Photo credit: USFWS (public domain)

Mussel Mania

Do you ever wonder how the native mussels are similar and/or different than the invasive zebra and quagga mussels?

Grade Level
Middle School

Subject Areas
Life Science, Environmental Science, Ecology, and Human Impacts

Key Topics
Aquatic invasive species, mollusks, life cycles, filter feeders

Duration
Preparation Time: 20 min
Activity Time: 50 min

Setting
Classroom (Groups of 3-4)

Skills
Comparing and contrasting; Applying information; Drawing conclusions

Standards

NGSS:

MS-LS1-3 and MS-LS1-4
CORE IDEA(S):
LS1.A: Structure and Function
LS1.B: Growth & Development
CROSSCUTTING CONCEPT(S):
Cause and Effect
SCIENTIFIC & ENGINEERING PRACTICE(S):
Engaging in Argument

Common Core:

WHST.6-8.4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Overview
Students will compare and contrast native freshwater mussels to invasive zebra and quagga mussels, and learn how their life cycles, anatomy, and habitat preference are similar or different to each other.

Objectives
Students will be able to:
- identify the function the freshwater mussel structures.
- explain how native mussel life cycles differ from invasive mussels.
- compare and contrast native to invasive mussel habitat preference.
- use evidence to support the argument that zebra and quagga mussels are more successful at survival, reproduction, and dispersal than native mussels.

Materials
Warm Up/Activity/Wrap Up
- Computer, projector
- Student worksheets #1-5
- Station A
  - Colored pencils
  - Mussel anatomy cards (4 sets)
  - 4 Zebra mussel anatomy posters
  - 3-4 3D printed quagga mussel shells
  - 1 zebra vs. quagga vs. Asian clam resin display
  - 1 zebra vs. quagga mussel resin display
  - 1 zebra or quagga mussel shell size comparison resin display
- Station B
  - 4 Native freshwater mussel and life cycle posters
  - 4 Invasive mussel life cycle posters
- Station C
  - 4 Mussels of Montana posters

Advanced Preparation
- Print the student worksheets #1-5 (double-sided and stapled).
- Arrange the classroom so that the students can work in groups of 3-4. Place the materials for the each activity on the group tables.
  - NOTE - There are enough materials to set up two stations for each activity.

Funded by the Montana Department of Natural Resources and Conservation and FLBS.

Background

Bivalves are mollusks with two valves or shells that are connected by a hinged ligament. Marine and freshwater bivalves can be found in a variety of habitats worldwide. Clams and mussels are two types of bivalves found in North America. Freshwater mussels native to Montana are often found buried in the pebbles, gravel, or sandy soft sediments of the streams, rivers, and/or lakes.

There are three native species of mussels found in Montana: the giant floater (*Pyganodon gandis*), the fatmucket (*Lampsili siliquoidea*), and the Western pearlshell (*Margaritifera falcata*). The giant floater and fatmucket are two large species found in rivers in Eastern Montana. These mussels can both grow up to 6 inches in length. In contrast, the smaller, thin-shelled Western pearlshell mussels are a species of concern found in western Montana that can grow up to 4 inches in length. The Western pearlshell mussel populations are in decline and at great risk in Montana, Wyoming, and Idaho.

There are also three non-native, introduced species of mussels that are found in Eastern Montana: the black sandshell (*Ligumia recta*), the white (creek) heelsplitter (*Lasmigona complanata*), and the mapleleaf (*Quadrula quadrula*). These species are fairly tolerant of silt and warmer water temperatures and, therefore, can be found in a wide range of habitats.

