (make sure the current is not too fast).

4. You will need one person to hold the net while another person stirs up the macros. Have one person place the net bottom firmly against the streambed in the middle of the current, with the current flowing directly into the net. The person holding the net should be standing downstream from the net, facing upstream.

5. The other participant then disturbs the area directly upstream and in front of the net. To do this, pick up rocks and gently rub them to wash off any macroinvertebrates. Once a rock is cleaned, put it aside and continue the process covering an area of about one meter wide by one meter long.

6. Next kick up the stream bed in front of the net by digging your feet into the ground, stirring up the stream bottom.

7. Lift the net up and out of the water carefully so nothing washes off.

8. While the net is being brought back to the bank, replace the rocks where you sampled.

9. Fill the ice cube trays with water and begin sorting through the macroinvertebrates found in the net. Sort by placing the same organisms together in the tray. Begin the process of identifying the species with the help of the *Macroinvertebrate Identification* sheet.

10. Once the net has been thoroughly combed over, go through the tray and count how many of each macroinvertebrate type was found. Record this information on the *Biological Survey* worksheet.

11. Allow others to repeat the procedure in different areas and record results.

12. Once all groups have had an opportunity to sample the stream, have the students calculate their scores. Review the data found.

    - Did different groups get different macroinvertebrate scores?

- Did students find a wide variety of species or were there only a few species found?
- Do you think, based on the macroinvertebrate score, that this would be a suitable place for a trout release?

13. Does the score given in this survey match up with that from the visual survey?

14. Do they think this is an accurate way of assessing a stream? What faults might there be in assessing a stream this way? How does it compare to the visual survey?

Evaluation

1. Students identify the two characteristics that scored the lowest on the visual survey. Have students write a paragraph explaining how the two characteristics could be improved, citing two suggestions for each characteristic.

2. Students present data from the biological survey in graph form, showing the numbers for each type of macroinvertebrate found. Supplement the graph with an explanation of why the stream got the score it did – diversity in species found, pollution tolerance of those species, etc.

3. Students explain in a paragraph why they believe the visual or biological survey is the better of the two surveys when assessing stream health. Discuss factors such as accuracy, ease, safety, costs, and time taken to complete the survey.

Extension

1. Investigate other ways scientists assess stream and habitat quality.

2. Investigate how adaptations of macroinvertebrates allow them to inhabit different niches in an aquatic ecosystem.

Make Your Own Kick Net

Materials:

- 3.5’ x 4’ nylon mesh (1/16” mesh)
- 2 broom handles or wooden dowels
- Staple gun and staples
- Duct tape, needle and thread, or sewing machine

Directions:

1. Hem the 4’ sides of the mesh by folding over and taping or sewing to prevent the mesh from fraying.
2. Lay the netting out flat and lay the dowels out along the short sides.
3. Roll 6” of netting around each dowel and staple.

Student Worksheet 1 of 3 **Name:**_____

Visual Survey

Date _____

Stream Name _____

Outside Temperature _____ Weather Today _____

Weather Yesterday _____

For all the characteristics below, pick out the description that best matches your stream. You may have to use your judgment and estimate. Next to that description is a score for the characteristic you are judging. Circle the score and write it on the last page under 'Visual Assessment Scores'.

Water Temperature _____

< 55°F	10
55 - 75°F	7
> 75°F	3

pH _____

6.0 - 7.5	10
5.5 - 6.0	7
< 5.5 or > 7.5	3

Riparian Zone

The riparian zone is the area right next to the stream that is covered with plants, including trees and shrubs. The riparian zone is important for several reasons. The plants stabilize the stream banks, preventing erosion. The plants also shade the water, keeping the water temperatures cooler. In addition, plants drop leaves into the stream, providing food for aquatic insects. Mowed grass does not qualify as a healthy riparian zone.

The riparian zone is two times as wide as the stream.	10
The riparian zone is as wide as the stream.	8
The riparian zone is half as wide as the stream.	5
The riparian zone is one third as wide as the stream.	3
The riparian zone is less than one-third as wide as the stream.	1

Water Clarity

Water clarity refers to how clear water is, or how well you can see through it. When water is clear, it means there are few things mixed in the water. The opposite of clarity is turbidity. It refers to the cloudiness or murkiness of the water. Most often water becomes cloudy from sediments and soil, which can harm fish and other aquatic life. Water often looks turbid after a storm because of soil carried by runoff into the stream. Clarity of the water is an easy feature to assess. The deeper an object in the water can be seen, the lower the amount of turbidity. If the water is less than 3 feet deep, do not assess this characteristic.

Can see 3 to 6 feet deep into the water.	10
Can see 1.5 to 3 feet deep into the water.	7
Can see only 0.5 to 1.5 feet deep into the water.	3
Cannot see deeper than 0.5 feet.	1

Nutrients

High levels of nutrients in the water (especially phosphorus and nitrogen) can cause too much algae or too many aquatic plants to grow. The presence of some aquatic vegetation is normal in streams. Algae and plants provide habitat and food for stream animals. However, too much aquatic vegetation is not good for most stream life. Too many plants can cause a decrease in dissolved oxygen in the water. As the amount of nutrients in the water increases, the water becomes greenish in color. Clear water and a diverse aquatic plant community are ideal for a healthy stream.

Clear water; little algae present; low quantities of aquatic vegetation	10
Fairly clear or slightly greenish water along the stream; moderate amounts of algae on stream substrate	7
Greenish water along the stream; overabundance of lush green macrophytes or plants; abundant algal growth	3
Pea green, gray or brown water along the entire reach; dense stands of aquatic vegetation clog stream; thick algae mat in stream	1

Barriers to Fish Movement

Barriers that block the movement of fish or other aquatic organisms must be considered in the overall stream assessment. If the barriers are high enough, they can prevent the movement and migration of fish or deny access to important feeding grounds. Some barriers are natural (waterfalls or boulder dams) while some are developed by humans. Note the presence of barriers, their size and whether there are ways the fish can get around the barrier, such as a fish ladder.

No barriers to movement	10
Seasonal low water levels will prevent movement	7
Dams, culverts, or other diversions (less than one foot high) are within the reach	3
Dams, culverts or other diversions (greater than one foot high) are within the reach	1

Student Worksheet 3 of 3 Name: _____

In-stream Fish Habitat

This measures the availability of habitat for fish. The health of a fish community is dependent on the variety and amount of habitat and cover. Check the box next to the cover types present in this site.

Cover types:

- ❒ Logs/large woody debris – fallen trees or parts of trees that provide hiding places for fish
- ❒ Deep pools – areas with a smooth, undisturbed surface and generally slow current
- ❒ Overhanging vegetation – trees, shrubs, or other vegetation that hangs over the stream, providing shade and cover
- ❒ Boulders/cobbles – boulders are rounded stones more than 10 inches in diameter or large slabs more than 10 inches in length; cobbles are stones between 2.5 and 10 inches in diameter
- ❒ Undercut banks – eroded areas extending horizontally beneath the surface of the bank forming underwater pockets for fish to hide
- ❒ Thick roots – dense roots or rootlets (generally from trees) at or beneath the water surface
- ❒ Dense aquatic vegetation beds – beds of aquatic vegetation thick enough to provide fish cover
- ❒ Riffles – areas characterized by broken water surface
- ❒ Backwater pools – areas cut off from the main channel (or connected as a side channel) with no flow except in periods of high water

>7 cover types available	10
6 - 7 cover types available	8
4 - 5 cover types available	5
2 - 3 cover types available	3
None - 1 cover type available	1

Visual Assessment Scores

Water Temperature _ _ _ _ _ _____

+

pH _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _____

+

Riparian Zone _ _ _ _ _ _ _ _ _ _ _____

+

Water Clarity _ _ _ _ _ _ _ _ _ _ _ _____

+

Nutrients _ _ _ _ _ _ _ _ _ _ _ _ _ _____

+

Barriers to Fish _ _ _ _ _ _ _ _ _ _ _____

+

In Stream Habitat _ _ _ _ _ _ _ _ _ _ _____

=

Total _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _____

_____÷_____

Total ÷ # of characters assessed

= _____

Overall Stream Score

<6.0 = Poor

6.1 - 7.4 = Fair

7.5 – 8.9 = Good

> 9.0 = Excellent

Visual Health Assessment is_____

Name: _____

Biological Survey

Mark a check next to the name of any macroinvertebrates you have found while sampling. Use the *Macroinvertebrate Identification* sheet to help identify organisms. Only macroinvertebrates listed below are counted toward the macroinvertebrate score. Write the total number of individuals (estimate if there are greater than 20 individuals) found in each organism type under the number column. Count the number of boxes checked under each organism type (intolerant, moderately tolerant, and tolerant) and mark that total at the bottom of the column. Determine the index values for each column and total the three index values to find the macroinvertebrate score.

Pollution Intolerant Organisms			**Moderately Tolerant Organisms**			**Pollution Tolerant Organisms**		
Name	**Present (check)**	**Number**	**Name**	**Present (check)**	**Number**	**Name**	**Present (check)**	**Number**
Stonefly larvae			Dragonfly nymph			Midge larvae		
Mayfly larvae			Damselfly nymph			Blackfly larvae		
Caddisfly larvae			Alderfly larvae			Lunged snails		
Dobsonfly (Hellgrammite)			Crane fly larvae			Leeches		
Water penny larvae			Scuds			Aquatic worms		
Riffle beetle adult			Sowbugs			Mosquito larvae		
Gilled snails			Crayfish					
			Clam or mussel					
			True bugs					
No. of boxes checked x 3 = index value (IV)			No. of boxes checked x 2 = index value (IV)			No. of boxes checked x 1 = index value (IV)		

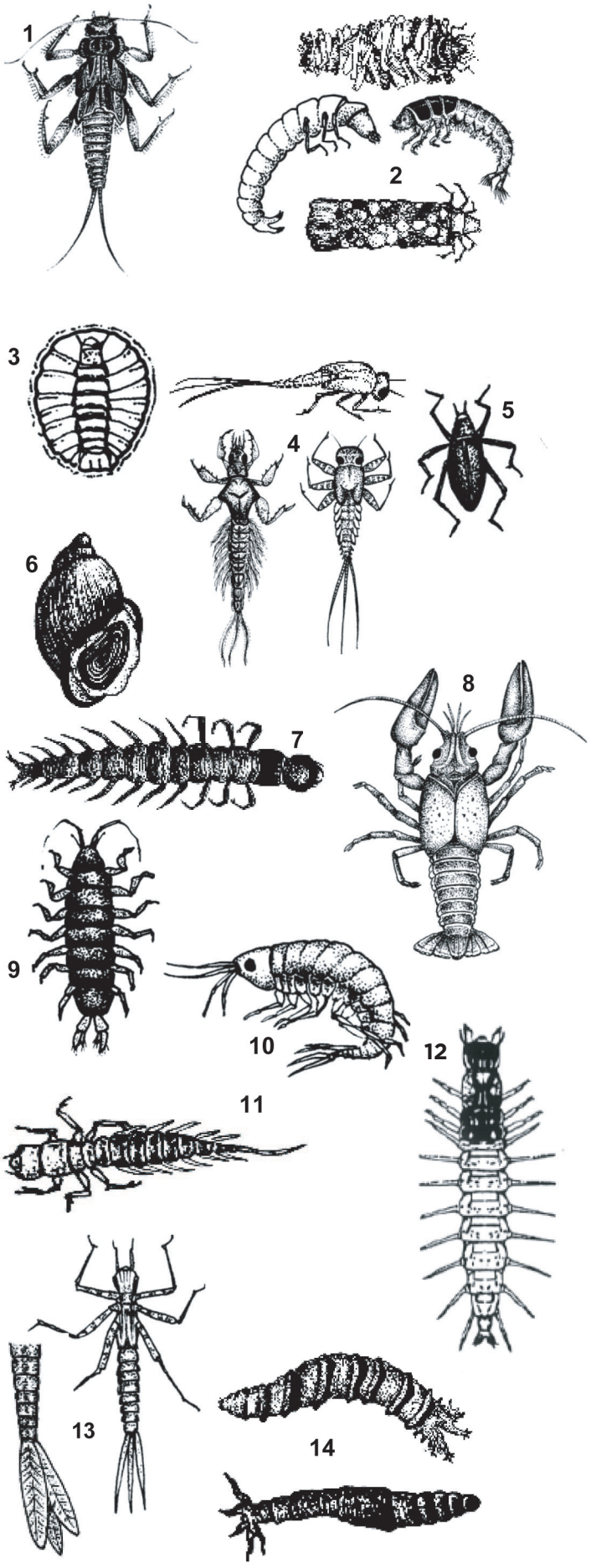
_____ + _____ + _____ = _____

Column 1 IV + Column 2 IV + Column 3 IV = macroinvertebrate score

Macroinvertebrate score = _____

Excellent = >22
Good = 17 – 22
Fair = 11 – 16
Poor = <11

Macroinvertebrate Identification



POLLUTION INTOLERANT SPECIES

1. **Stonefly nymph:** 5—35 mm; 6 legs; antennae; two hair-like tails, no gills on abdomen

2. **Caddisfly larva:** 2—40 mm; often found in "houses" made of pebbles, wood, sticks, leaves, sand or shells; 6 legs; 2 hooks at back end; may have fluffy gill tuffs on lower half; move with characteristic wiggling—back and forth then up and down

3. **Water penny:** 3—5 mm; flat, saucer-shaped body; brown, black or tan colored

4. **Mayfly nymph:** 3—30 mm; 6 legs; usually 3 hair- like tails (some species have 2); feathery gills line sides of abdomen

5. **Riffle beetle (adult or larva):** Adult: 1—6 mm; 'beetle' appearance; hardened, stiff body; black in color; oval body covered with tiny hairs

6. **Gilled snail:** 2—70 mm; with point held up, opening is on your right and faces you; shell opening covered by thin plate (operculum)

7. **Dobsonfly (Hellgrammite):** 10—90 mm; 6 legs; 7—8 pairs of lateral filaments on abdomen with paired gill tufts along underside; large pinching jaws; 2 tails and 2 pairs of hooks at back end

MODERATELY TOLERANT SPECIES

8. **Crayfish:** 3—15 cm; eyes on stalks; long antennae; 2 large claws; yellow, green, white, pink, or dark brown in color

9. **Sowbug:** 5—20 mm; gray oblong body wider than it is high; more than 6 legs; long antennae

