ANY FIN IS POSSIBLE | EDUCATOR

Links to Next Generations Science Standards |

MS-LS4-2: Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

Links to Common Core Standards |

CCSS.ELA-LITERACY.RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

S T E M

Supplement Video |
https://www.youtube.com/watch?v=yZtk6MEx9UI
https://vimeo.com/166222552 (password: exploration)
Pacing | 1 - 2 class periods (45 minutes each)
Background Needed | Understanding of basic ecology, food web dynamics, natural selection, and the relationship between structure and function
Assessment | Scientific Modeling and Communication Rubric provided
Materials/Resources |

- Paper
- Markers / colored pencils
- Printable fish parts (http://nautl.us/2dRYTjw) or additional craft supplies for creating your fish

Overview

In this module, students will learn about a variety of fish adaptations for marine and freshwater environments. Students will design a fish and justify the adaptation choices given to the species with information about how that fish has evolved to be successful for its environment.

Objectives & Learning Outcomes

- Students will be able to explain how adaptations and physiology allow certain organisms to be successful in their environment.
- Students will be able to apply the concept of natural selection to explain the traits of certain organisms in an ecosystem.
- Students will design an organism to be successful in an ecosystem while understanding how each structure contributes to the organism's success.

Guiding Questions

- What characteristics do all fish share?
- What's the difference between anatomy and physiology?
- How are fish physically and physiologically adapted to their home habitats?
- What environmental challenges do fish face living in extreme environments?

Extensions & Adaptations

Introductory |
Simplify adaptation chart or provide teacher edition (no matching), provide information for each ocean environment instead of student research.

Students can build a digital fish through http://www.aquariumofpacific.org/teachers/buildafish

Advanced |
Elaborate on buoyancy control, pressure adaptations, physiological changes and euryhalinity.

Extensions |
Make digital model or 3D printer model; Have students present to the class; Student panel for questioning rationale (peer review); Have students make a dichotomous key for class species list.

Encourage students to share new species with younger students and teach them about adaptations.

Activity/Tasks

Students will:

- Learn vocabulary and basic body designs of fish.
- Complete adaptation matching worksheet to pair fish structures with adaptation functions. Discuss trends as a class.
- Design a fish using the materials provided. Printable body shapes are included. Students may draw fish or build them from classroom materials.
- Complete a new species worksheet to describe the capabilities of their fish and justify all anatomical and physiological decisions in written form.
- Share their model with the class.

Lesson Procedure/Directions

1. Introduction
   - Use selected biology highlights to introduce students to biology of the deep
   - Ask students to discuss the introduction from the student sheet

Teaching Tip: After having students read the introduction, ask the students to brainstorm possible traits that link fishes to their lifestyle or environment. Use the discussion to introduce the difference between physiology and anatomy.

   - Guide students through vocabulary and adaptation matching worksheet.

2. Designing a new fish species:

Encourage students to consider these questions: What part of the ocean does your fish live in? Does your fish migrate, maintain a territory or live in one location? What type of prey does it hunt or forage? How does it catch its prey? What is the primary sense used to find prey? What types of sensing organs are needed in this habitat? What predators is your fish trying to avoid? Does your fish live in schools, pairs or solitarily?

   - Walk around the classroom and provide guidance for the groups as they design, sketch, and build their fish.

3. Analysis/Conclusion
   - Facilitate a reflective discussion where students share their fish and explain the reasons behind their fishes' adaptations.

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Teaching Tips |

- After the students define vocabulary and fish basics, begin the adaptation matching worksheet. This activity can be done individually, in groups, or as a class.
- Students will use adaptations to design a new fish species. You may assign habitats and ask students to build fish for that environment or have students justify their fish designs by also identifying the fish's habitat.
- To wrap up the lesson, explore NautilusLive videos of deep sea fish. Keyword search "fish" in the search field or find videos in the highlight section. Point out deep sea adaptations you touched on as a class. Discuss the correlation between extreme adaptations and environments.