All six native and introduced mussel species in Montana require a fish host for their **glochidia,** or parasitic larval stage. The eggs of these species are fertilized internally when the female uses her incurrent siphon to draw in water containing sperm. The embryos develop into glochidia inside of the female and are then released into the water to find a fish host. Some of these species have unique extensions on their mantle that mimic the fish's food. When the mussels come in contact with the fish they release the glochidia into the fish's mouth. Alternatively, some of these species can release their glochidia in **conglutinates,** or worm/insect-like packages, that resemble the host fish's food. When the fish attempts to eat the conglutinates, the glochidia infect the fish. Once inside the fish, the larvae close their shells and attach themselves to the fish's gills, scales, and/or fins. Each glochidium matures on the fish until it is ready to settle into a desired habitat. When ready, these juvenile mussels use their muscular **foot** to swim and move to the bottom. Their foot also contains **cilia** that help them stick to aquatic plants, rocks, or other woody debris as they search for a suitable habitat. Since the glochidia can stay attached to the host fish for up to 3 months, all of the introduced mussels found in Montana were accidentally introduced as glochidia while imbedded on the non-native fish.

Native freshwater mussels in Montana:

Photo credit: Cliff White (Missouri Dept. of Conservation)

Giant floater mussels prefer pools and side channel areas of small to large prairie rivers with mud, sand, or gravel substrate. They are tolerant of silt and warm water habitats.

Photo credit: Jim Rathert (Missouri Department of Conservation)

Fatmucket mussels prefer side-current areas, runs, and pools of medium to large cool to warm rivers with pebble, sand, or silt substrates.

Photo credit: Dan Gustafson (MT Field Guide)

Western pearlshell mussels prefer runs and riffles in main-current channel areas of trout streams and intermountain. rivers with stable gravel substrates.

Mussel Mania

Zebra mussels (*Dreissena polymorpha*) and their close relative, the quagga mussels (*Dreissena rostriformis bugensis*), are two unique freshwater mussels that use external fertilization. Unlike the native mussels in Montana, the females and males of dreissenid mussels both use their **excurrent siphons** to release their gametes into the water. Following fertilization, the **veligers** or planktonic larvae drift with the water currents for up to one month. These microscopic mussel larvae eat plankton, grow, develop, and use their cilia to swim freely in the water. During this time, they can drift great distances and also be transported to new locations through human activities. When ready, the juvenile dreissenid mussels use their foot to swim and find a suitable substrate to grow on. Once settled, they begin to form **byssal threads**. These strong protein threads allow the mussels to stick to a wide variety of substrate surfaces.

Despite their differences, the native, introduced, and invasive dreissenid mussels share basic anatomical features that help them survive in their preferred habitats. All bivalve bodies contain two gills, a heart, a digestive tract (palp, mouth, stomach, intestine, and anus), and gonads (reproductive organs). They all use a **mantle**, or outer fold of skin, to enclose their organs and to secrete the shell-building chemicals. They also have strong adductor muscles that allow them to open and close their shells, and **incurrent** and **excurrent siphons** that help them take in water and food and expel water, waste, and gametes. As the water passes their gills, the oxygen is drawn into gill and the food is caught by cilia on the gill's surface. The food is then swept to the **labial palp**, a paired structure that places the food into the mussel's mouth. These remarkable animals can filter large amounts of bacteria and phytoplankton out of the water in a short period of time.

All of the native and introduced species of freshwater mussels currently found in Montana use their muscular **foot** to bury their bodies into the pebbles, gravel, or sand along the lake, river, or stream bottoms. In contrast, the invasive dreissenid mussels use their foot and **byssal threads** to attach to surfaces. These invasives can often be found growing on the exoskeleton of crustaceans and the shell surfaces of native mussel. These fast growing mussels will also grow all over the bottom substrate, which effectively blocks the buried mussels from food.