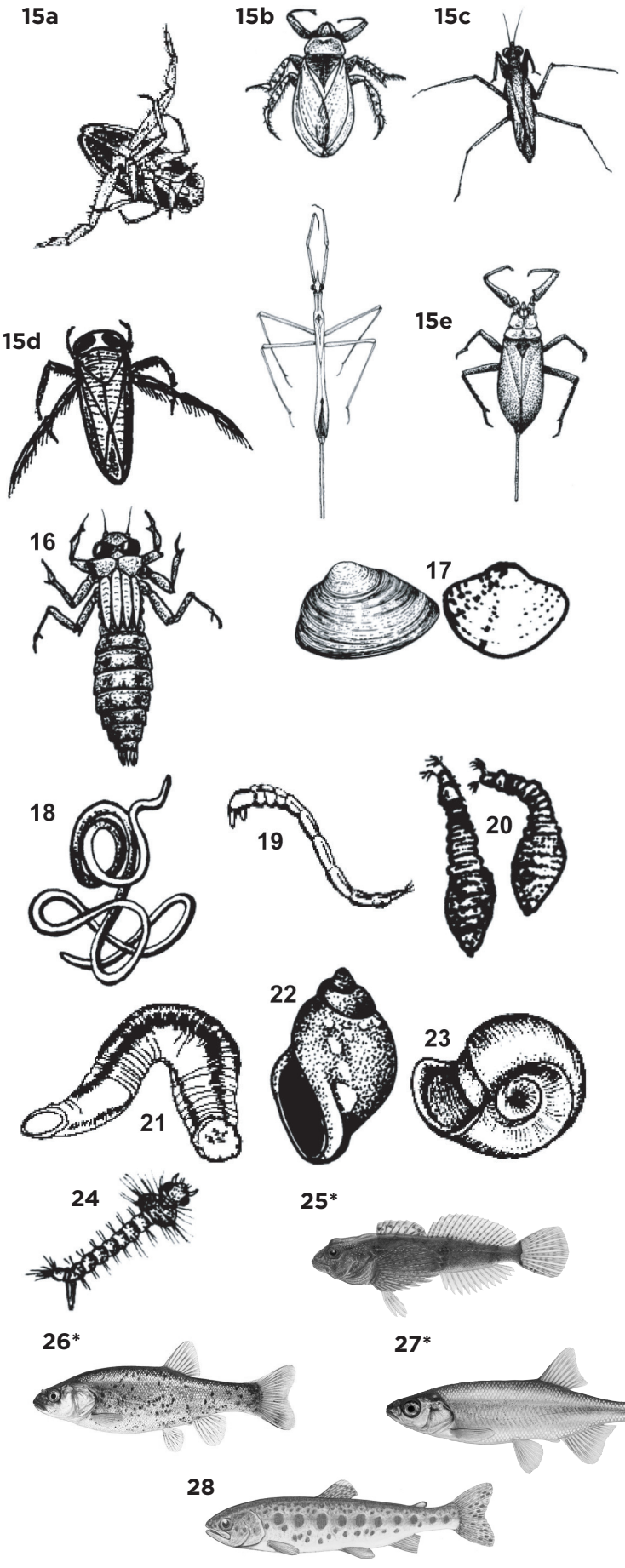
10. **Scud:** 5—20 mm; shrimp-like, white to clear to pink in color; distinct black eyes; swims on side

11. **Alderfly larva:** 20—30 mm; looks like small hellgrammite but has 1 long, thin, branched tail at back end (no hooks); no gill tufts underneath

12. **Fishfly larva:** 10—90 mm; looks like small hellgrammite but often a lighter reddish-tan color and no gill tufts underneath

13. **Damselfly larva:** 15—30 mm; 6 legs; no gills on sides of abdomen; 3 paddle-shaped tails; large eyes

14. **Cranefly larva:** 10—100 mm; plump, caterpillar- like body; no true legs; milky, light brown, or greenish in color; finger-like appendages that extend from back end



15. **True bugs:** 1—65 mm; head and eyes often well developed; 3 pairs of legs may be dissimilar; wings, when at rest, are held close over the back and overlap
    a. Backswimmer
    b. Giant water bug
    c. Water strider
    d. Water boatman
    e. Water scorpion (2 species)

16. **Dragonfly larva:** 20—50 mm; large eyes; 6 legs; wide, oval abdomen; no tail

17. **Clams:** two shells attached by a hinge

POLLUTION TOLERANT SPECIES

18. **Aquatic worm:** 1—70 mm; long, thin body; can be very tiny; red, tan, black, or brown in color

19. **Midge fly larva**: 2—20 mm; hardened, dark head capsule; worm-like, segmented body; 2 tiny legs on each side

20. **Blackfly larva**: 3—12 mm; bowling pin-shaped body; single proleg directly under head; black head

21. **Leech:** 5—100 mm; brown, slimy body; usually much wider than aquatic worms; suction pad on end

22. **Lunged snail and pond snail:** 2—70 mm; with point held up and shell opening facing you, opening is on your left; no plate-like covering over shell opening

23. **Other snails:** no operculum; shell coils in one plane

24. **Mosquito larva:** 8—12 mm; well-developed head; no legs; tube-like siphon at end of abdomen; will cling to surface of the water

FISH

You may find the following fish while sampling. They do not count toward the survey but are fun to identify!

25. **Sculpin**

26. **Dace**

27. **Shiner**

28. **Juvenile trout**

* by Joeseph Tomelleri

When it's Hot...

Summary

Students use data concerning fish species and water temperature to create graphs and infer information concerning fish using the graphs made.

Objectives

Students will...

- organize data found in charts by creating bar and line graphs
- compare fish species found in Idaho
- recognize the relationship between dissolved oxygen and temperature
- relate the graphs to infer relationships
- hypothesize the affects humans can have on fish

Materials

- graphing paper
- copies of *Tolerance Limit Worksheet*, one per student
- copies of *Dissolved Oxygen Worksheet*, one per student

Background

Some fish can live in warm water while other fish require colder water. By experimenting with different kinds of fish and raising water temperature a little bit at a time, biologists have learned a lot about how fish respond to changes in temperature in their environment.

One way to measure the temperatures a fish can tolerate or live through is called the 12-hour tolerance limit median (12-hr TLm). To measure this, fish are exposed to warmer and warmer water temperatures. At a certain point, the water will become so warm that one half (50%) of the fish will not tolerate the temperature and will die. If that temperature was at 84°F, we can say the 12-hr TLm is 84°F for that species. The first table in this exercise lists the 12-hr TLm for species found in Idaho. The table also notes whether the species is native or has been introduced to Idaho waterways.

The second table compares dissolved oxygen levels in water to the water temperature. The dissolved oxygen level is important to fish because it is a measurement of the amount of oxygen mixed in with the water and available for fish to breathe. It should not be confused with the oxygen atom found within one molecule of water (H_2O). The line graph created in this exercise will show that dissolved oxygen levels are directly related to water temperature. As water temperature increases, the dissolved oxygen level decreases.

Grade Level
4-12

Subject Areas
Math, Science

Time
Part One: 45 minutes

Part Two: 30 minutes

Vocabulary
dissolved oxygen, environment, introduced species, native species

Part One: Tolerance Limit

Procedure

1. Ask the class if fish can live at any temperature. Do all fish like the same temperature? It should be evident that trout are particular about the temperature of their water. If your TIC tank got very warm, your trout would begin to die. Explain that when biologists are studying certain fish and their habitats, it is important to know what temperatures the fish can tolerate. Biologists have studied fish to determine their tolerance for heat. Explain that 12-hour tolerance limit median is the temperature where half the number of a certain species will die.

2. Pass out graph paper and copies of the *Tolerance Limit Worksheet.*

3. Read the instructions together. Ask students what it means to be native to an area. What do they think it means if a fish is native?

   - Native fish are fish that occur naturally in a given area.
   - Introduced fish, conversely, are fish that are native to a different area and are brought to Idaho. Fish are often introduced to new areas because of their popularity as game fish.

4. Have students work (independently or in groups) to graph and complete the questions on the worksheet. Remind students to create graphs with the proper labeling of axes and units.

5. Ask the class why this information is important to biologists.

   - It allows biologists to predict the effects of a stream warming on certain fish species.

6. Ask students to think of what would cause a stream to increase in temperature.

   - Cutting down the trees around a stream reduces the shade and warms the water.

- Use of water as a coolant (especially power plants) which is then put back into the stream.
- Rain runoff that is heated up on pavement in the summer.

Part Two: Dissolved Oxygen

Procedure

1. Have students get out their graphs from Part One and review the graph. Make sure everyone understood the information and how to graph it. Next, ask why the students think fish start to die in hot water. Discuss their ideas.

2. Pass out copies of the *Dissolved Oxygen Worksheet.* Read the directions together. Review what dissolved oxygen is and why it is important.

3. Have students work (independently or in groups) to graph and complete the questions on the *Dissolved Oxygen Worksheet.* Remind students to create graphs with the proper labeling of axes and units.

4. Review the connection the graph showed between dissolved oxygen and temperature. What connection does this have to 12 hr TLm?

Evaluation

Students' properly create graphs and complete worksheets.

Extension

Use the data provided in the tables to create graphs in Excel.

Name:_____

Tolerance Limit Worksheet

Fish species	12-hr TLm (°F)	Native or Introduced
Steelhead	80	Native
Bluegill	94	Introduced
Bullhead catfish	97	Introduced
Carp	106	Introduced
Rainbow trout	80	Native
Cutthroat trout	77	Native
Pumpkinseed	94	Introduced
Largemouth bass	98	Introduced
Coho salmon	77	Native
Yellow perch	87	Introduced
Redside shiner	95	Native
Brook trout	78	Introduced
Longnose dace	88	Native

Instructions

The table lists fish species in Idaho, their 12-hr TLm, and whether they are native or introduced to Idaho. Using graph paper, create a bar graph showing the 12-hr TLm for each species in the table. Label the x-axis as the temperature and list the fish species along the y-axis. List the fish with the lowest 12-hr TLm at the bottom all the way up to the fish with the highest at the top of the y-axis. Following each species' name put an (i) or (n) to designate if the fish is introduced or native. Use this information to answer the questions that follow.

Questions

1. Which would be the first five species to be negatively affected from an increase in water temperature?

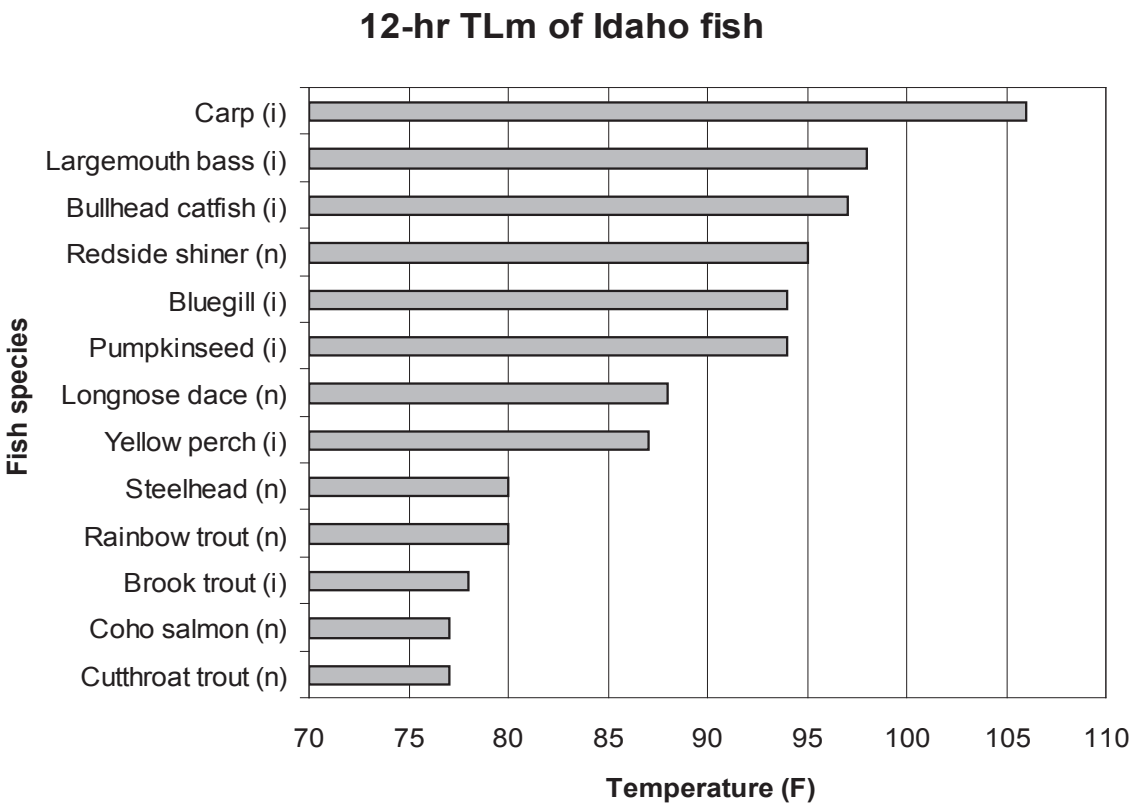
2. Which six species would be the most tolerant or able to survive higher temperatures?

3. Which would most likely have the lower water temperature: a small, shallow pond or a mountain stream? Why?

4. Where would you be more likely to find native fish: a small pond or a mountain stream? Why?

ANSWER KEY

Tolerance Limit Worksheet



Questions

1. Which would be the first five species to be negatively affected from an increase in water temperature?

   cutthroat trout, coho salmon, brook trout, rainbow trout, and steelhead

2. Which six species would be the most tolerant or able to survive higher temperatures?

   carp, largemouth bass, bullhead catfish, redside shiner, bluegill, and pumpkinseed

3. Which would most likely have the lower water temperature: a small, shallow pond or a mountain stream? Why?

   The answer to this question was not specifically addressed in the activity. However, by using reasoning skills, most students should be able to come up with the correct answer. The "why" may be more difficult to answer, and you may want to grade that section leniently. A mountain stream would most likely have the lower water temperature. Small, shallow ponds are easily warmed by the sun's energy and typically have very small inputs of cool water. Mountain streams, on the other hand, receive a constant supply of cold water from melting of snow and ground-water. They are also constantly moving so they are not as easily warmed by the sun.

