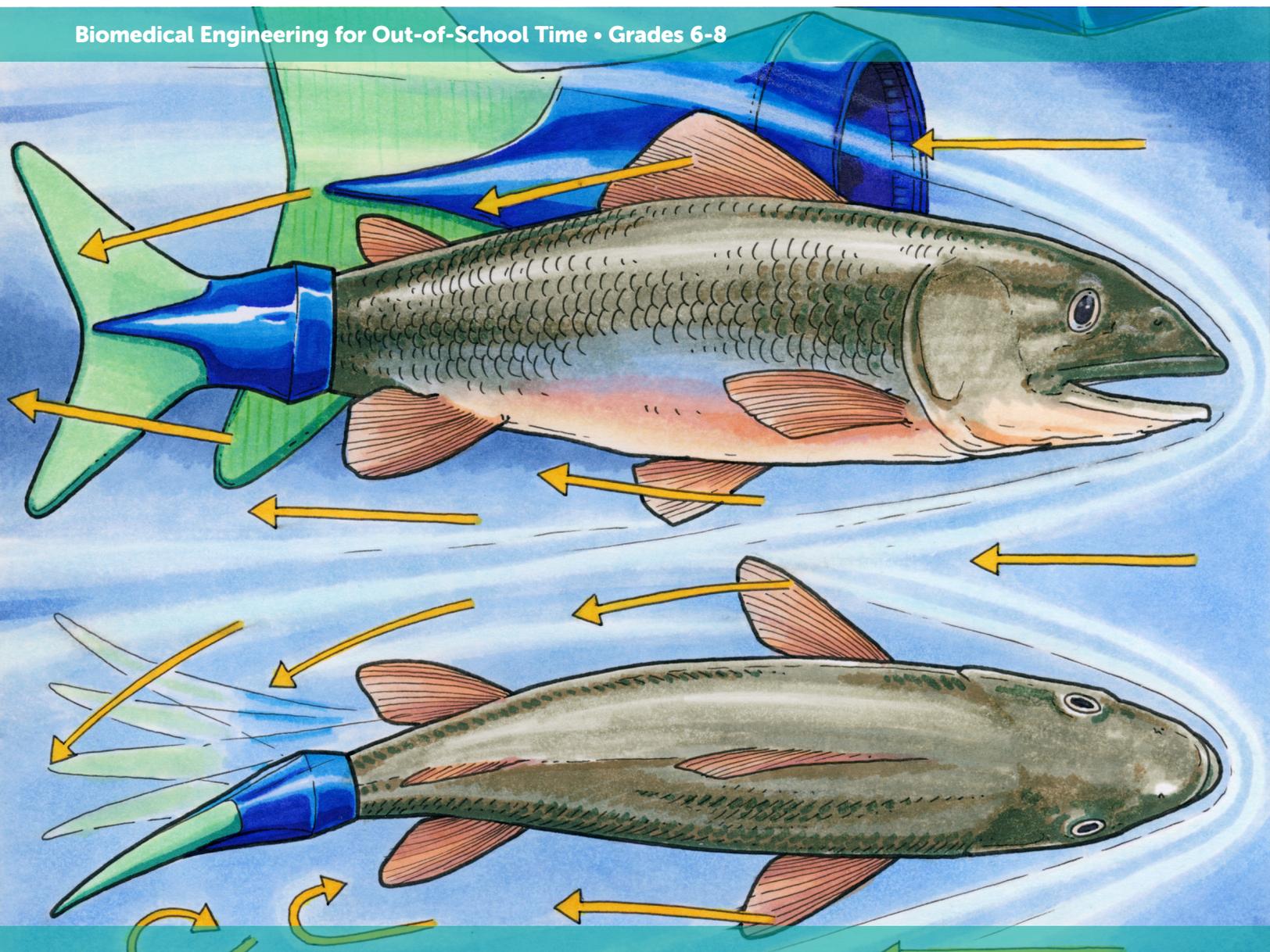


Engineering
Everywhere

Go Fish: Engineering Prosthetic Tails

Biomedical Engineering for Out-of-School Time • Grades 6-8



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Engineering is Elementary® Team

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Developed by the Museum of Science, Boston

Engineering
Everywhere

Overview: Youth will engineer a model prosthetic beak that needs to be able to perform several functions of a real bird beak.

Note to Educator: Youth will complete a second prosthetic device design challenge. Using what they learn, they will add to the *Prosthetic Devices Reference* chart. The chart and the knowledge gained during this activity will support them as they start their final design challenge in the next activity: engineering a model prosthetic tail for a model fish.