Vocabulary

Adductor muscles – Strong muscles that hold a bivalve's two shells together, and help to tightly close the shells.
Bivalve – A mollusk with two valves or shells that are connected by a hinged ligament.
Byssal threads – Strong protein threads used by zebra and quagga mussels to attach to surfaces.
Cilia – Microscopic hair-like projections in mollusks that help them move in the water and along surfaces.
Conglutinates – Worm or insect-like packages of glochidia that attract the freshwater mussel's host fish.
Excurrent siphon – A tubular organ used to move water, waste, and gametes out of aquatic mollusks.
Filter feeder – An organism that filters food out of water.
Foot – A muscular organ found in mollusks that helps them to move and adhere to substrates.
Gills – Paired respiratory organs of mollusks, amphibians, and fish used to extract oxygen from passing water.
Glochidium – The parasitic larval stage of native freshwater mussels that attach to a fish host.
Gonad – The reproductive organ that produces gametes (ex. eggs or sperm).
Incurrent siphon – A tubular organ used to move water, food, and gametes into aquatic mollusks.
Ligament – The strong connective tissue that allows a bivalve's shells to open.
Labial palp – Pair of elongated structures that help move food from the mollusk's gills to their mouth.
Mantle – An outer fold of tissue that encloses a mollusk's organs and secretes a shell-building substance.
Marsupium – A brood pouch attached to the native female mussels' gills that develop the larval glochidia.
Plankton – Microscopic organisms that drift with surrounding water currents.
Veliger – The planktonic larval stage of dreissenid mussels, containing two ciliated flaps used for swimming and feeding.

Procedure

◆ Warm Up (5 minutes)

- Turn on the projector, pass out the student worksheets #1-5, and play the following video: http://www.viewpure.com/I0YTBj0WHkU?start=0&end=0
- Students record two adaptations the *Lampsilis* mussels have that help them successfully reproduce and distribute their larvae.
- Explain that the Fatmucket mussel is a native *Lampsilis* mussel found in Eastern Montana that uses similar techniques to reproduce and disperse their offspring.
- Tell the students that they will be completing activity stations to compare and contrast the life cycles, anatomy, and physiology of the native/introduced mussels to the invasive zebra and quagga mussels.

◆ The Activity (30 minutes – 10 minutes per station)

Students will rotate through three activity stations and complete their worksheets as they go.

STATION A: Freshwater Mussel Anatomy and Physiology

- Students use the Zebra Mussel Anatomy Poster, colored pencils, and key to label and color the zebra mussel anatomy diagram on their worksheet.
- Students use the Mussel Anatomy Cards to match the mussel structures to the correct functions.
  - *Students ask the teacher to check the cards to make sure they are correctly matched before the students move on.*
- Students examine the resin displays to determine at what size the invasive mussels begin to reproduce and what the zebra mussel, quagga mussel, and Asian clam have in common.
- Students identify two differences between the zebra and quagga mussel shells.

STATION B: Native vs. Invasive Mussel Life Cycles

- Students use the Native and Invasive Mussel Life Cycle Posters to fill in the provided facts into the Venn diagram on their worksheet.

STATION C: Native Mussels of Montana

- Students use the Mussels of Montana posters to complete the table on their worksheet.
- Students provide one reason why they think the Western pearlshell populations are declining and at risk.
  - *Potential answers: habitat loss and/or disturbance, declining host fish populations, poor water quality, pollution, etc.*
- Since the zebra and quagga mussels can attach to surfaces in both freshwater lakes and rivers, how would the native mussels be impacted by an infestation?

◆ Warm Down (15 minutes)

- Students use **SPECIFIC EVIDENCE** collected during this activity to create an argument supporting the following statement: *Zebra and quagga mussels would be more successful at survival, reproduction, and dispersal than native freshwater mussels in Montana*.
  - Students may write/draw/describe their response in the box on their worksheet.
  - Teachers may ask the students to share their responses verbally.

Teacher Resources

Assessment Options

Have students:

- **complete the Mussel Mania worksheet** to compare and contrast the native and non-native mussels.
- **create a video or visual collage/portrait** summarizing their understanding of how native and invasive mussels are similar and different to each other.

Modifications

- Teachers may set up one or two sets of activity stations.
- If there is time, students may also watch the 10-minute bivalve or freshwater mussel dissection video (see online resources) as an extension to the warm up.
- Students may work individually at each station or in groups.
- Enlarge the students' worksheets as needed.