4. Where would you be more likely to find native fish: a small pond or a mountain stream? Why?

   Most of Idaho's native fish are not tolerant to warm water. Therefore, you are more likely to find our native fish in mountain streams.

Name: _____

Dissolved Oxygen Worksheet

Water temperature (°F)	Dissolved oxygen (mg/L)
50	8.8
55	8.2
60	7.7
65	7.3
70	6.9
75	6.5
80	6.2
85	5.8
90	5.5
95	5.2
100	4.9
105	4.6

Instructions

Create a line graph using this information comparing dissolved oxygen levels to water temperature. Dissolved oxygen (DO) is the amount of oxygen mixed in with the water. Fish need DO in order to breathe. Label the x-axis as the temperature and the y-axis as dissolved oxygen.

Questions

1. What does your line graph tell you about the relationship between DO and temperature?

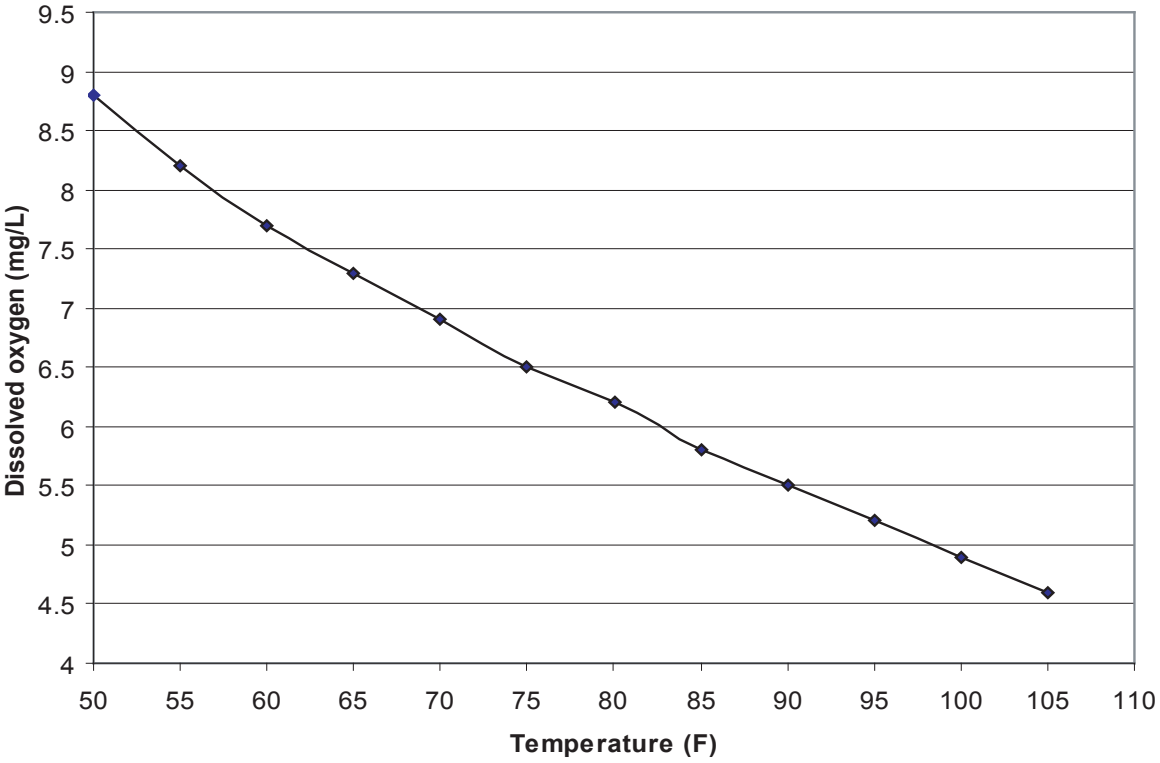
2. If we know the ideal water temperature for trout is 50 – 70°F, what DO range matches this temperature range?

3. Rainbow trout have a 12-hr TLm at 80°F. What would the DO be at this temperature?

4. Speckled dace cannot live in water with a DO level below 5.8 mg/L. What temperature is associated with this DO level?

ANSWER KEY

Dissolved Oxygen Worksheet



Questions

1. What does your line graph tell you about the relationship between DO and temperature?

   As the water temperature increases, dissolved oxygen levels decrease.

2. If we know the ideal water temperature for trout is 50 – 70°F, what DO range matches this temperature range?

   8.8 – 6.9 mg/L

3. Rainbow trout have a 12-hr TLm at 80°F. What would the DO be at this temperature?

   6.2 mg/L

4. Speckled dace cannot live in water with a DO level below 5.8 mg/L.
   What temperature is associated with this DO level?

   85°F

Assessing Your Impact

Grade Level
4-12

Subject Areas
Math, Science

Time
Part One: 30-45 minutes

Part Two: 45 minutes

Vocabulary
conservation, contamination, erosion, fertilizer, non-point source pollution, pesticide, point source pollution, pollution

Summary

Students gather data to explore water use, sources of non-point source pollution, and identify actions to lessen their impact on water resources.

Objectives

Students will...

- monitor their water use
- identify, develop and practice responsible water conservation behavior
- identify non-point source pollution and the effects on water quality, humans, and wildlife
- propose personal choices that will help reduce non-point source pollution

Materials

- copies of the *How Much Water Does Our Household Use?* worksheet for each student
- gallon-sized container
- copies of the *Non-point Source Pollutants* worksheet for each student
- blank sheet of paper for each student to draw on

Background

If water is constantly being cleaned and recycled through the Earth's water cycle, why do we need to conserve it? We need to conserve because people use up our planet's freshwater faster than it can be naturally replenished. To provide enough clean fresh water for people, water is cleaned at water treatment plants before it is used. After water is used, it is cleaned at wastewater treatment plants or by a septic system before being put back into the environment.

Saving water is good for the Earth, your family, and your community. When you use water wisely, you help the environment. Water conservation reduces or prevents destruction of natural habitats by lessening the need for dams and other interventions. When you use water wisely, you also save energy. You save the energy that your water supplier uses to treat and move water to you and the energy your family uses to heat your water. Finally, when you use water wisely you save money. Your family pays for the water you use. If you use less water, you'll have more money left to save or spend on other things.

Below are some easy ways to reduce the amount of water your household uses daily.

- In the shower, rinse yourself off and then turn the water off while you lather up. Turn it back on to rinse off. This will reduce the number of minutes the shower is on.
- Install a water-saving shower head.
- When brushing your teeth, turn off the water until brushing is complete and you are ready to rinse. This can save up to two gallons of water.
- Wash only full loads of laundry.
- Only run the dishwasher with a full load.
- Fill the bathtub only half way to save 20 gallons of water.
- If you have an older toilet, consider replacing it with a newer water-friendly model or place a plastic bottle filled with water in the tank. Toilets made after 1992 use an average of 1.6 gallons per flush.
- Use a carwash that recycles water. This saves 40 gallons and reduces water pollution.
- Water your yard once per week, deeply in the early morning (to reduce evaporation).
- Use a bucket to catch water in the kitchen or bath while waiting for water to warm up. Use this water for plants.
- Encourage the planting of native and drought-tolerant plants because they need less water.
- Use a broom instead of a hose to clean the driveway or patio.

With that said, water use is inevitable. It is important that we are aware of how we affect water each time we use it. Once water is diverted from its natural path and used by humans, it is often contaminated or polluted. Pollution entering the water cycle can have damaging consequences on people, wildlife, and the environment.

Water pollution can either be from a "point source" or a "non-point source." Point source pollution is pollution that you can literally point to the source. For example, when an oil refinery has a discharge pipe draining directly into a local waterway, the pollution it discharges is point source pollution. We know the pollution is

coming from one single point. Alternatively, the source of non-point source pollution is not as clear. This type of pollution is also known as 'people pollution' because we all contribute to it. It is contaminated runoff starting from an undefined place, often a variety of places. The car oil that leaks onto the street, animal wastes that we do not pick up, litter we do not put in the trash can, road salt we put down, and pesticides we put on our lawns all constitute non-point source pollution. With each rainfall, pollutants from these activities are washed from lawns and streets into storm drains that lead directly to the nearest body of water, such as a stream, river, lake or ocean. This water is not sent to a water treatment plant.

With this knowledge, we can work to prevent potential toxins like pesticides, detergents, fertilizers and motor oils from entering the water cycle. We have the ability to affect both the quantity and quality of available water through personal and public conservation practices.

Part One: Water Conservation

Procedure

1. Ask the students what is absolutely essential for all life on the Earth. Water! Introduce a brief discussion of water and its uses. Wherever we live, we do things each day that affect water and influence the well-being of trout, other wildlife, and people. Do the students know there is a fixed amount of water on Earth? Share the following facts with the students:

    - The Earth is 71% water.
    - 97% of the water on Earth contains salt (oceans, seas or salt water lakes and rivers).
    - Another 2% of the water is locked in ice caps and glaciers.
    - A small amount of water is unavailable because it is too far underground, polluted, trapped in soil, etc.
    - Less than 1% of the water on Earth is available freshwater. This small percentage is what fills up all of the freshwater lakes, rivers and ground water that provide humans, trout and other wildlife with the water they need to survive.

2. Since our water resources are limited, is it important for humans to conserve water, use it wisely, and protect its quality. Have the students guess how much water they use daily in gallons (show a container to help them visualize the size of a gallon). Record the class's estimated daily water use.

3. Distribute the *How Much Water Does Our Household Use?* worksheet and ask students to keep track of how much water is used in their homes for seven days.

    - Students may post the worksheet on their refrigerator. Family members put a mark in the section designated after each water use.
    - The "other" section is for special uses not listed (filling a fish tank, bathing the dog, etc.).
    - After seven days, students bring in their results and figure the number of gallons used in each category and gallons used total for the week.

4. Make a master chart that summarizes the total household use for the class.

    - Compare the class's predicted use to their actual use.
    - Brainstorm ways to conserve water and record them in a list.
    - Challenge each student to reduce use and invite families to join.

5. Hand out another *How Much Water Does Our Household Use?* worksheet. Have students monitor and tabulate water use for another seven-day period while using some of the water conservation tips brainstormed by the class.

6. Compare week 1 with week 2. Was there a significant reduction in water use? Lead a discussion on what was easy to change and what was harder. Does the class think they will be able to keep up their water conservation practices?

Part Two: Non-point Source Water Pollution

Procedure

1. Remind students that wise conservation practices are only one part of water stewardship. Are there any other ways we can affect the water around us? By preventing pollution! Humans make choices daily about what they put down the drain. Keeping water free of pollutants is important for humans, plants, and wildlife.

2. Ask students what they know about different types of pollution. Have they heard of non-point source pollution? Do they know what it means? What are some examples?

    - Non-point source pollution is contaminated runoff originating from an indefinite or undefined place, or more often a variety of places.
    - Contaminated water that runs into a river from storm drains is considered non-point source pollution because the contamination comes from many sources. Emphasize that water from storm drains *is not* treated at a wastewater treatment facility. Water from storm drains runs directly into local rivers, streams, lakes and ponds.

- Examples include: sediments from erosion, animal wastes, pesticides and fertilizers, bacteria, and litter on the street.

3. Pass out the *Non-point Source Pollutants* handout. Review the listed pollutants and their multiple sources. Encourage any thoughts on other types of non-point source pollution or sources.

4. Hypothesize the effects of these pollutants based on what the class has learned about water and the environment. Fill in the 'effects' column with their ideas. Supplement the class's list with the answers listed on the answer key.

5. Have students consider the non-point source pollution that may be around their school. Take the class outside to walk around the school. Have the students record any sources of non-point source pollution on the school grounds, including the parking lot.

6. Return to the classroom and have students draw a map of the school and the area around it. Include the parking lot, streets, parks and any other major buildings in the area. Locate potential areas of non-point source pollution and have students draw it on their map. Potential sources around the school may include:

   - Playgrounds, ball fields (trash, fertilizers, pesticides, animal wastes)
   - Sewage system, including restrooms, cafeteria, and science classes (trash, excess nutrients, detergents, chemicals, pathogens)
   - Parking lot (trash, heavy metals, dripping oil, heat from the sun)
   - Sidewalks and outdoor hallways (trash)
   - Construction sites (trash, sediments)
   - Residential areas (trash, fertilizers, pesticides, detergents from car washing)

7. Attempt to track where the pollution would go. Locate storm drains and try to determine the closest body of water they drain into.

8. Brainstorm actions students and their families can take to reduce pollutants entering the watershed from their household. Examples:

   - Put your trash in garbage cans (storm drains carry litter into local waterways).
   - Dispose of chemicals at approved household hazardous waste collection sites. Do not dump them on the ground or down storm drains. The Idaho Department of Environmental Quality's website offers advice on recycling household chemicals.
   - Walk pets on grassy areas and pick up after your pets to prevent pet waste from entering the storm water system.
   - Keep cars well maintained and free of leaks.
   - Recycle used motor oil.
   - Compost yard waste and don't dispose of leaves or grass clippings in your storm drain.
   - Landscape your yard to prevent water runoff.
   - Never exceed manufacturers' recommendations for use of fertilizers or other chemical products.
   - Use as few pesticides as possible. Use "natural" approaches to pest control and organic gardening techniques.

Extension

1. Consider ways for students to help reduce non-point source pollution in their community and educate others. Possible activity suggestions:

   - Create a Water Wise campaign, working to educate peers and school faculty about water conservation and non-point source pollution.
   - Create a newsletter sharing what you have learned with the school and community.
   - Use maps and information from this activity to create a non-point source pollution display for the school and community.
   - Make a list of pollutants your school is generating (detergents, pesticides, fertilizers), discuss with school staff non-point source pollution and suggest alternative products.
   - Conduct a storm drain labeling activity around your school to alert people about the hazards of non-point source pollution. Contact your local public works department to find out about their labeling program.

2. Consider other stewardship actions such as:

   - planting trees, shrubs or grasses at the school or in your community
   - participating in a river clean-up day

Activity adapted from *American River Salmon Educator Activity Guide,* published by CA Department of Fish and Game, Project WILD.

Name:_____

Starting Date_____Ending Date_____

How Much Water Does Our Household Use?