Vocabulary |

1. Adaptation: *a change or the process of change by which an organism or species becomes better suited to its environment.*
2. Anatomy: *the branch of biology concerned with the study of the structure of organisms and their parts.*
3. Evolution: *the process by which different kinds of living organisms are thought to have developed and diversified from earlier forms during the history of the earth.*
4. Natural Selection: *the process whereby organisms with different adaptations better suited for their environment tend to survive longer and produce more offspring.*
5. Physiology: *the branch of biology that examines how living systems function.*

Describe the function of each fish body part and label it on the fish below.

Caudal fin: *tail fin of fish, main mechanism of propulsion for most fish, may be many shapes for specialized function*

Pectoral fin: *paired fins on the side of the body; function primarily for maneuverability; some fish scull/ paddle with these fins for propulsion*

Pelvic fin: *forward paired set of fins on the base of the body; function as stabilizing fins; can be highly modified for bottom dwelling fish*

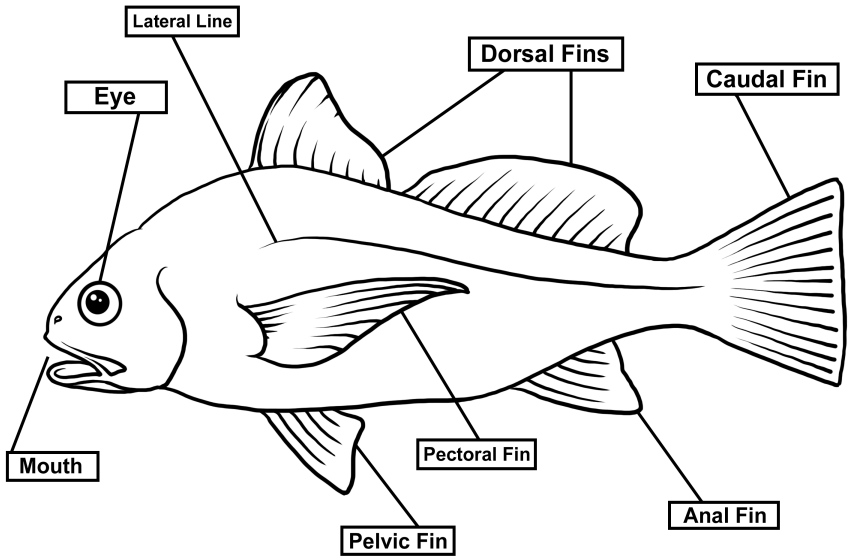
Anal Fin: *rear fin on the base of the body; functions as a stabilizing fin*

Dorsal fins: *fin(s) along the top of the body; many fish have forward and rear sets, some fish have fused dorsal fins; function as stabilizers against rolling*

Lateral Line: *system of sensory structures along the side body; functions to detect motion and vibration in surrounding water via pressure waves*

Mouth: *highly specialized for prey type; function also in eating, mating, or to pump water over the gills*

Eye: *sensory organ to detect light or images from habitat; fish eyes have rods and cones for color vision but are highly adapted within each species.*



Adaptation Matching Worksheet Answer Key

Body Shape: Most fish bodies are fusiform, meaning wide in the middle and tapered at each end. Specific adaptations to this basic blueprint provide advantages for speed or stealth. Pair these body shapes and example fish to their adapted function.

1. ___C____ Torpedo (large at front, skinny at the back) [tuna]
2. ___A____ Laterally (side-to-side) compressed [angelfish]
3. ___F____ Dorso-ventrally (top-to-tummy) compressed [catfish]
4. ___B____ Humpbacked [pink salmon]
5. ___E____ Attenuated (long body compared to diameter) [hagfish]
6. ___D____ Slender, tapering body [Grenadier rattail]

A. Rapid maneuverability in small spaces
B. Added stability in fast moving water
C. Efficient shape for sustained swimming
D. Reduced muscle mass for minimized metabolism
E. Minimized water resistance
F. Low-profile for bottom dwelling

Mouths: Mouth size, jaw orientation, and tooth shape are all adaptations which make fish specialized for a particular hunting style and prey type. Pair these adaptations and example fish with the function of their adapted jaws.