Extensions

Students can:

- **create a distribution map** that shows where the native and introduced mussel species are currently found in Montana.
- **dissect a bivalve** to learn the external and internal anatomy.

Books

Elton, C. S. (2000). *The Ecology of Invasion by Animals and Plants* (new ed.). Chicago, IL: University of Chicago Press.

Lockwood, J. L., Hoopes, M. F., & Marchetti, M. P. (2013). *Invasion Ecology* (2nd ed). West Sussex, UK: John Wiley & Sons, Ltd.

Online Resources

Lampsilis Mussel and Bass video:
http://www.viewpure.com/I0YTBj0WHkU?start=0&end=0
Bivalve (freshwater mussel) dissection video:
http://www.viewpure.com/C-3GqvLswc8?ref=search
Freshwater mussels of the Upper Mississippi River Guide:
http://wiatri.net/inventory/mussels/images/MusselGuide.pdf
USGS zebra mussel fact sheet:
https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=5

Acknowledgements

Many thanks to Eric Thorsen for designing and producing the 3D quagga mussels for this lesson. Additional thanks to David Stagliano for providing the Mussels of Montana posters and native and introduced shell samples.

Introduced freshwater mussels in Montana:

Photo credit: Carnegie Museum of Natural History

Black Sandshell mussels prefer medium to large warm prairie rivers in riffles or runs with pebble, gravel, or form sand substrates.

Photo credit: Jim Rathert (Missouri Department of Conservation)

White (Creek) Heelsplitter mussels prefers pools in medium to large sluggish prairie rivers with mud, sand, or fine gravel bottom.

Photo credit: Jim Rathert (Missouri Department of Conservation)

Mapleleaf mussel prefer pools or runs in large prairie rivers or reservoirs with a mud, sand, or gravel bottom.

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 Name _____

Warm Up

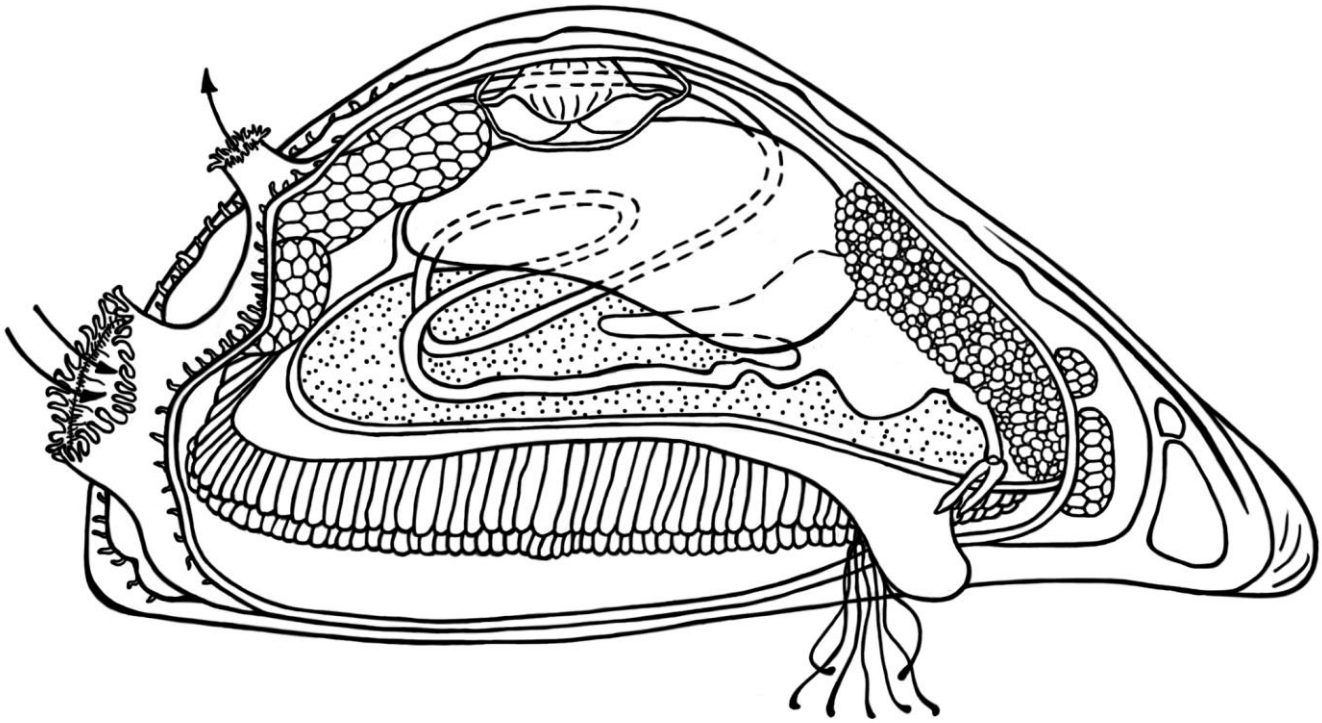
Watch the following video and then answer the question below:
http://www.viewpure.com/I0YTBj0WHkU?start=0&end=0