Use	Gallons per use	No. of times (tally)	Total Gallons
Flushing toilet	3	x	=
	1.6 (with low flow)	x	=
Brushing teeth	3 (with water running)	x	=
	1 (with water off)	x	=
Shower for ____ minutes	5 gal/min (with old shower head)	x	=
	2.5 gal/min (with new shower head)	x	=
Taking a bath	40 (with tub full)	x	=
Dishwasher	20	x	=
Washing dishes by hand	30 (with water running)	x	=
	10 (sink with stopper)	x	=
Washing clothes	40 per load	x	=
Watering lawn	40	x	=
Washing car	40 (if by hand)	x	=
	0 (if at carwash that recycles water)	x	=
Other:		x	=
Other:		x	=
Total =			

Name:_____

Non-point Source Pollutants

Pollutant	Source	Effect
Debris/litter (plastics, glass, metals, woods, cigarettes)	• Runoff from roads, landfills and parking lots into storm drains • Sewer systems • Beach and boating activities	
Sediments	• Runoff from construction sites, agricultural lands and logging areas • Flash floods eroding streams and rivers	
Excess nutrients (fertilizers, animal wastes, sewage, yard waste)	• Runoff from livestock, pets, gardens and lawns • Sewage treatment systems • Failing septic systems	
Toxins (acids, salts, heavy metals)	• Runoff from roads, landfills, and parking lots • Road salt • Leaching at dump sites	
Organic chemicals (pesticides, oil, detergents)	• Runoff from forests, farmlands, lawns and golf courses • Sewage treatment plants	
Pathogens (coliform bacteria)	• Municipal and boat sewage • Animal wastes (livestock or pets) • Leaking septic and sewer systems	
Heat	• Runoff from streets and parking lots in the summer	

ANSWER KEY

Non-point Source Pollutants

Pollutant	Source	Effect
Debris/litter (plastics, glass, metals, woods, cigarettes)	• Runoff from roads, landfills and parking lots into storm drains • Sewer systems • Beach and boating activities	Can harm aquatic life by entanglement or ingestion
Sediments	• Runoff from construction sites, agricultural lands and logging areas • Flash floods eroding streams and rivers	Clouds water, decreases plant productivity, suffocates bottom-dwelling organisms and fish redds
Excess nutrients (fertilizers, animal wastes, sewage, yard waste)	• Runoff from livestock, pets, gardens and lawns • Sewage treatment systems • Failing septic systems	Causes excessive growth of algae and plants (which will deplete oxygen) and causes odor
Toxins (acids, salts, heavy metals)	• Runoff from roads, landfills, and parking lots • Road salt • Leaching at dump sites	Toxic to aquatic life. It can be taken up by organisms and bioaccumulate (never-leave their body); other animals (including humans) may ingest these toxic organisms and become sick or die.
Organic chemicals (pesticides, oil, detergents)	• Runoff from forests, farm-lands, lawns and golf courses • Sewage treatment plants	Toxic effects on wildlife and humans; many are carcinogens (cause cancer)
Pathogens (coliform bacteria)	• Municipal and boat sewage • Animal wastes (livestock or pets) • Leaking septic and sewer systems	Causes diseases such as: typhoid, hepati-tis, cholera, dysentery
Heat	• Runoff from streets and park-ing lots in the summer	Causes a decrease in the dissolved oxygen in water, harming fish and other aquatic organisms

Water Cycle Challenge

Grade Level
6-12

Subject Areas
Science

Time
30-45 minutes; several days for experiment to take place

Vocabulary
condensation, evaporation, precipitation, transpiration, water cycle

Summary

Students are presented with the challenge of moving water from one container into another container by using their knowledge of the water cycle.

Objectives

Students will...

- design a model of the water cycle
- work in teams to create the model

Materials

- large clear glass bowls or beakers with sides higher than the height of a coffee mug, one for each group of students
- dry ceramic coffee mugs or glass beakers that can fit into the glass bowls or beakers, one for each group of students
- sheets of clear plastic wrap, one for each group of students
- long piece of string, rubber band or tape to secure plastic wrap around large beaker or bowl, one for each group of students
- water
- small weight to funnel water (such as a stone), one for each group of students

Background

The Earth has a limited amount of water and that water keeps going around and around in what we call the water cycle. Driven by heat energy from the sun and gravity, the main movements of water are...

- evaporation and transpiration
- condensation
- precipitation

Evaporation occurs when the sun heats up water in its liquid form (in rivers, lakes or oceans) and turns it into vapor or steam. **Transpiration** is the process by which plants lose water out of their leaves. Transpiration gives evaporation a bit of a hand in getting the water vapor back up into the air. **Condensation** occurs when water vapor in the air cools and changes back into a liquid state, forming clouds. **Precipitation** occurs when so much water has condensed that the air cannot hold it anymore. The clouds get heavy, and water falls back to the Earth in the form of rain, hail, sleet or snow. When water falls back to Earth as precipitation, it may fall back in oceans, lakes or rivers or it may end up on land. When water ends up on land, it will soak into the Earth and become ground water or run over the soil and collect in oceans, lakes or rivers where the cycle starts. These processes work together to move water around, through and over Earth.

The challenge: Students fill a large bowl about $^1/_4$ of the way full with water and place a mug in the middle of the water, making sure not to splash any water into the center of the mug. The students must figure out a way to move the water from outside the mug to inside the mug without touching the mug or water and keeping the bowl level.

The solution: The key to this problem is using the sun's energy and the processes of evaporation, condensation, and precipitation. Stretch plastic wrap across the top of the bowl and secure it with string, a rubber band, or tape. Make sure the bowl is sealed so no water vapor can escape. Set the bowl on a sunny windowsill. The sunlight will cause the water to evaporate. That water will then condense on the plastic wrap. When enough water collects, it will fall back down into the mug. To help funnel the water into the mug, place a small object (like a rock) on top of the plastic wrap directly above the mug.

Procedure

1. Review the basic concepts of the water cycle and the processes which move water around the Earth.

2. Show the students a bowl with the mug and water inside. Present to them this challenge—move the water from outside the mug to inside the mug with the following caveats:

   - The bowl must stay level (no tipping or turning the bowl).
   - The mug cannot be touched by anything.
   - The water cannot be touched by anything.
   - They can only use the items given: large glass bowl, mug, plastic wrap, rock and a rubber band, piece of string or tape.

3. Break the students into groups and let them set up the experiment on their own. If they are having trouble, give them clues.

- Think “water cycle”.
- Let them know it may take more than a day for the water to move.
- They must use energy from an outside source.

4. Once students have come up with an experimental design, have them assemble their experiment. Place the experiments by a window being careful not to splash water into the mug.

5. After a few days, have the students check their experiments. Is there water in the mug? Review the solution and the proper experimental design. Did their group come up with the same design? What energy sources did they use to move the water? (Both sunlight and gravity) What cycle does this exemplify on a smaller scale? (water cycle)

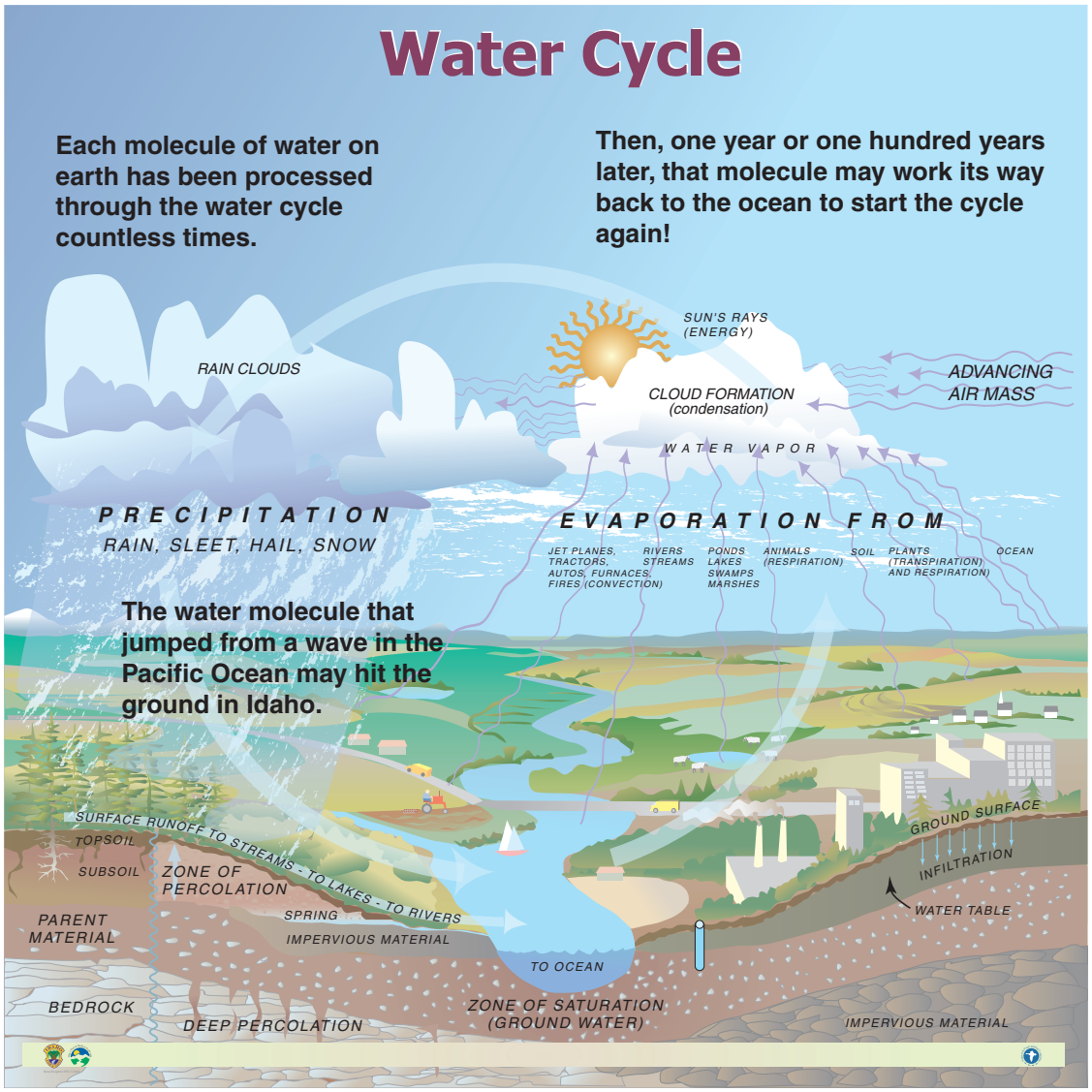
Evaluation

1. Have the students write a paragraph explaining why their experimental design did or did not work and the processes of the water cycle the experiment was trying to demonstrate (evaporation, condensation, precipitation).

2. Ask students to identify the different places water can go as it moves through and around Earth. Write these responses on the board – clouds, oceans, lakes/ponds, rivers/streams, plants, ground water, and glaciers. Have students write stories about the travels of a drop of water. They should include a description of what conditions were necessary for water to move to each location and the state the water was in as it moved.

Extension

Repeat the experiment with a ‘control’ bowl and a variable bowl in a different location, with a different water temperature, or with a mixture (such as salt and water). Hypothesize what may occur and observe the results.



Kokanee Population Survey

Grade Level
5-12

Subject Areas
Math, Science

Time
45 minutes

Vocabulary
census, population, survey

Summary

Students use the Peterson Method Mark-Recapture Population Survey to estimate the population of a simulated lake.

Objectives

Students will:

- estimate the population of kokanee in a lake using a formula involving multiplication and division
- conduct a fish survey simulation to estimate the fish population in a lake
- give two examples of how fish surveys and research are used in fisheries management

Materials:

- clear fishbowl or large glass bowl
- large box of fish-shaped crackers
- picture of kokanee, optional
- empty one to five gallon opaque, plastic container OR glass aquarium with the sides covered
- small aquarium net
- small, short, wide plastic containers (holding at least 16 oz.), one for each group of students
- one or two bags of dried white beans (about 300 beans for each group of students)
- one or two bags of dried brown beans (about 300 beans for each group of students)
- plastic sandwich bags, one for each group of students
- calculators, optional depending on the ability of students
- post-it notes or small pieces of paper with tape, one for each group of students
- *Tagging Survey Sheet,* one per student
- *Lake Survey Data Sheet,* one per student
- *Lake Survey Data Sheet Questions,* one per student

Background

Knowing the population of fish in a given body of water is important to fisheries managers. Scientific data is used to create and measure the success of fishing regulations; to help answer questions about the health of fish populations; and to estimate the size of fish populations.

One scientific method fisheries managers use to estimate a population is a tagging survey. This method is used to estimate the number of fish of a given species in a lake. For example, if managers notice an increase in lake trout in a lake, it could mean a decrease in other species over time, such as kokanee. Lake trout are predators on kokanee. As the population of lake trout increase, they may eat more kokanee than the kokanee population can sustain. Changing regulations to increase the number of lake trout caught and removed from the lake may help keep the kokanee population from dramatically dropping.

To conduct a mark-recapture population survey, a sample is taken from a lake and a targeted group out of that sample is tagged or marked. Tagging may be done in a variety of ways. Biologists may clip a fin or place a plastic or metal tag on a fin or jaw. Once tagged, the fish are released back into the lake. Samples are then taken from different locations throughout the lake. For each sample, the biologists record the total number of a fish caught and the number of tagged fish that are recaptured.

Fisheries biologists know that the total number of a particular fish species in the lake can be estimated by a ratio. They look at the number of tagged fish recaptured in the nets to the number of known tagged fish that were released in the lake at the beginning of the survey. The number of originally marked fish (M) times the total number of fish caught (both marked and unmarked) in a second sample (C); divided by the number of marked fish in the second sample that are recaptured (R); equals the estimated number, or population, of fish in the lake (N).

$$N = \frac{M \times C}{R}$$

Procedure

1. Ask students how they might determine the number of students in the class. They will probably say count the students. Would it be as easy to determine the number of people living in Idaho?

2. Ask students if they have heard of a population census. A census is a government count of a population of people in a community, state or nation. A census

can provide certain information such as population growth over time or the proportion of children to adults in a population. This information can be used to determine a need for new schools in a community. What if we want to find out the number of fish in a lake? How do fisheries biologists conduct a fish census?

3. Hold up a fishbowl full of fish crackers. Ask a student to count the number of fish in the bowl. You can decide that counting might take too long. How can we more quickly figure out how many fish are in the bowl? Ask the students to guess and write their guess and name on a piece of paper. Collect the guesses. Now have a student or students count the fish crackers in the bowl. Determine whose guess was most accurate. Ask students what methods they used to make their guesses.