Activity Timing:

Introduction: 10 min
 Model Beak: 15 min
 Create: 25 min
 Communicate: 10 min

60 min

21st Century Skill

Highlight:

Creativity
 Collaboration

Activity 2 Materials

For the whole group

- Engineering Design Process* poster
- Prosthetic Device Reference Chart*
- small objects, such as small balls, beads, straws, pencils
- 1 roll of aluminum foil
- 10 sheets of foam
- 25 pipe cleaners
- 10 sheets of construction paper

For each group of 3

- 1 cup, 8 oz.
- 1 hole punch
- 1 marker
- 1 measuring tape
- 1 pair of scissors
- 1 roll of tape
- 2 craft sticks
- 12 strands of string, 10" each

For each youth

- Engineering Notebook

Activity 2 Preparation

1. Post the *Engineering Design Process* poster and the *Prosthetic Device Reference Chart*.
2. Set aside the materials groups will use for the beaks: cups, tape, foam, aluminum foil, construction paper, pipe cleaners, measuring tape, hole punch, markers.
3. Cut 12 strands of string, about 10" long, for each group of three.
4. Have some objects available for youth to *test* their beaks ability to pick up objects, such as small balls or beads, straws, and pencils.
5. Optional: Make one model beak base for youth to reference. See *Making the Model Beak Base*, p. 8 in the Engineering Notebook for instructions.

Activity 3 Pre-Preparation

1. Activity 3 requires extra preparation time to build the model fish. Make sure to review in advance the process and materials on *How to Build the Model Fish*, pp. 32-34 of this guide.

Notebook Pages for Activity 2

Beauty's Prosthetic Beak, p. 7

Activity 2

Beauty's Prosthetic Beak

In 2005, a bald eagle was discovered injured and scavenging for food at a landfill in Alaska. Sadly, the upper part of the bird's beak had been shattered by a poacher. The injury made it incredibly difficult for the bird to catch and eat food. For an eagle, trying to eat with half of a beak is like trying to pick something up with a single chopstick.



Eating is only one of the many important functions of a bird's beak. Birds use their beaks to preen themselves (clean and straighten their feathers) and gather materials to make nests. With a damaged beak, it would be very hard for a bird to survive in the wild.

The eagle was named "Beauty" and was relocated to a raptor rehabilitation center in Idaho where she was nursed back to health by a team of volunteers. They worked with scientists, medical specialists, and engineers to design and *create* a prosthetic upper-beak that would restore Beauty's ability to eat and take care of herself.

When the design was complete, the team enlisted the help of a dentist to attach the prosthetic device to the end of Beauty's injured beak. After the procedure was over, Beauty's recovery continued and she was soon able to feed herself and preen her feathers.

As Beauty and her injured beak continue to grow, the team will consider *improvements* to prosthetic device to make sure that she remains happy and healthy.



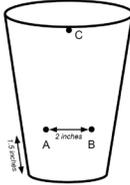
Article adapted from: Birds of Prey Northwest, *The Story of Beauty and The Guardian*, *Restoring Beauty*
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Making the Model Damaged Beak, p. 8

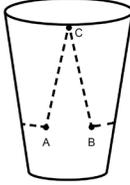
Activity 2

Making the Model Damaged Beak

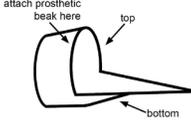
Follow the instructions below to make a model damaged beak, which you can use to *test* your prosthetic beak designs. You will need a small paper cup, a marker, a measuring tape, and a pair of scissors.



- Draw **Dot A** 1.5 inches from the bottom of the cup.
- Draw **Dot B** 2 inches to the right of **Dot A**.
- Draw **Dot C** on the rim of the cup in-between **Dot A** and **Dot B**.



- Draw a straight line connecting **Dot A** and **Dot C**.
- Draw a straight line connecting **Dot B** and **Dot C**.
- Draw a straight line connecting **Dot A** and **Dot B** around the back of the cup. Keep the line parallel to the bottom of the cup.



- Cut along the lines and keep the bottom portion of the cup. This will serve as your model damaged beak.
- Note the area on the top of the model damaged beak where you will attach the prosthetic beak that you design.

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Testing Your Beak: Preening, p. 9

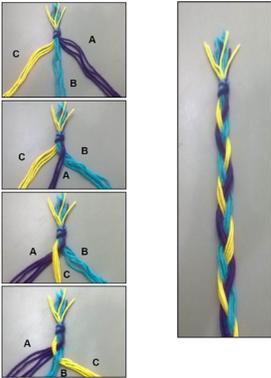
Activity 2

Testing Your Beak: Preening

To see if your prosthetic beak can preen, you will need to undo and straighten strings that have been braided.

Make Your Braid

- Cut 12 pieces of string, each about 10 inches long.
- Tie a knot at one end of all the strings.
- Divide the string into three groups (four pieces of string each).
- Take A (the string on the right) and cross it over B.
- A should now be in the middle.
- Take C (the string on the left) and cross it over A.
- C should now be in the middle.
- Take B (the string now on the left) and cross it over C, so it is in the middle.
- Continue this pattern until you've braided the whole length of the strings.



Test Your Prosthetic Beak
On the line below, rate how well your prosthetic beak separates the strands of the braid.

10 ————— 5 ————— 1

It easily separates the whole braid It can separate some strands It cannot separate any strands

Improve Your Prosthetic Beak
What *improvements* might you make in order to better separate the braid?

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Testing Your Beak: Picking Up, p. 10

Activity 2

Testing Your Beak: Picking Up

To see if your prosthetic beak can help a bird eat, you will need to be able to pick up small items.