1. What are two adaptations the *Lampsilis* mussels have that help them successfully reproduce and distribute their larvae?
   -
   -

Station A: Freshwater Mussel Anatomy and Physiology

2. Use the mussel anatomy diagram, colored pencils, and key (below) to **label and color** the following:

- ☐ Posterior adductor muscle (light green)
- ☐ Anterior adductor muscle (light green)
- ☐ Excurrent siphon (red orange)
- ☐ Incurrent siphon (violet)
- ☐ Digestive gland (grey)
- ☐ Gills (pink)
- ☐ Kidney (white)
- ☐ Foot (orange)
- ☐ Byssal threads (dark green)
- ☐ Mantle (blue)
- ☐ Gonad (yellow)
- ☐ Labial palp (sky blue)
- ☐ Mouth (sky blue)
- ☐ Stomach (sky blue)
- ☐ Intestine (sky blue)
- ☐ Anus (sky blue)
- ☐ Ligament (brown)
- ☐ Heart (red)



Station A (continued)

3. Next, use the provided Mussel Anatomy Cards to **match the structures to the correct functions**.

Ask your instructor to check and make sure your cards are correctly matched before you move on!

Examine the zebra or quagga mussel shell size display.

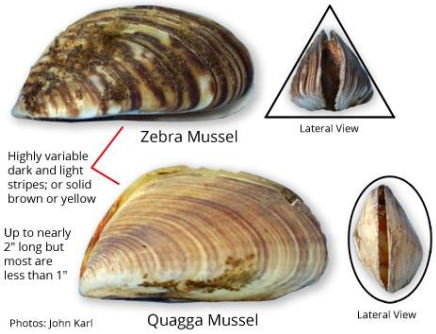
4. At what size do zebra and quagga mussels become adults and begin to reproduce? _____ mm

Examine the zebra vs. quagga vs. Asian clam display.

5. What do the three invasive mollusks have in common?

Learn how to recognize these invaders!

6. What are two differences between the zebra and quagga mussel shells?
   -
   -



Use the ruler below to measure one of the 3-D quagga mussel shells. Shell length = _____ mm

The picture to the left shows the actual size of an adult native Western pearlshell mussel.

How much bigger is the native shell?