4. Tell the students that there are ways that scientists estimate the size of a population when counting every individual isn't practical. An estimate determines the approximate value or number of something. The methods for making estimates are more accurate than guessing.

5. Ask the students why scientists may want to count fish. Briefly explain that fisheries biologists collect information to help them set fishing rules and regulations. This information may also help biologists solve problems that fish may be facing in their habitat. Knowing if a fish population is going up or down will help fisheries managers make decisions that will help the fish over time.

6. Display the plastic container or covered aquarium with 300 white beans in it. Tell the class this is a fictitious lake, and they need to determine the population of kokanee in the lake. Show the class pictures of kokanee if they are unfamiliar with the species. (Kokanee are a land-locked form of sockeye salmon.)

7. Ask the class how many kokanee are in the lake. This will be difficult since they cannot see the "fish" (beans). Ask if students have any ideas about how they may determine or estimate the kokanee population using a sample.

8. Announce to the students that they will be using a survey method that fisheries biologist use when they want to determine the population of fish in a lake, called the Peterson Method Mark-Recapture Survey. Explain that fish are caught, tagged and released back into the lake. Tagging the fish may be done in a variety of ways (clip a fin, place a plastic or medal tag on a fin or jaw). At a later date, another survey is done, the tagged and untagged fish caught are counted, and a math formula is used to estimate the fish population.

9. Pass out a *Tagging Survey Sheet* to each student.

10. Ask a student volunteer to come to the front of the class. Explain the proper sampling technique: don't look at the "lake" while sampling, take one quick scoop in the lake with the aquarium net. Have the student take one scoop of "fish" from the lake and count the number captured.

11. Mark the captured kokanee by exchanging the white beans with an equal number of brown beans. Have the class record this number for the "M" value on the *Tagging Survey Sheet* under the Mark Run Data. Have the volunteer put the brown beans, or "marked kokanee" into the container, remember do not add the white beans back into the container. Stir the beans for 15 seconds to simulate the fish swimming around the lake.

12. Choose another student volunteer to come to the front of the class to sample a "recapture run." Again explain proper sampling techniques (no looking and one quick scoop) for consistent sampling.

13. Count the number of beans in the net, both white and brown, and write the number on the sheet for "C". This is the total number of fish caught. Now count the number of brown beans and write the number down for "R". The brown beans in the student's sample represent the recaptured marked fish.

14. Review with students what the letters M, C, R and N represent. As a class, complete the calculations to get the number of kokanee in the lake (N).

15. Tell the students that there were actually 300 kokanee in the lake. How did the estimate compare to the actual number of kokanee? Do the students think that the mark-recapture method is a good way to estimate the number of kokanee in a lake? Why?

16. Break students into groups and tell them that they will now conduct their own lake surveys.

17. Give each group a plastic container of 250 white beans, a plastic bag containing 250 brown beans and a *Lake Survey Data Sheet* for each student.

18. Have the students conduct their surveys following the instructions on the sheet, helping as needed.

19. On the whiteboard, draw a graph with the x-axis labeled student teams and the y-axis labeled population estimates (use 200 – 350). Have each team place their estimates on this graph.

20. Ask each group to write their kokanee population estimates on a Post-it note and place it on the graph.

21. Pass out a *Lake Survey Data Sheet Questions* paper to each student.

22. As a class or individually, complete the *Lake Survey Data Sheet Questions* paper.

Evaluation

Check for correct answers on the *Lake Survey Data Sheet Questions* student sheets.

Lake Survey Data Sheet Questions **Answers**

Answers to questions 1 – 4 and 6 will vary.

5. mean

7. It is an estimate. The method allows biologists to estimate population sizes. It is not feasible to count every fish in a lake.

8. Most likely, students will say the class mean is closer. Why? Using more than one sample and averaging all the survey teams' results provides a more accurate number than an individual team estimate that used fewer samples.

9. Using more than one sample in a survey can show a more accurate population estimate.

10. 1) to help set fishing rules and regulations; 2) to help solve problems with habitats; 3) to help answer questions about the health of fish populations; 4) to estimate the size of fish populations; 5) to make decisions that will help the fish over time.

Name: _____

Tagging Survey Sheet

Peterson Method Mark-Recapture Population Survey

Mark Run Data

M = _____

Recapture Run Data

C = _____

R = _____

What do These Letters Mean?

M = the number of kokanee originally **M**arked or tagged and released into the lake (number of brown beans from the mark run)

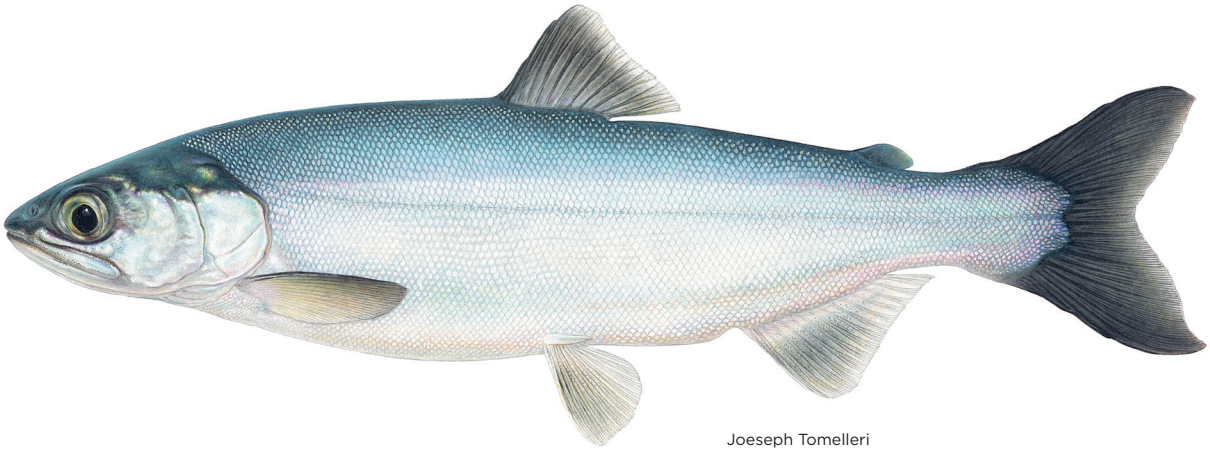
C = the **C**atch sample size taken in the recapture run (total number of white and brown beans)

R = the number of marked kokanee in the sample that are **R**ecaptured (brown beans)

N = the estimate of the total **N**umber of kokanee in the lake (estimate of the total number of all beans in the lake)

Calculating N

$$N = \frac{M \times C}{R} = \frac{\_\_\_\_\_ \times \_\_\_\_\_}{\_\_\_\_\_} = \_\_\_\_\_$$



Joeseph Tomelleri

Name:_____

Lake Survey Data Sheet

You and your team have been assigned to conduct a lake survey. Use the Peterson Mark-Recapture Method to estimate the population of kokanee in the lake.

Mark Run Data

Use your fingers as a net to capture kokanee (white beans) from the lake (container). Count the number of beans and set them aside. Write the number in the blank below. Count out the same number of brown beans and put them in the lake. (Do not put the white beans back in the lake.)The brown beans represent the marked kokanee.

M = _____

(number of marked kokanee)

Recapture Run Data

Stir the beans for 15 seconds. Without looking into the lake, use your fingers to capture another sample of kokanee. Count the total number of kokanee caught (both white and brown beans). Write this number by C. Now count the number of brown beans, or marked kokanee. Write this number by R.

C = _____

R = _____

Calculating N

Write the values for M, C and R in the blanks below. Now do the math! What did you get for N, the kokanee population for the lake?

$$N = \frac{M \times C}{R} = \frac{\_\_\_\_\_ \times \_\_\_\_\_}{\_\_\_\_\_} = \_\_\_\_\_$$

Joeseph Tomelleri

What do These Letters Mean?

M = the number of kokanee originally **M**arked or tagged and released into the lake (number of brown beans from the mark run)

C = the **C**atch sample size taken in the recapture run (total number of white and brown beans)

R = the number of marked kokanee in the sample that are **R**ecaptured (brown beans)

N = the estimate of the total **N**umber of kokanee in the lake (estimate of the total number of all beans in the lake)

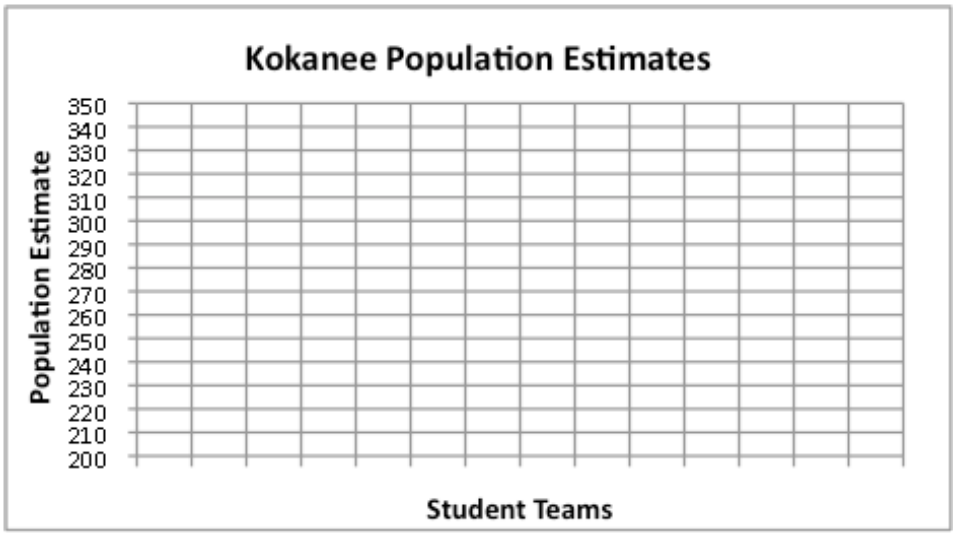
Name: _____

Lake Survey Data Sheet Questions

1. What is your survey team's estimate for the kokanee population in the lake?

2. Place the values for each survey team's kokanee population estimate on the graph.

3. What is the range of values on the graph for our class survey data?



4. Find the class average estimate for the number of kokanee in the lake. Sum all of the team population estimates and divide the sum by the total number of teams.

5. Is the class average estimate the median, mean or mode for the class survey data?

6. The actual number of kokanee in the lake was 250. Is the class average value greater than, less than or equal to the actual number of kokanee in the lake?

7. The class average estimate value probably is not the same number as the actual number of kokanee in the lake. Why?

8. Compare your team's estimate to the class average estimate. Which estimate is closer to the actual number of kokanee in the lake? Why?

9. Why might a fisheries biologist take more than one sample for a lake survey?

10. Give two examples of how a fisheries biologist may use information from a fish survey.

Hatchery Visit

Summary

Students visit a hatchery to observe how fish are raised.

Objectives

Students will...

- observe how fish are raised in a hatchery
- compare the hatchery habitat to a wild habitat
- learn about fisheries management in Idaho

Materials

- student journals

Background Information

In Idaho, hatcheries exist for three reasons: fish production, endangered species protection, and fish consumption. The Idaho Department of Fish and Game operates hatcheries for two reasons: to supplement existing sport fish populations for anglers and to prevent the extinction of endangered species, such as sockeye salmon. Only private hatcheries work for-profit to raise trout and other fish for consumption. In fact, Idaho produces most of the trout sold in grocery stores and restaurants throughout the country.

Fish raised in hatcheries have a much higher survival rate than wild fish. Hatchery fish have a 70-80% survival rate, whereas wild fish have only a 10-15% survival rate. The improved survival rate of hatchery fish is due to several factors. Hatchery fish are not subject to predation and are well fed. The hatchery environment is also constant, with cold, clean water continuously running through the fish-rearing facilities. Wild fish, on the other hand, must cope with predators, possible food shortages, and possible habitat changes. Hatchery fish have it easy in comparison to their wild cousins and are therefore not as well suited for life in the "real world."

For this reason, hatchery fish cannot replace wild fish, and fish managers do not want hatchery trout genes mixing with wild populations' genes. To prevent the mixing of genes, hatchery fish are sterilized before being stocked in Idaho waterways. Thirty-three minutes after hatchery eggs are fertilized, they are put in a pressure chamber at 900 psi for five minutes. This pressure treatment causes the eggs to have three sets of chromosomes (triploid) rather than two (diploid), rendering the fish sterile.

Grade Level
2-12

Subject Areas
Language Arts, Science

Time
45 - 60 minutes, not including travel time

Vocabulary
alevin, diploid, egg, eyed eye, fingerling, fry, hatchery, incubation, parr, raceway, sac fry, spawn, triploid

Procedure

1. Call a nearby hatchery to see if they offer school tours and schedule a tour. Following, you will find a list of hatcheries operated by Idaho Fish and Game.

2. Ask your students to think of three reasons why hatcheries exist.

    - To raise fish for fishermen to catch.
    - To prevent species from going extinct.
    - To raise fish for food.

3. Before embarking on the trip, your class should develop a code of behavior for their hatchery experience. Listed below are safety hazards your students may encounter. Review the hazards with your students and discuss solutions to avoid any problems or dangerous situations.

    - Floors are often wet and slippery. Sometimes there are special non-slip walkways or areas provided.
        - Solution: no running, wear non-slip shoes (sneakers), stay on non-slip walkways whenever possible
    - Hatcheries are cold!
        - Solution: dressing warmly
    - There may be ponds or areas of open water.
        - Solution: stay behind guardrails and stay a few feet away from the edge of ponds without rails
    - Machinery is part of hatchery operations.
        - Solution: keep hands, feet, and clothing away from machinery
    - Hatcheries are operated to keep diseases and contamination out of the water to keep eggs and fish healthy.
        - Solution: keep hands out of the water and do not throw anything into the water
    - Hatcheries are big places – it is easy to wander into areas that are off limits.
        - Solution: stay with your group, always

- Hatcheries are noisy, with water running constantly. It can be difficult to hear.
    - Solution: stay close to the tour leader and listen carefully to what is being said
- Most hatcheries have small restrooms with room for only one person at a time.
    - Solution: use the restrooms before leaving school

4. Take a guided tour of the hatchery. Encourage your students to bring their journals so they can draw/write interesting points.