1. ___A____ Protruding lips, sucker-shaped mouth [carp]
2. ___G____ Terminal mouth (points forward from body front, equal length jaws) [mahi mahi]
3. ___C____ Mouth points up; long lower jaw [barracuda]
4. ___D____ Large round jaws [bass]
5. ___F____ Sharp serrated teeth [tiger shark]
6. ___B____ Dull, flattened plate teeth [spotted eagle ray]
7. ___H____ Teeth fused together into beak [parrotfish]
8. ___E____ Duckbill, v-shaped jaws [pike]

A. Feeds on small plants and animals
B. Crush prey in shells
C. Feeds on prey the fish looks up at
D. Gulp/ surround prey
E. Feeds on fast-moving prey, captured from side
F. Cut/ shred prey
G. Feeds in mid-water on prey ahead
H. Scrapes reefs for algae and polyps

Adaptation Matching Worksheet Answer Key (continued)

Fins: Most fish gain locomotion primarily from their caudal fins while adding stability or maneuverability from the pectoral, anal and pelvic fins. Fin size, shape and orientation are all important factors. Highly active and sedentary fish have very different adaptations. Match these fin adaptations and example fish with the function of their fin design.

1. ___F___ Rounded caudal fin [grouper]
2. ___E___ Lunate (crescent) caudal fin [swordfish]
3. ___B___ Deeply forked caudal fin [pilotfish]
4. ___D___ Elongated, reinforced pelvic fins [tripod fish]
5. ___C___ Round, high-surface area pectoral fins [clownfish]
6. __G___ Pointed pectoral fins [surgeonfish]
7. ___A___ Large, angled pectoral fins [sculpin]
8. ___H___ Continuous (fused dorsal, pectoral, caudal) fins [American eel]

A. Create drag, reduce lift in swift currents
B. Most efficient shape for non-stop swimming
C. Increase stability at slow swimming speed
D. Stable platform to keep body still for ambush
E. Most effective shape to produce speed
F. Slow swimming with short burst acceleration
G. Helpful for turning, added maneuverability
H. Locomotion in small places

Coloration: Coloration and patterns help disguise fish while hunting and from being hunted. Coloration can serve as warnings to others or lures to mates. Match these coloration trends and example fish to their adaptation function.

1. ___H___ Countershading: dark dorsal, light belly [whale shark]
2. ___A___ Disruptive coloration: spots [butterflyfish]
3. ___E___ Disruptive coloration: stripes [perch]
4. ___H___ Mottled coloration [soapfish]
5. ___C___ Muted green/brown [trout]
6. ___D___ Silver/ blue [trevally jack]
7. ___H___ Red scales [orange roughy]
8. ___B___ Bold, bright colors [longhorn cowfish]

A. Disguises fish's true orientation
B. Warning, truthful or untruthful, about toxicity
C. Difficult to see in murky/turbid waters
D. Difficult to see in well-lit open ocean
E. Disguises fish's shape in vegetation
F. Camouflage among rocks or sediment
G. Difficult to see in low light conditions
H. Defense against predation from above/below

Sensory Structures: Fish have organs and complex senses to see, smell, hear, taste, touch, and detect electrical impulses from their environment. Rainbow trout can detect chemical concentrations as low as a thimble-full of bile acids in one billion gallons of water. Most fish have a lateral line, a row of pressure and vibration sensors along their body, used in schooling, predation and orientation. Depending on habitat and lifestyle, this sensory structure and others may be specifically adapted. Match these select sensory characteristics and example fish to their adaptation function below.