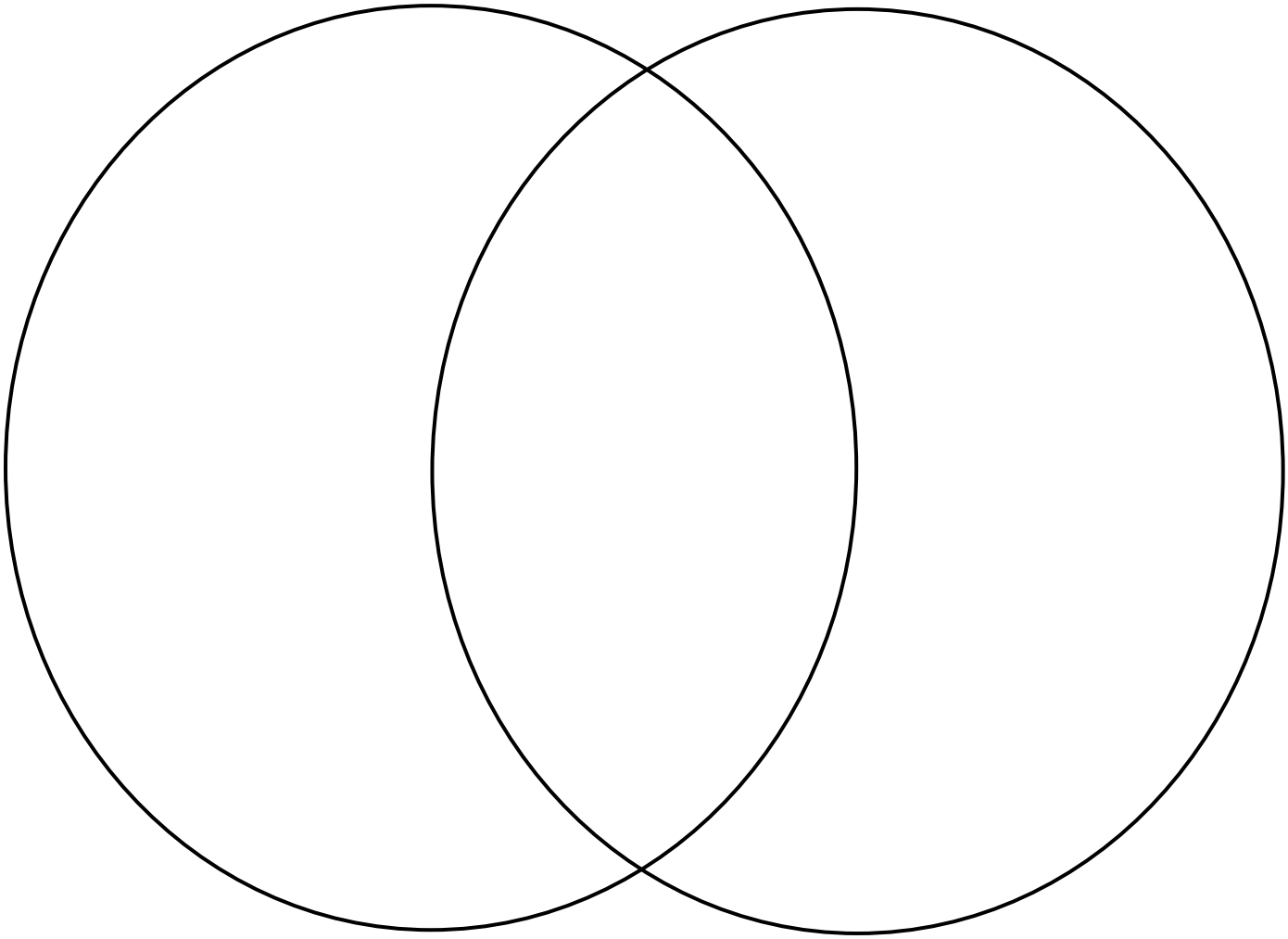
_____ mm

Station B: Native vs. Invasive Mussel Life Cycles

7. Use the Native and Invasive Mussel Life Cycle posters to enter the items below into the Venn diagram.

- Need a fish host
- Produce planktonic veliger larvae
- Produce parasitic glochidia larvae
- Use a foot to stick to & move on a substrate
- Use byssal threads
- Typically live 3-9 years
- Typically live 20-40 years
- Juveniles are benthic
- Live in the sediment
- Live on surfaces
- External fertilization occurs in the water
- Fertilization occurs inside of the female
- Filter feeder
- Bivalve
- Undergo metamorphosis
- Eat plankton and organic detritus
- Use a marsupium or brood pouch
- Produce 40,000-1,000,000 eggs per year