5. Ask your students what their favorite part of the visit was? How does the hatchery habitat compare to a wild habitat? How does it compare to a classroom aquarium?

Evaluation

Have your students write a letter of thanks to hatchery personnel. In the letter, have the students explain three things they learned during their visit to the hatchery. Conclude the letter by thanking the personnel for sharing their workplace and time with the students.

Extension

Have your students write a first person narrative, using the voice of a hatchery fish, describing the hatchery experience.

Idaho Department of Fish and Game Hatcheries

American Falls Hatchery
2974 S. Hatchery Rd.
American Falls, ID 83211
(208) 226-2015

Cabinet Gorge Hatchery
1070 Cabinet Gorge Rd.
Clark Fork, ID 83811
(208) 266-1431

Clark Fork Hatchery
1400 E. Spring Creek Rd.
Clark Fork, ID 83811
(208) 266-1141

Clearwater Hatchery
118 Hatchery Roe Dr.
Ahsahka, ID 83520
(208) 476-3331

Eagle Hatchery
1800 Trout Rd.
Eagle, ID 83616
(208) 939-4114

Grace Hatchery
390 Fish Hatchery Ln.
Grace, ID 83241
(208) 427-6364

Hagerman State Hatchery
1060 State Fish Hatchery Rd.
Hagerman, ID 83332
(208) 837-4892

Hayspur Hatchery
71 US Hwy. 20
Bellevue, ID 83313
(208) 788-2847

Henry's Lake Hatchery
3850 Hwy. 87
Island Park, ID 83429
(208) 558-7202

Mackay Hatchery
4848 North 5600 West
Mackay, ID 83251
(208) 588-2219

Magic Valley Hatchery
2036 River Rd.
Filer, ID 83328
(208) 326-3230

McCall Hatchery
300 Mather Rd.
McCall, ID 83638
(208) 634-2690

Nampa Hatchery
3806 S. Powerline Rd.
Nampa, ID 83686
(208) 465-8479

Niagara Springs Hatchery
2131 Niagara Springs Rd.
Wendell, ID 83355
(208) 536-2283

Rapid River Hatchery
543 Rapid River Rd.
Riggins, ID 83549
(208) 628-3277

Sawtooth Hatchery
HC 64, Box 9905
Stanley, ID 83278
(208) 774-3684

Springfield Hatchery
1830 West 950 South
Springfield, ID 83277
(208) 994-8371

Upper Pahsimeroi Hatchery
71 Fish Hatchery Ln.
May, ID 83253
(208) 876-4475

Pop Can Casting

Grade Level
2-12

Subject Areas
Language Arts, Physical Education

Time
Part One – Knot Tying: 15 - 20 minutes

Part Two – Making Pop Can Casters: 15 - 20 minutes

Part Three – Practice Casting: 25 minutes

Vocabulary
casting plug, clinch knot, fishing line

Summary:

Students make fishing rigs out of pop cans and practice casting at targets.

Objectives:

Students will...

- learn to tie a clinch knot
- make a fishing rig from a pop can
- demonstrate how to accurately cast a line

Materials:

- copies of *Tying a Clinch Knot* and *Making a Pop Can Caster,* one per student
- four to seven hula-hoops
- quarter-inch thick rope or cord cut in two-foot lengths – five pieces per hula-hoop
- one clean pop can for each student
- six-pound test monofilament line – enough for each student to wrap pop can 50 times
- masking tape
- nail clippers
- one casting plug or heavy sinker per student
- if actually fishing with pop can caster:
  - #6 or #8 hooks
  - bobbers
  - split shot sinkers
  - needle-nosed pliers
  - bait

Background

Traditionally, native peoples have fished for subsistence. Fishing was a way to feed families. The survival of many ancient civilizations depended on fishing skills. Sport fishing, or fishing for recreation and enjoyment, began in medieval times.

Many techniques for harvesting fish have been developed over the centuries. Techniques include: catching fish with bare hands, hooks and lines, spears, nets, and traps. In many parts of the world, people still catch fish by hand with a hook and line. The rod and reel assembly used by most modern anglers was first documented in the fifteenth century.

Today people can purchase many different fishing rods and types of gear, but expensive high-tech gear is not necessary to catch a fish or enjoy fishing. People have long used everyday materials to make fishing gear. In this lesson, students will learn to tie a basic clinch knot, make a casting rig out of a pop can and practice casting.

Procedure

Part One – Tying a Clinch Knot:

1. Ask students to think about native peoples, early explorers and settlers in Idaho. Were fish an important source of food for these early residents of our state? Discuss the different methods these people may have used to catch fish. What materials did they use and where did they find their materials?

2. Where do we get materials for fishing gear today? Do we need expensive equipment to catch fish? Tell students that if they know how to rig a line, they can use everyday materials to catch fish.

3. The first step is to learn how to tie a good knot. Without a sturdy knot, you may lose your fish. Pass out the instruction sheet for tying a clinch knot. Using a hula-hoop and piece of rope, demonstrate how to tie the clinch knot. The hula-hoop represents the eye of the fishing plug or hook; the rope represents the fishing line.

4. Untie the knot and have the students talk you through the steps and tie the knot.

5. Divide the class into groups of four to five students. Give each group a hula-hoop and each student a piece of rope. Ask the students to practice tying the knot onto the hula-hoop. The students can sit around the hula-hoop and talk each other through the steps. Assist students as needed and encourage those who tie the knot successfully to help others.

6. Once everyone has mastered the knot, gather up the hula-hoops and pieces of rope.

Part Two – Making Pop Can Casters:

1. Set up empty pop cans, masking tape, fishing line, clippers and casting plugs on tables around the room.

2. Hand out instructions for making a pop can caster. Demonstrate how to make a pop can caster to the class.

3. Have students follow the steps on the sheet and assist where needed.

Part Three – Practice Casting :

1. Set up a casting area outside or in the gym. Draw or use a line on the ground for students to stand while casting. Place hula-hoops about 10 to 20 feet away from the casting line to use as targets.

2. Demonstrate how to cast the fishing line with the pop can caster.

    a. Unwind the line from the can about four feet.

    b. Hold the top end of the pop can in one hand and the fishing plug in the other hand. Remember not to cover the line wrapped on the pop can with your hand or fingers as you cast.

    c. Point the bottom end of the pop can at the center of a hula-hoop.

    d. Toss the fishing plug underhand toward the hula-hoop.

    e. The rest of the line should unwind and follow.

    f. To reel in the line, just wrap it around the can, keeping the line tight. Secure the line with a piece of tape when not in use.

    g. After all the students have practiced casting, bring the students back together and discuss how things went. Did they find a technique that worked best? Remind students that they don't need expensive equipment to go fishing. Once they know how to tie a clinch knot, they can attach a hook, sinker and bobber to their pop can caster and go fishing at their local ponds.

3. If taking the class fishing, this set up will work well for a pond.

    a. Remove the fishing plug with clippers.

    b. Have the students pull a two-foot length of line from the pop can.

    c. Tie a hook onto the end on the line using a clinch knot. It is helpful to tape the hook to the top of a table or desk with the eye exposed over the edge. The sharp hook is safely secured, and the students then have both hands free for tying the knot.

    d. Using needle-nosed pliers, attach a split shot sinker about six inches above the hook.

    e. Attach a bobber about eight to ten inches above the sinker.

    f. To cast this set up, use the same method as the plug, but pinch the top of the hook with the thumb and pointer finger and hold the bobber on the palm of the hand. Toss bobber and hook underhand the same way as the fishing plug.

    g. This pop can rig works best when fishing for crappie, bluegill or perch.

Evaluation

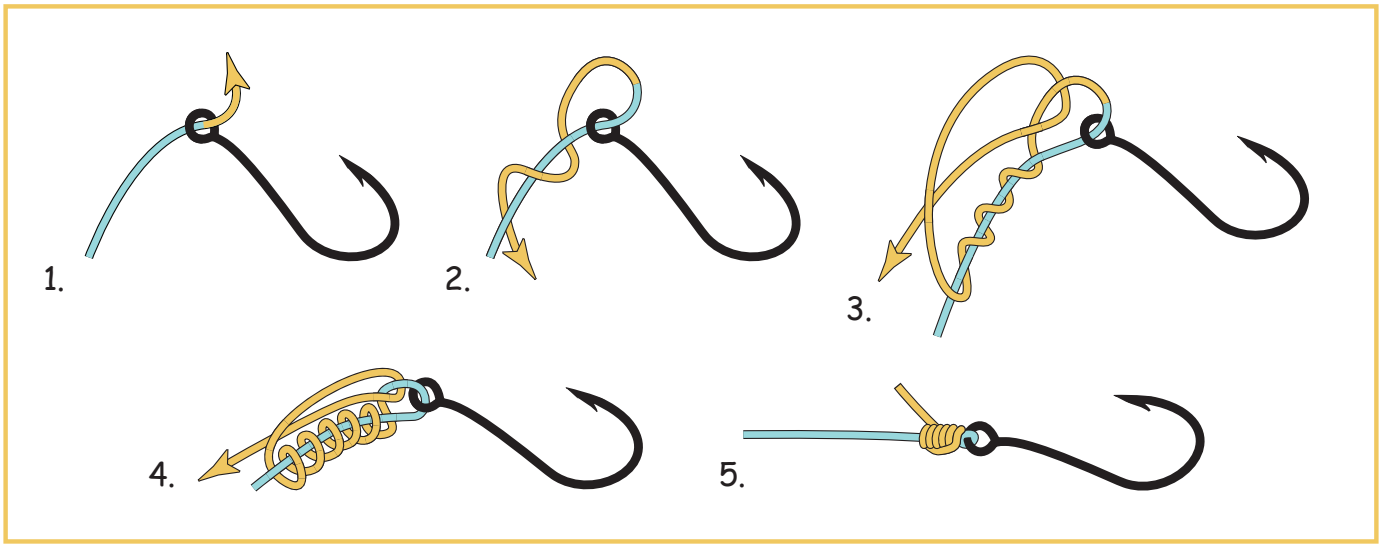
1. Have each student demonstrate how to tie a clinch knot and cast for accuracy using their pop can casters.

2. Ask students to write step-by-step instructions for tying a clinch knot and describe why this type of knot is popular with anglers.

3. Have students write a paragraph or two on their experiences casting and fishing with their pop can casters.

Tying a Clinch Knot

The clinch knot is one of the most popular fishing knots. When properly tied, it is very strong and will not slip. You can use this knot to attach fishing plugs, hooks and lures to your fishing line.



1. Thread the line through the eye on the fishing plug or hook.
2. Wrap the line around itself five times to make five twists. With fewer than five wraps, fish might pull out the knot. With more than five wraps, the line may break.
3. Take the loose end of the line and put it through the loop made by the first wrap near the fishing plug or hook.
4. Notice the new loop you have made? Pass the line through the new loop.
5. Pull gently on the line and slide the whole knot down to the fishing plug or hook. It helps to wet the line to make it slide easier and make a tight knot. Make sure that the coils are tightly lined up. If there are loose wraps, or wraps on each side of the eye, the knot may snag and break. There should be neatly stacked coils lined up next to the eye. Using clippers, cut off the loose end close to the knot.

Making a Pop Can Caster

You don't need expensive equipment to fish. Once you know how to tie a clinch knot, you can make your own pole and reel from an empty, clean pop can! With a fishing plug, you have a great rig for practicing casting. Add a hook, sinker and bobber to your pop can caster, and you can catch fish in a pond!

What You Need:

- One empty, clean pop can (Make sure the can is clean. You don't want to attract bees!)
- Masking tape
- 6 pound test fishing line (enough for 50 wraps)
- Fingernail clippers
- Fishing plug

To Build Your Pop Can Caster to Practice Casting:

1. Tie the fishing line to the tab on the pop can.
2. Securely tape the fishing line near the top of the pop can.
3. Wrap the fishing line around the can 50 times. Tape the line down, leaving about 2 feet of line loose from the can.
4. Attach a fishing plug to the line using a clinch knot.

To Cast Your Pop Can Caster:

1. Unwind about four feet of line from the can.
2. Hold the top end of the pop can in one hand and the fishing plug in the other hand. Remember not to cover the line wrapped on the pop can with your hand or fingers as you cast.
3. Point the bottom end of the pop can where you want your line to go and toss the fishing plug underhanded. The rest of the line should unwind and follow.
4. To reel in the line, just wrap it around the can, keeping the line tight. Secure the line with a piece of tape when not in use.

To Go Fishing:

1. Cut the plug off of the line with clippers.
2. Tie a hook to the end of the line using a clinch knot. It is helpful to tape the hook to the top of a table or desk with the eye exposed over the edge. This way the sharp hook is secure, and you have both hands free for tying the knot.
3. Using needle-nosed pliers, attach a split shot sinker about 6 inches above the hook.
4. Attach a bobber about 8 to 10 inches above the sinker.
5. To cast, use the same method as the plug, but pinch the top of the hook with the thumb and pointer finger and hold the bobber on the palm of the hand. Carefully toss bobber and hook together underhanded.

Let's Go Fishing

Summary

Students learn the basics of fishing and travel to a local pond for a fishing trip.

Objectives

Students will...

- demonstrate how to tie a clinch knot
- demonstrate how to cast a fishing rod with a closed-faced reel
- demonstrate how to set up a fishing line with a bobber, sinker, weight, and hook

Materials

Part One: Knot Tying

- 4 or 5 hula-hoops
- 2-foot sections of nylon string, one per student or pair of students
- 2-foot sections of fishing line, one per student
- one fishing hook per student
- nail clipper
- masking tape
- copies of *Tying a Clinch* Knot, one per student or pair of students

Part Two: Casting

- rods and reels (instructions are for spinning rods with closed-face reels)
- casting plugs
- casting targets, such as hula hoops

Part Three: Fishing Trip

- fishing rods and reels, one per student
- hooks with barbs flattened
- bobbers
- sinkers
- bait, such as worms
- nail clippers
- needle-nosed pliers, one per volunteer
- fishing regulations
- educational fishing permit
- volunteers, 1 for each group of 4 to 5 students

Background

People have fished for thousands of years, initially for food and more recently for recreation. Fishing is a lifelong sport that can be enjoyed at any age. If you have little or no fishing experience, do not let that be a deterrent to taking your class fishing. There are countless fishing clubs throughout the state with members that enjoy teaching kids how to fish. Contact a fishing club in your area to see if they have any volunteer fishing instructors, or contact your local Fish and Game office for contact recommendations. Even if you are an experienced angler, it is highly recommended, if not essential, that you seek out volunteers to assist your students on the field trip.