Test Your Prosthetic Beak

Try picking up many different items with your prosthetic beak and list your findings below.

Item	Can you pick it up?	Notes
	<input type="checkbox"/> Yes <input type="checkbox"/> No	
	<input type="checkbox"/> Yes <input type="checkbox"/> No	
	<input type="checkbox"/> Yes <input type="checkbox"/> No	
	<input type="checkbox"/> Yes <input type="checkbox"/> No	
	<input type="checkbox"/> Yes <input type="checkbox"/> No	
	<input type="checkbox"/> Yes <input type="checkbox"/> No	
	<input type="checkbox"/> Yes <input type="checkbox"/> No	
	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Improve Your Prosthetic Beak
What improvements might you make to your prosthetic beak design to better pick up various objects?

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Youth will learn:

- a prosthetic device is designed to function like the body part it is replacing.
- engineers use the Engineering Design Process when designing prosthetic devices.
- they are engineers!

Tip: Have youth identify the professions of all of the people who helped engineer Beauty's beak (engineers, volunteers, scientists, medical specialists, dentists). Point out that engineers often work with people with all sorts of expertise when completing their designs.

Tip: After youth make their model beaks, have them try using it to pick up objects. This will help them see firsthand how difficult it would be for a bird to function with just the lower half of its beak.

Introduction (10 min)

1. Remind youth that engineers have *created* prosthetic devices for many different types of animals and for the next hour they are going to be engineering a model prosthetic beak for an eagle.
2. Explain that this challenge is based on a real engineering problem involving a bald eagle named Beauty from Alaska. Have youth read the article *Beauty's Prosthetic Beak*, p. 7 in their Engineering Notebooks. Ask:
 - **What part of Beauty's body was injured?** *The upper-part of her beak.*
 - **What did the prosthetic beak allow Beauty to do?** *Eat and preen herself.*
3. Have youth refer to the *Prosthetic Device Reference Chart*. Ask:
 - **Which factors do you think the engineers kept in mind when designing the prosthetic beak?** *They focused on restoring the function of her beak and making it so that it could be attached by a dentist.*
4. Have youth add notes to the "Solutions" column of the *Prosthetics Devices Reference Chart* to describe how each criteria was achieved in the design of Beauty's prosthetic beak. Remind youth they will add to this chart as they encounter additional animals with other engineered prosthetic devices.

Making a Model Beak (15 min)

1. Explain that today youth will engineer a prosthetic device to help restore a model of a damaged beak just like Beauty's.
2. Show youth the template on *Making the Model Damaged Beak*, p. 8 in their Engineering Notebooks. These are the steps they will follow to create the model of the damaged beak. After making this model, youth will design their prosthetic devices to restore the upper part of the beak.
3. Separate youth into groups of three and have them follow the directions to make their model damaged beak.

Create and Test (25 min)

1. Before groups begin engineering model prosthetic devices for their model damaged beaks, discuss the two *tests* they will use to

evaluate their designs, outlined on *Testing Your Beak*, pp. 9-10 in their Engineering Notebooks:

- One function of the beak is to help birds preen themselves. Youth will see if the model prosthetic beaks they design can unravel string that has been braided.
 - Another function of a beak is to allow birds to pick up pieces of food. Youth will *test* to see if the model prosthetic beaks they design are able to pick up small objects.
2. Show youth the materials they will have available to engineer their model prosthetic beaks. Tell youth that because Beauty's beak was attached with an adhesive, they may use tape to attach their model prosthetic beaks directly to the model damaged beak.
 3. Encourage groups to *imagine* their prosthetic beaks. Just like in Beauty's case, groups should try to design a prosthetic beak that restores function to the beak. Ask:
 - **What functions or tasks might our prosthetic beaks need to be designed for?** *Eating, preening, picking things up.*
 4. Tell youth they will have 25 minutes to engineer.
 5. As groups are working, circulate and check in on their progress. Ask:
 - **What materials are you choosing to create your prosthetic beak?**
 - **What shapes do you think will help you best complete the tests?**
 6. Groups should record their test results on *Testing Your Beak*, pp. 9-10 in their Engineering Notebooks.
 7. Let youth know at regular intervals how much time they have left to engineer.

Communicate (10 min)

1. Have groups place their beaks around the room. They should display their *test* results from Engineering Notebooks, pp. 9-10, along with the braid and a small object their beak can pick up.
2. Give youth a few minutes to observe and *test* other groups' beaks.
3. After having seen the work of other groups, give youth a few minutes to reflect on possible improvements to their own designs on the bottom of *Testing Your Model Beak*, p. 10. Ask:
 - **What materials and shapes worked best in your design?**
 - **What would you need to change if you were designing a beak that could crack nuts?**
 - **How would you improve your design?**
 - **What steps of the Engineering Design Process did you use as you engineered your prosthetic beak?**
4. Explain that youth will have the chance in the next activity to apply all they have learned about prosthetic devices as they engineer a prosthetic tail for a model fish.

Note: The next activity requires extra preparation time to build the model fish. Make sure to review in advance the process and materials on *How to Build the Model Fish*, pp. 32-34 of this guide.