Native Freshwater Mussels **Invasive Zebra & Quagga Mussels**



Station C: Native and Introduced Mussels of Montana

8. Use the provided Mussels of Montana Poster to complete the following table:

Type of Mussel	**Native or Introduced**	**Length (in.)**	**Primary Habitat**	**Host Fish** native (n) Introduced (i)	**Key Watersheds in Montana**
Giant Floater			Prefer pool and side channel areas of small to larger warm prairie rivers with a mud, sand, or gravel substrate.		
			Prefer side current areas, runs, and pools of medium to large cool to warm rivers with pebble, gravel, sand or silt substrates.		Missouri, Milk, Yellowstone, and Little Missouri River drainages.
	Native Species of Concern			W. Cutthroat Trout (n) Steelhead Salmon (n) Chinook Salmon (n) Rainbow Trout (i) Brook Trout (i)	
Black Sandshell		5-6 in.	Medium to large warm prairie rivers in riffles or runs with pebble, gravel, or firm sand substrates.		
	Introduced	4-6 in.		Sauger (n) Carp (i) Green Sunfish (i) Largemouth Bass (i) Walleye (i)	Missouri Basin: from Lower Milk River upstream and Beaver Creek
Mapleleaf		3-5 in.		Channel Catfish (n) Yellow Bullhead (i) Black Bullhead (i)	

9. Which mussel would be found in Northwest Montana? _____
   Why do you think these mussels would not be found in Eastern Montana?

10. Provide one reason why you think the Western Pearlshell populations are declining and at risk?

11. Since the zebra and quagga mussels can attach to surfaces in both freshwater lakes and rivers, how could the native mussels be impacted by an infestation?

Wrap Up

AFTER YOU HAVE FINISHED ALL THREE ACTIVITY STATIONS…SHOW ME WHAT YOU KNOW! ☺

12. Use **SPECIFIC EVIDENCE** to create an argument supporting the following statement:
    Zebra and quagga mussels would be more successful at survival, reproduction, and dispersal than native freshwater mussels in Montana.

You may write/draw/describe your response in the box below.

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Mussel Structure and Function Cards

Structure: **Adductor muscles**	Function: **Strong muscles that hold a bivalve's two shells together and help to tightly close the shells.**
Structure: **Byssal threads**	Function: **Strong protein threads used by zebra and quagga mussels to attach to surfaces.**
Structure: **Cilia**	Function: **Microscopic hair-like projections in mollusks that help them move in water and along surfaces.**
Structure: **Excurrent siphon**	Function: **A tubular organ used to move water, waste, and gametes out of aquatic mollusks.**
Structure: **Foot**	Function: **A muscular organ found in mollusks that helps them to move and adhere to substrates.**
Structure: **Gills**	Function: **Paired respiratory organs of mollusks, amphibians, and fish used to extract oxygen from passing water.**

Lesson #4: Mussel Mania

Mussel Anatomy Cards

FLATHEAD LAKE
BIO STATION
UNIVERSITY OF MONTANA

Lesson #4: Mussel Mania

Mussel Anatomy Cards

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Mussel Anatomy Cards

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Mussel Structure and Function Cards

Structure: **Gonad**	Function: **The reproductive organ that produces gametes (ex. eggs or sperm).**
Structure: **Incurrent siphon**	Function: **A tubular organ used to move water, food, and gametes into aquatic mollusks.**
Structure: **Ligament**	Function: **The strong connective tissue that allows a bivalve's shells to open.**
Structure: **Labial palp**	Function: **Pair of elongated structures that help move food from the mollusk's gills to their mouth.**
Mussel Structure: **Mantle**	Function: **An outer fold of tissue that encloses a mollusk's organs and secretes a shell-building substance.**
Mussel Structure: **Marsupium**	Function: **A brood pouch attached to the native female mussels' gills that develop the larval glochidia.**

Lesson #4: Mussel Mania

Mussel Anatomy Cards

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Lesson #4: Mussel Mania

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