Grade Level
2-12

Subject Areas
Physical Education

Time
Part One: 30 minutes

Part Two: 45 minutes

Part Three: 1-2 hours

Vocabulary
bait, bobber, casting plug, catch-and-release, clinch knot, closed-faced reel, fishing line, hook, line guides, spinning rod, split shot sinker

Choose a local fishing pond with safe, easy access for students. Your Fish and Game office should be able to provide recommendations. A variety of fishing equipment exists; however, to get started, a closed-faced spinning rod and reel combo, also called a spin-casting rod, is an ideal option. This lesson describes how to use this equipment with very basic tackle, including a bobber, weights and a hook. Loaner rods and reels are available at no charge through the Idaho Department of Fish and Game Rod Loaner Program. Educational Fishing Permits are also available. Permit applications may be found on Idaho Fish and Game's website http://fishandgame.idaho.gov under the Learn to Fish tab. This permit will allow those 14 years old and older to fish without a license while attending the educational event. Contact your local Regional Fish and Game office for more information.

Part One: Tying a Clinch Knot

Procedure

1. Ask your students to raise their hand if they have ever been fishing before. What skills are needed in order to go fishing? Knot tying is one important fishing skill. Tell your students that they are going to learn the improved clinch knot, a knot that is very useful for tying hooks onto fishing line.

2. Pass out the instruction sheet for tying a clinch knot. Using a hula-hoop and piece of rope, demonstrate how to tie the clinch knot. The hula-hoop represents

the eye of the fishing plug or hook; the rope represents the fishing line.

3. Untie the knot and have the students talk you through the steps and tie the knot.

4. Divide the class into groups of four to five students. Give each group a hula-hoop and each student a piece of rope. Ask the students to practice tying the knot onto the hula-hoop. The students can sit around the hula-hoop and talk each other through the steps. Assist students as needed and encourage those who tie the knot successfully to help others.

5. Once everyone has mastered the knot, gather up the hula-hoops and pieces of rope.

6. Pass out the hooks and two-foot sections of fishing lines to the students. Point out the eye of the hook (the small hole through which they will thread their line) and the barb. It is helpful to tape the hook to the top of a table or desk with the eye exposed over the edge. The sharp hook is safely secured, and the students then have both hands free for tying the knot.

7. Have each student tie a clinch knot. Remind the students to lubricate the fishing line with saliva or water before they tighten the knot. Complete the knot by clipping off the extra line with the nail clippers.

Part Two: Casting

Procedure

1. Choose a casting location, such as the gym or an open field, with few obstacles on which to become tangled. Avoid trees.

2. Set up the casting targets at variable distances from where the students will cast (15-30 feet is appropriate).

3. For those students that have been fishing before, do they know what type of rod and reel they used? There are many different kinds of rods and reels. Today they will be learning to cast a closed-face spinning rod.

4. Go over the main parts of a rod and reel combo: rod, line guides, closed-faced reel.

5. Give each student a rod and reel combo and a casting plug. If the rods are not already set up with casting plugs, have the students thread the fishing line through the guides and tie a casting plug onto their line using the clinch knot they learned in Part One.

6. Demonstrate how the reel works. Hold the grip in your hand with the reel on top. Using the same hand that holds the reel, push the button on the reel with your thumb and hold it in. Notice that nothing happens. Now release your thumb and watch how the line comes out and the casting plug drops. Pull some line out of the reel and notice how it keeps coming. Turn the reel handle forward and listen for a click. Now try to pull more line out. It shouldn't come out. Reel in the line.

7. Demonstrate an overhead cast. Hold the button in with your thumb. The rod should be straight in front of you. Make sure the line is not wrapped around the tip of the rod. Remember to look over your shoulder to make sure no one is standing behind you when you cast; look overhead and behind you for any obstructions, such as power lines or tree branches. Lift and bend your elbow to bring the rod tip back over your shoulder as you watch it. Then bring the rod tip forward over your shoulder, watching it until you are pointing the rod to a point just above the horizon. Release your thumb as you bring the rod forward, and point the rod tip in the direction you want the casting plug to go. Watch as the casting plug takes the line straight out in front of you.

8. Allow the students to practice casting to the targets. Have a few students cast to each target, casting one at a time. Have the students rotate targets, so they practice casting different distances.

9. Was casting easy or difficult? How many people made it into the target on their first try? What could the students do to improve their casting skills? Practice.

Part Three: Fishing Trip

Procedure

1. Ask your students if they know what the word "steward" means. A steward is someone who takes action to protect the environment. Tell the students that one of the most important traits an angler can possess is being a good steward. Ask your students how they can be good stewards while fishing?

   Some examples include:

   - Read and follow the regulations.
   - Do not litter. This includes fishing hooks, line and bait.
   - Practice catch-and-release fishing when you do not plan to eat your catch.
   - Learn how to identify the fish that you catch.
   - Do not release aquarium fish into the wild.

2. Discuss general safety rules. Recommended rules include:

   - Stay within the boundaries the teacher sets.
   - Fish ten feet from anyone else.
   - Always look behind you before casting.
   - Do not go in the water.

3. Have groups of students look up the regulations for the water they are about to fish and discuss the regulations/rules. Discuss the reasons for having rules and regulations. Do they need a fishing license? No, because the entire class has an educational fishing permit. However, if students return to fish on their own, they need a fishing license if 14 years old or older. For younger students, hold up the regulations; discuss the rules for fishing and the reasons why rules are set.

4. Demonstrate the appropriate way to retrieve a snagged line. Inevitably, your students will become hooked on the bottom of the pond or on a branch. It is very easy to break a rod tip if one is not aware of the appropriate technique for retrieving a snagged line. Point the tip of your rod to where the hook is stuck and pull straight back on the line. Do not allow the rod to bend, as this will break the rod. You may lose some line and your hook, but the most important thing is that the rod and reel remain intact.

5. Hand out fishing rods. If the rods are not set up for fishing, demonstrate and have the students follow along to set up their rods. Have volunteers help as needed.

   - Tie a hook to the end of the line using a clinch knot.
   - Using needle-nosed pliers, attach a split shot sinker about 6 inches above the hook.
   - Attach a bobber about 8 to 10 inches above the sinker.
   - Thread worm or other bait onto the hook.

6. Divide the students into groups of four or five. Have at least one adult volunteer accompany each group. The adult should be familiar with basic fishing techniques. Students will likely need assistance with correct fishing techniques and the proper way to release any fish caught. Students should be required to release any fish they may catch, unless the class will cook the fish as a group.

7. After fishing, regroup and ask the students these questions: Did any students catch fish? What types of fish were caught? Where were fish caught? Where weren't fish caught? Why do the students think fish were caught in certain areas and not others? Was the habitat better in the areas where fish were caught?

Evaluation

1. Have each student show you the knot they tied. Some students may not have the dexterity to tie the knot well; these students may need more practice.

2. Each student should be able to demonstrate the appropriate way to cast a rod, including looking behind them for people prior to casting. Students should not be graded on accuracy.

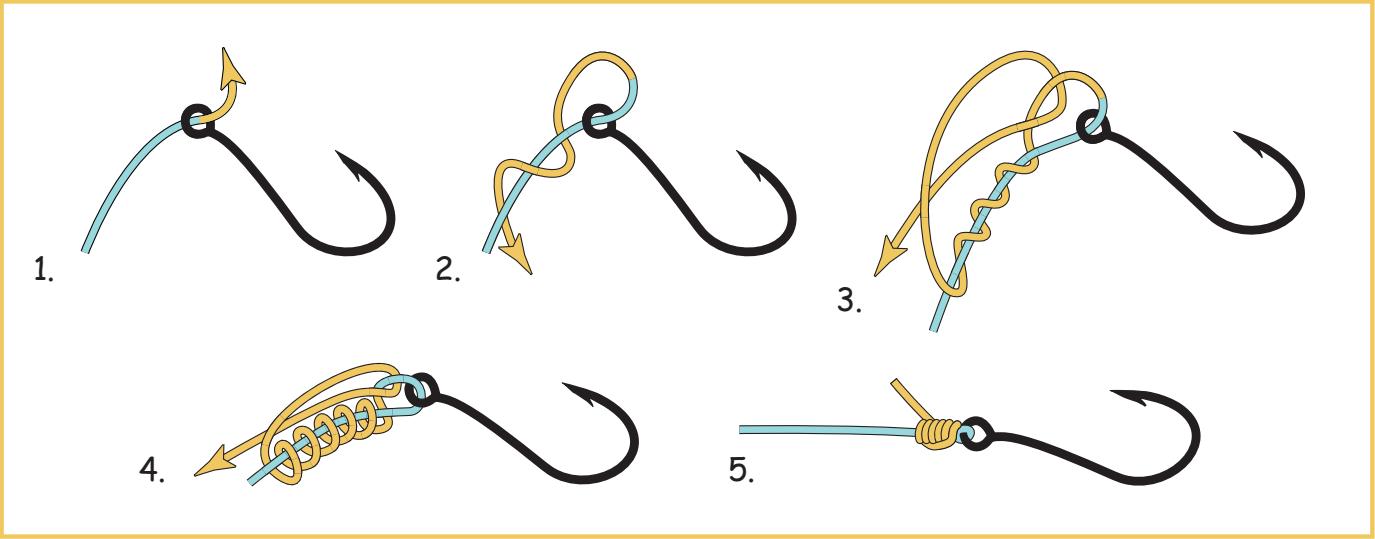
Extension

1. Play PIG or HORSE with the casting targets.

2. Have open-faced spinning rods and fly rods available for students who are interested in trying out different types of equipment.

Tying a Clinch Knot

The clinch knot is one of the most popular fishing knots. When properly tied, it is very strong and will not slip. You can use this knot to attach fishing plugs, hooks and lures to your fishing line.



1. Thread the line through the eye on the fishing plug or hook.
2. Wrap the line around itself five times to make five twists. With fewer than five wraps, fish might pull out the knot. With more than five wraps, the line may break.
3. Take the loose end of the line and put it through the loop made by the first wrap near the fishing plug or hook.
4. Notice the new loop you have made? Pass the line through the new loop.
5. Pull gently on the line and slide the whole knot down to the fishing plug or hook. It helps to wet the line to make it slide easier and make a tight knot. Make sure that the coils are tightly lined up. If there are loose wraps, or wraps on each side of the eye, the knot may snag and break. There should be neatly stacked coils lined up next to the eye. Using clippers, cut off the loose end close to the knot.

Tackling Your Tackle Box

Grade Level
4-12

Subject Areas
Math, Science

Time
40-50 minutes

Vocabulary
bait, crankbait, fishing line, hook, jig, lure, spinner, spinnerbait, tackle

Summary

Students go "shopping" for fishing tackle for a particular species of fish. Without any information on their species, students choose tackle from a price list, figure their total spent and change from $20. After receiving information about their species, students then go "shopping" for tackle again. Shopping lists are compared to see if knowledge about the species helped them make better shopping choices.

Objectives

Students will:

- select tackle appropriate for catching a particular type of fish
- describe how knowledge of fish characteristics leads to economical and effective choices of tackle box items
- use addition, subtraction and multiplication while working with decimals (money)
- work cooperatively in small groups

Materials

- tackle box full of various items (hooks, lines, bobbers, split shot sinkers, bait, jigs, etc.)
- *Tackling Your Tackle Box Price List*, two for each group of three or four students
- *Fish Information Cards*, one card for each group of students
- *Tackle Information Cards*, one card for each group of students to go with the appropriate fish card

Background

Anglers have a huge assortment of tackle options available at sporting goods stores. There are as many choices in tackle as there are types and sizes of fish. Making smart purchases can save an angler money and frustration when out enjoying a day fishing. It is helpful to learn a few things about the fish that you are hoping to catch – mouth size, food preferences, where it may be located in its habitat, and its typical size. Knowing these things will help in selecting the proper gear. No one item can guarantee that you will catch a fish, but proper gear can make a fishing trip more pleasant and successful. Here is some information on the tackle students will "shop" for in this activity.

Hooks: Hooks come in a variety of sizes and styles. Hooks need to be large enough to hold the bait, but small enough to fit in the fish's mouth. Hook size 10, 8 and 6 work well for smaller-mouthed fish, such as bluegill and trout. Larger hooks such as 2, 1, and 1/0, are required for larger fish such as walleye, northern pike and largemouth bass.

Fishing line: Fishing line comes in different sizes or "tests," measured in pounds. The higher the pound-test the heavier or stronger the line. For example, 4-pound test line is appropriate for catching bluegill, trout and perch. The line won't break unless there is four pounds or more of pull on the line. Fishing for northern pike calls for 12-pound test or higher. The line is stronger and more durable than lower test line that could break if tugged by larger fish.

Artificial Lures: Selecting fishing lures can be overwhelming with many different types. Each lure style comes in a dazzling variety of shapes, sizes and colors. Some of the more popular lures are listed below.

- **Jigs and jig heads** have a weighed head and a hook. A jigtail, made of feathers, hair or soft plastic, can be purchased separately and slid over the hook to make a tail. Jigs resemble natural fish food such as insects and small fish. They are lifted and lowered near the bottom. Feather jigs are used to catch smaller fish, like panfish. Twistertail jigs are used to catch all species.
- **Plastic worms** are commonly used to catch bass but other fish will also bite them. They are made of soft plastic and come in many shapes and sizes. Some contain scents attractive to fish. They don't have hooks, so they are threaded onto a basic hook or another lure attached to a line. An easy way to use a plastic worm is to hook it to a plain jig head.
- **Spinners** have one or more blades that spin around a metal shaft. Fish are attracted to the flash and vibration of the revolving blades. Most have tails made of soft plastic or animal hair that resemble natural fish food such as insects. Common types are straight-line spinners and spinnerbaits. Spinnerbaits look like an open safety pin with a spinning blade on one end and a jig on the other. Spinners can be used to catch all species.