1. ___F___ Magnetoreception (ability to detect magnetic fields) *[salmon]*
2. ___B___ Large eyes *[chimaera]*
3. ___H___ Chin barbels (sensory whiskers) *[saddle goatfish]*
4. ___C___ Biofluorescent skin (reflecting nonvisible light) *[catshark]*
5. ___D___ Eyes reduced to eyespots *[cavefish]*
6. ___A___ Eyes raised onto stalks *[mudskippers]*
7. ___G___ Illuminated lures (modified dorsal fin) *[anglerfish]*
8. ___E___ Movable nictitating membrane on eyes *[blue shark]*

A. Increased peripheral (all around) vision
B. Precise vision in low light
C. Communication without visibility to predators
D. Metabolic energy not spent on a non-essential sense for this habitat
E. Eyes protected while feeding
F. Ability to locate/ recognize specific locations
G. Attract prey in dark environments
H. Enhanced chemical reception in sediment

ANY FIN IS POSSIBLE | STUDENT

Learning Goals

- Explain how adaptations and physiology allow certain organisms to be successful in their environment.
- Apply the concept of natural selection to explain the traits of certain organisms in an ecosystem.
- Design a fish to be successful in an ecosystem while understanding how each structure contributes to the organism's success.

Challenge: Learn about fish adaptations and create a new fish species with the necessary characteristics to thrive in an ocean environment.

Introduction |

From the shoreline, the ocean can look like a single continuous habitat. However, under the waves, the habitats vary tremendously from warm surface waters to the deep sea, nearshore shallows to open mid-ocean. Fish have evolved to be successful in many environments through diverse and specific adaptation. An adaptation is a feature that is common in a population because it provides improved function and is produced by natural selection. Adaptations can take many forms like novel behavior or proteins that function better at specific salinity or temperature; in this lesson you'll look at anatomical adaptations that allow fish to avoid predators or access valuable new resources. Did you know there are about 22,000 species of fish that began evolving 480 million years ago? Bony fish share some features: gills for breathing, fins for motion, a mouth for eating, and most have scales for protection. However, some fish need strong muscles for constant swimming in the open ocean; other fish species are better adapted to hiding among the coral reef. Some fish have specialized mouths to eat only one food; some have modified scales as spines for defense. Remotely Operated Vehicle (ROV) *Hercules* encounters many different fish species traveling from the sunny shallows to the ocean floor, each one specifically adapted for their habitat. In this module, you will explore the variability in fish features and use your new observation skills to design and describe a new fish species. Be creative! As the ocean shows us, "any fin is possible!"

DON'T MISS PLAYLIST

Check out these exciting deep sea clips from Nautilus Live!

- **Strange Behavior: Crabs Fend off Cat Shark**: http://nautl.us/210bbFJ
- **Predation and Digestion in the Galapagos:** http://nautl.us/1VJ9f2M
- **Fish Goes Crazy in Brine Pool**: http://nautl.us/1S6S2kO
- **Creepy Ghost Shark with Parasites:** http://nautl.us/1LKlBSH

Guiding Questions |

1. What characteristics do all fish share?

2. What's the difference between anatomy and physiology?

3. List five ways fish can differ physically or physiologically based on their home habitat.

4. What environmental challenges do fish face living in extreme environments?

Materials |

- Paper
- Markers / colored pencils
- Printable fish parts or additional craft supplies for creating your fish

Procedure |

1. Define the vocabulary and fish anatomy terms.
2. Read each fish structure section and complete matching to pair adaptations with functions.
3. Using your new knowledge, design your own fish with special adaptations!
4. Complete a new species worksheet to describe the capabilities of your fish and justify your decisions in written form.
5. Share your new species with the class.

THINK About It!

What is the most unique creature you have ever seen? Discuss the following with a partner:

- What features did the creature have that made it unique?
- What do you think this creature uses its features for?
- What kind of habitat did the creature live in?
- How might the features be useful in this habitat?

Vocabulary |

1. Adaptation:
2. Anatomy:
3. Evolution:
4. Natural Selection:
5. Physiology:

Describe the function of each fish body part and label it on the fish below:

Caudal fin:

Dorsal fins:

Pectoral fin:

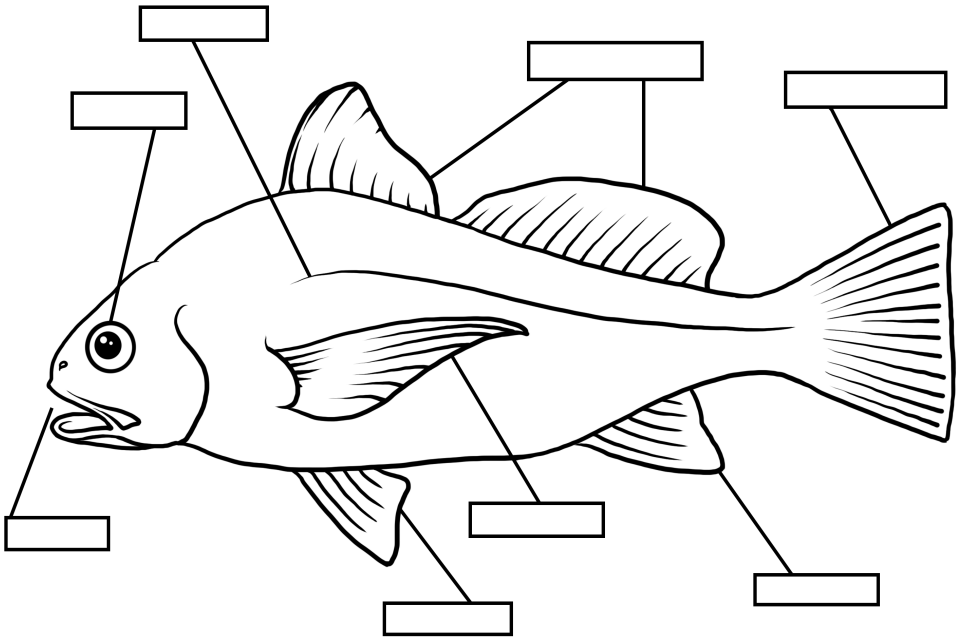
Lateral line:

Pelvic fin:

Mouth:

Anal fin:

Eye:



Adaptation Matching Worksheet

Match each fish feature and example fish to the adapted function in the section below. Use a computer to investigate the fish you are unfamiliar with.

Body Shape: Most fish bodies are fusiform, meaning wide in the middle and tapered at each end. Specific adaptations to this basic blueprint provide advantages for speed, stealth or acceleration. Pair these body shapes and example fish to their adapted function.

1. _____ Torpedo (large at front, skinny at the back) [*bluefin tuna*]
2. _____ Laterally (side-to-side) compressed [*angelfish*]
3. _____Dorso-ventrally (top-to-tummy) compressed [*catfish*]
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6. _____ Pointed pectoral fins [*surgeonfish*]	F. Slow swimming with short burst acceleration
7. _____ Large, angled pectoral fins [*sculpin*]	G. Helpful for turning, added maneuverability
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3. _____ Disruptive coloration: stripes *[perch]*	C. Difficult to see in murky/turbid waters
4. _____ Mottled coloration *[soapfish]*	D. Difficult to see in well-lit open ocean
5. _____ Muted green/brown *[trout]*	E. Disguises fish's shape in vegetation
6. _____ Silver/ blue *[trevally jack]*	F. Camouflage among rocks or sediment
7. _____ Red scales *[orange roughy]*	G. Difficult to see in low light conditions
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C. Communication without visibility to predators

D. Metabolic energy not spent on a non-essential sense for habitat

E. Eyes protected while feeding

F. Ability to locate/ recognize specific locations

G. Attract prey in dark environments

H. Enhanced chemical reception in sediment

Time to get CREATIVE- any fin is possible!

I. Use the adaptations you learned above and these guiding questions to design your own fish. Create a model or drawing of this new species.

What part of the ocean does your fish live in? Does your fish migrate, maintain a territory or live in one location? What type of prey does it hunt or forage? How does it catch those prey? What is the primary sense used to find this prey? What types of sensing organs are needed in this habitat? What predators is your fish trying to avoid? Does your fish live in schools, pairs or solitarily?

- Label each feature accurately.
- The selected features must make sense for the habitat and lifestyle of the fish.