- **Diving lures and crankbaits** imitate baitfish with "lips" that cause them to dive and wiggle. The size and angle of the lip and the weight of the lure determine how deep the lure will travel. Crankbaits are great for attracting larger predatory fish that swim in deeper areas, such as northern pike, walleye and bass.
- **Surface lures** float on the surface of the water. They resemble insects or frogs and can be used for all species, especially sunfish, bass and northern pike. Some, called poppers, have flat or scooped-out fronts that splash as they are jerked across the water.
- **Live bait** can be worms purchased at the store or grasshoppers caught along the edge of a stream. Some live bait listed in this activity may be illegal or have restrictions in Idaho. Please check regulations before using live baits.

Procedure

1. Ask students what they think they would need if they wanted to go fishing. Brainstorm a list of items with your students. Write the list on the board. The list might include worms, fish eggs, fishing line, fishing rod, hooks, fishing lures, fish stringer, tackle box, etc.

2. Show the students a tackle box full of items. Display and describe what some of the items are called and their uses. A helpful hint—the larger the number size of a fish hook, the smaller the hook size. A size 1 hook is actually much larger than a size 10 hook.

3. Divide students into groups of three or four. Tell the students that they will be "shopping" for items to fill a tackle box. In particular, they will be shopping for hooks, line, live bait and fishing lures.

4. Give each group of students a *Tackling Your Tackle Box Price List* sheet. Tell the students that they have $20.00 to spend on their tackle items. Each group needs to decide which items on the list to purchase to help them catch their target fish.

5. Assign each group a fish (bluegill, yellow perch, black crappie, rainbow trout, bullhead, walleye, smallmouth bass, largemouth bass, catfish, or northern pike). Have the students write down the fish species on the *Tackling Your Tackle Box Price List* sheet.

6. Have the students multiply the number of individual items selected by the price of each item and write the total in the cost line across from the item. They need to write the reason for the purchase in the space provided.

7. Remind students to add up the total cost of their purchases from each page and figure the change left over from their $20.00.

8. Ask a spokesperson from each group to present what they purchased, what it cost and how much money they had left over. How did the group decide on which items to purchase? How were they sure of their decisions? Have the students set aside the worksheets to refer to them later.

9. Ask the students what fish species they were targeting for their fishing trip. Would knowing some information about their fish have been helpful in purchasing the correct tackle items? Hand out the appropriate *Fish Information Card* to each group of students. Have them read the information within their group.

10. Hand out a second *Tackling Your Tackle Box Price List* to each group. Have the students repeat the shopping exercise with the information on their fish species in mind, again with $20.00 to spend.

11. Have each group compare the second price list to their first price list. How do the shopping lists differ? Was it easier to decide what to buy with information on the fish species?

12. Tell the students that you have information on the tackle recommended for catching each species. Hand out the appropriate *Tackle Information Card* to each group.

13. Ask the students to compare what they purchased with the items on the *Fish Tackle Card.* How did they do? Did they spend their money more wisely on the first shopping trip or the second shopping trip? Have each group report to the class about their experiences.

Evaluation

1. Evaluate each group's presentation after the second shopping trip. Presentations should include:
   - Name of fish species they were buying tackle for
   - Differences in what was purchased after receiving more information about their species
   - List any items purchased and money spent on tackle not suited to their species
2. Collect price list forms and check for correct computations.

Names: _____

Fish Species: _____

Tackling Your Tackle Box Price List

Item	Price	Number	Total Cost	Why did you choose this item?
Hooks 				
10 Hooks, size 10	$1.50			
10 Hooks, size 8	$1.50			
10 Hooks, size 6	$1.50			
10 Hooks, size 2	$1.50			
10 Hooks, size 1	$1.50			
10 Hooks, size 1/0	$1.50			
Line 				
4-pound Test Line	$5.00			
6-pound Test Line	$5.00			
10-pound Test Line	$6.00			
12-pound Test Line	$6.00			
20-pound Test Line	$7.00			
Jigs and Plastic Baits 				
Jig Head, 1/16 oz.	$0.25			
Jig Head, 3/8 oz.	$0.25			
Jig Head, 1 oz.	$0.25			
				
Jig Tail, 2 inches	$0.20			
Jig Tail, 3 inches	$0.20			
Jig Tail, 4 inches	$0.20			
Plastic Worm, 5 inches 	$0.35			
Spinners				
Straight-line Spinner, size 0	$2.60			
Spinnerbait 				
Spinnerbait, $^{1}/_{16}$ oz.	$2.00			
Spinnerbait, $^{3}/_{8}$ oz.	$3.50			
Spinnerbait, 1 oz.	$5.50			
Total Cost Page 1				

Item	Price	Number	Total Cost	Why did you choose this item?
Diving Lures				
Crankbait, 2 inches, shallow runner	$2.50			
Crankbait, 3 inches, shallow runner	$3.80			
Crankbait, 4 inches, shallow runner	$4.80			
Crankbait, 3 inches, deep runner	$3.80			
Crankbait, 4 inches, deep runner	$4.80			
Crankbait, 5 inches, deep runner	$6.00			
Crankbait, 7 inches, deep runner	$7.00			
Surface Lures 				
Surface Lure, 2 $^{1}/_{2}$ inches, $^{3}/_{8}$ oz.	$3.50			
Surface Lure, 7 $^{1}/_{2}$ inches, 2 $^{1}/_{2}$ oz.	$5.50			
Spoons 				
Spoon, 1 $^{3}/_{8}$ inches, $^{3}/_{16}$ oz.	$2.30			
Spoon, 2 $^{7}/_{8}$ inches, $^{3}/_{4}$ oz.	$4.80			
Spoon, 5 $^{3}/_{8}$ inches, 3 $^{1}/_{4}$ oz.	$5.80			
Live Bait 				
Wax Worms or Grubs, 1 dozen	$1.50			
Worms, 1 dozen	$2.50			
Nightcrawlers, 1 dozen	$2.50			
Leeches, 1 dozen	$2.80			
Crickets, 1 dozen	$2.80			
Crayfish, 5	$2.75			
Crappie Minnows, small, 1 scoop	$2.50			
Fathead Minnows, medium, 1 scoop	$2.50			
Sucker or Shiner Minnows, large	$6.80			
Total Cost Page 2				

Total Cost Page 2	
+ Total Cost Page 1	
= Total Cost Both Pages	
Amount of Change Left Over from $20.00	

Fish Information Card

Rainbow Trout

Mouth Size: Small to medium

Fish Weight: Light

Fish Length: Short to medium

Primary Habitat: Shallow to mid-deep streams

Food Preferences: Insects, small fish

Fish Information Card

Black Crappie

Mouth Size: Small to medium

Fish Weight: Light

Fish Length: Short

Primary Habitat: Shallow to mid-deep streams

Food Preferences: Small fish, worms

Fish Information Card

Yellow Perch

Mouth Size: Small

Fish Weight: Light

Fish Length: Short

Primary Habitat: Shallow to mid-deep streams, lakes

Food Preferences: Small fish, worms, leeches, insects

Fish Information Card

Bluegill

Mouth Size: Small

Fish Weight: Light

Fish Length: Short

Primary Habitat: Shallow water

Food Preferences: Insects, worms, leeches

Fish Information Card
Bullhead

Mouth Size: Small to medium

Fish Weight: Light

Fish Length: Short to medium

Primary Habitat: Shallow to mid-deep water, likes bottoms

Food Preferences: Insects, worms, leeches, crayfish, snails

Fish Information Card
Catfish

Mouth Size: Large

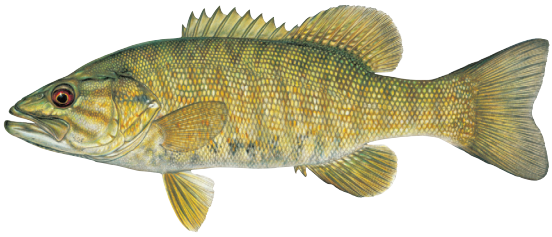
Fish Weight: Heavy to very heavy

Fish Length: Long

Primary Habitat: Shallow to deep water, likes big rivers

Food Preferences: Frogs, crayfish, large fish, decaying matter

Fish Information Card
Smallmouth Bass



Mouth Size: Medium

Fish Weight: Medium

Fish Length: Medium

Primary Habitat: Medium to deep water

Food Preferences: Medium fish, insects, crayfish

Fish Information Card
Largemouth Bass

Mouth Size: Large

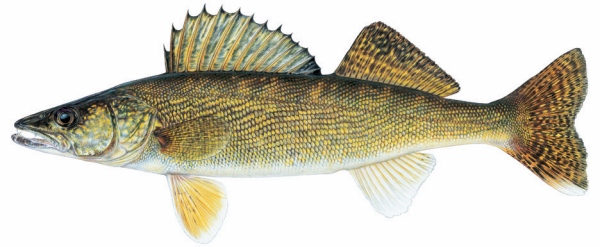
Fish Weight: Medium to heavy

Fish Length: Medium to long

Primary Habitat: Shallow to medium water

Food Preferences: Frogs, medium fish, crayfish

Fish Information Card
Walleye



Mouth Size: Medium to large, with teeth

Fish Weight: Medium to heavy

Fish Length: Medium to long

Primary Habitat: Deep water

Food Preferences: Medium to large fish

Fish Information Card
Northern Pike

Mouth Size: Large, with teeth

Fish Weight: Heavy to very heavy

Fish Length: Long

Primary Habitat: Shallow to deep water

Food Preferences: Large fish

Tackle Information Card
Walleye

Hook Size: 2

Line Size: 6-pound test

Lures: Jig, crankbait, spoon

Lure Size: $^{3}/_{8}$ oz. jig with 3-inch tail, 4-inch deep diver crankbait, $^{3}/_{4}$ oz. spoon

Live Bait: Nightcrowlers, leeches, 2-4 inch minnows

Tackle Information Card
Northern Pike

Hook Size: 1/0 or larger

Line Size: 12-pound test or higher

Lures: Jig, spinnerbait, crankbait, surface lure, spoon

Lure Size: 1 oz. jig with 4-inch tail, 1 oz. spinnerbait, 7-inch deep runner crankbait, 2 $^{1}/_{2}$ oz. surface lure, 3 $^{1}/_{4}$ oz. spoon

Live Bait: 6-12 inch minnows

Tackle Information Card
Rainbow Trout

Hook Size: 6

Line Size: 4-pound test

Lures: Jig, straight-line spinner, crankbait, spoon

Lure Size: $^{1}/_{16}$ oz. jig with 2-inch tail, size 0 spinner, 2-inch shallow runner crankbait, $^{3}/_{16}$ oz. spoon

Live Bait: Worms, hellgrammites

Tackle Information Card
Black Crappie

Hook Size: 6

Line Size: 4-pound test

Lures: Jig, spinnerbait

Lure Size: $^{1}/_{16}$ oz. jig with 2-inch tail, $^{1}/_{16}$ oz. spinnerbait

Live Bait: Small minnows, wax worms

Tackle Information Card
Yellow Perch

Hook Size: 8

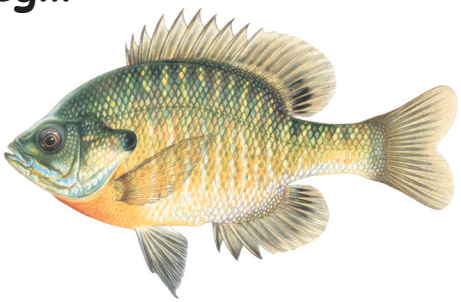
Line Size: 4-pound test

Lures: Jig, spinnerbait

Lure Size: $^{1}/_{16}$ oz. jig with 2-inch tail, $^{1}/_{16}$ oz. spinnerbait

Live Bait: Small minnows, worms, wax worms, leeches, crickets

Tackle Information Card
Bluegill



Hook Size: 10

Line Size: 4-pound test

Lures: Jig, spinnerbait

Lure Size: $^{1}/_{16}$ oz. jig with 2-inch tail, $^{1}/_{16}$ oz. spinnerbait

Live Bait: Worms, wax worms, leeches, crickets, grasshoppers

Tackle Information Card
Bullhead

Hook Size: 2

Line Size: 4-pound test

Lures: Not usually used

Live Bait: Worms, leeches, crayfish, snails, crickets

Tackle Information Card
Catfish

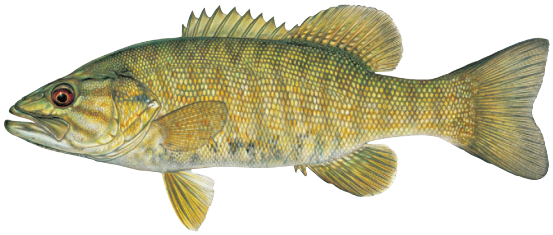
Hook Size: 1/0

Line Size: 10-pound test or higher

Lures: Not usually used

Live Bait: Frogs, nightcrawlers, crayfish, live or dead minnows (small minnows for smaller fish, 6-12-inch minnows for big catfish)

Tackle Information Card
Smallmouth Bass



Hook Size: 1

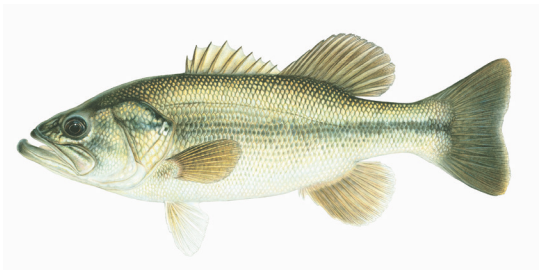
Line Size: 6-pound test

Lures: Jig, plastic worms, spinnerbait, crankbait, surface lure

Lure Size: $^{3}/_{8}$ oz. jig with 3-inch tail, hook with 4-inch plastic tail, $^{3}/_{8}$ oz. spinnerbait, 3-inch shallow or deep runner crankbait, $^{3}/_{8}$ oz. surface lure

Live Bait: Crayfish, 2-4-inch minnows, nightcrawlers, hellgrammites

Tackle Information Card
Largemouth Bass



Hook Size: 1/0

Line Size: 10-pound test or higher

Lures: Jig, plastic worms, spinnerbait, crankbait, surface lure

Lure Size: $^{3}/_{8}$ oz. jig with 3-inch tail, hook with 4-inch plastic tail, $^{3}/_{8}$ oz. spinnerbait, 3-inch shallow or deep runner crankbait, $^{3}/_{8}$ oz. surface lure

Live Bait: Frogs, 3-6-inch minnows, crayfish, nightcrawlers

Trout in the Classroom

Activity Guide

TROUT UNLIMITED

WILDLIFE & SPORT FISH RESTORATION