II. Complete the New Species Description worksheet to provide justification for the adaptations you see on your fish.

New Species Description Worksheet

Common Name _____

Scientific Name _____

Discovered by _____

1. Description of the Environment:

_____
_____
_____
_____

2. Body Shape:

_____
_____
_____
_____

3. Locomotion and Fin Design:

_____
_____
_____
_____

4. Coloration:

_____
_____
_____
_____

5. Feeding Style and Mouth:

_____
_____
_____
_____

6. Special Sensory Features:

_____
_____
_____
_____

Scientific Modeling and Communication Rubric

OBJECTIVE	CRITERIA			
	4 Exemplary	3 Commended	2 Emerging	1 Developing
Evidence of Planning and Research |	Student submits thoroughly completed and accurate worksheets, documents, outlines, drafts, etc. of preliminary planning and research on topic.	Student submits completed and mostly accurate worksheets, documents, outlines, drafts, etc. of preliminary planning and research on topic.	Student submits partially completed worksheets, documents, outlines, drafts, etc. of preliminary planning and research on topic. Some information may be inaccurate.	Student submits minimally completed worksheets, documents, outlines, drafts, etc. of preliminary planning and research on topic. Information may be inaccurate.
Student Model or Product |	Adheres to all guidelines and expectations set forth. Model or product exhibits neatness, creativity and thoughtfulness in design.	Adheres to most guidelines and expectations set forth. Model or product exhibits neatness, some creativity and thoughtfulness in design.	Adheres to some guidelines and expectations set forth. Model or product exhibits some neatness, creativity and thoughtfulness in design, or these may be inconsistent.	Adheres to few guidelines and expectations set forth. Model or product does not exhibit neatness, creativity or thoughtfulness in design.
Communication of Content |	Student is able to thoroughly discuss content through use of their model/ product. Student thoroughly completes all associated follow-up worksheets, questions, reports, etc. with no content errors. Student can answer questions about their ideas using examples from what they learned.	Student is able to discuss content through use of their model/product. Student completes follow-up worksheets, questions, reports, etc. with few content errors. Student can answer questions about their ideas using examples from what they learned.	Student is able to weakly discuss content through use of their model/ product. Student completes some associated follow-up worksheets, questions, reports, etc. There may be some content errors. Student can answer rudimentary questions about their ideas.	Student is able to minimally discuss content through use of their model/ product. Student minimally completes associated follow-up worksheets, questions, reports, etc. Student has difficulty answering questions about their ideas.
Total Score: _____	**Comments:**			

How Large is Nautilus Nation?

Tracking the reach of Ocean Exploration Trust's education programs is essential in ensuring we are funded to continue making discoveries and inspiring the next generation of explorers.

Name: **My Community (City, State):**

Email Address:

School's Name:

Instruction date: **Grade level instructed:**

Subject area:

My education space is a...

- ❑ Classroom
- ❑ After school program / Club meeting
- ❑ Fair / Festival / Event
- ❑ Museum / Science Center
- ❑ Other. Tell us more:

Who did you engage in your teaching?

Students

Community Members

Select all the OET materials you used in your instruction:

- ❑ STEM Learning Modules. Which ones? _____
- ❑ Digital Resource Library materials. Which ones? _____
- ❑ Nautilus Live website: photo albums ❑ highlight videos ❑ live stream
- ❑ Meet the Team STEM mentor profiles
- ❑ Facebook (NautilusLive) ❑ Twitter (@EVNautilus) ❑ Instagram (@nautiluslive)
- ❑ Other. Tell us more: _____

_____

What made working with OET resources valuable to your instruction (select all that apply)?

- ❑ Hands-on activities ❑ STEM career connections
- ❑ Easy to use lessons ❑ Standards-based lessons
- ❑ Website resource access ❑ Real world application of curricula topics
- ❑ Excitement of cutting-edge discoveries / Unfamiliarity of deep ocean
- ❑ Another reason. Tell us more: _____

_____

Using OET resources increased my confidence in teaching my science, technology, engineering, or math subjects.	❑ Yes	❑ No
OET provided me with helpful and relevant teaching resources.	❑ Yes	❑ No
Using OET resources increased my awareness of STEM careers.	❑ Yes	❑ No
If yes, how so? How can we improve?		

Please scan this document or snap a picture of it with your phone. Email the feedback or questions to education@oet.org. You can also submit feedback online: http://nautl.us/2cp3PNu

Thank You For All You Do!