# 8 Investigating Biomechanics

LABORATORY

1–2 CLASS SESSIONS

## ACTIVITY OVERVIEW

### NGSS CONNECTIONS

As they dissect a chicken wing, students explore the biomechanics of the muscles and tendons that allow natural movement in birds and in vertebrates. They apply this information to construct a diagram of a chicken wing and to explain its structure and function. Students are introduced to the concept of *biomimicry*, a popular engineering approach that leads to a more limited, but often successful, solution.

### NGSS CORRELATION

#### Performance Expectations

*Working toward MS-ETS1-4*: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

#### Disciplinary Core Ideas

*MS-ETS1.A Defining and Delimiting Engineering Problems*: Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.

*MS-LS1.A Structure and Function*: In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.

*MS-ETS1.B Developing Possible Solutions*: Models of all kinds are important for testing solutions.

#### Science and Engineering Practices

*Developing and Using Models*: Develop and/or use models to describe and/or predict phenomena.

*Constructing Explanations and Designing Solutions*: Construct an explanation that includes qualitative or quantitative relationships between variables that predict or describe phenomena.

*Connections to Nature of Science*: Scientific knowledge is based on logical and conceptual connections between evidence and explanations.

### Crosscutting Concepts

*Structure and Function*: Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

## INVESTIGATIVE PHENOMENA AND SENSEMAKING

Scientists and engineers use technologies. Technologies are often developed by engineers and scientists.

Students engage in sensemaking as they model the basic mechanics of motion in the body by dissecting a chicken wing. They use their laboratory results to make sense of how opposing muscle groups contribute to movement in birds and in vertebrates. Making sense of the external structure of a chicken wing will be useful to them in the subsequent design activity.

## WHAT STUDENTS DO

Students explore how the mechanics of motion are accomplished in a chicken wing. They explore the similarities and differences between a chicken wing and a human arm or hand. They discover that to move parts of the wing in opposing directions, two tendons are necessary, Students compare the internal structure of a chicken bone to their designed prototypes from the "Artificial Bone Model" activity.

## MATERIALS AND ADVANCE PREPARATION

- *For the teacher*
  - 1 Scoring Guide: DEVELOPING AND USING MODELS (MOD)
  - * 1 plastic tub filled with diluted bleach solution (3/4 cup of bleach per gallon of water)
  - * 1 plastic garbage bag (that can be tied shut or closed with a twist-tie) per class

- *For the class*
  - * 1 refrigerator for storing chicken wings
  - * access to sinks with hot running water and soap
  - * 1 pair of pliers (optional)

- *For each pair of students*
  - 1 toothpick
  - * 1 raw chicken wing

- * 1 medium or large pair of pointed dissection scissors
- * 2 pairs of forceps
- * 1 dissecting tray
- * paper towels
- * 1 hand lens (optional)

- *For each student*
  - 1 Scoring Guide: DEVELOPING AND USING MODELS (MOD) (optional)
  - * 1 pair of gloves (optional)

* *not included in kit*

The DEVELOPING AND USING MODELS (MOD) Scoring Guide can be found in the Assessment tab in the back of this Teacher Edition.

Check the rules about dissection in your school district. It may be necessary to send permission slips home before performing this activity or to provide an alternative activity for students who object to dissections. If you do not have adequate facilities for students to wash their hands with soap and hot running water, the activity should be done as a demonstration for students in groups of four to eight.

Obtain dissecting trays before the activity begins. You can use, for example, the foam trays in which meat is packaged at supermarkets.

Purchase the chicken wings just before doing the activity. Keep them refrigerated between sessions. Try the dissection ahead of time, both to familiarize yourself with the process and to have a model to show students.

If you are providing the optional gloves for the dissection, provide latex-free gloves if there are students in the class who are allergic to latex.

## SAFETY NOTE

During the dissection, it is extremely important to prohibit food and drink in the classroom.

Students should keep hands and laboratory equipment away from their faces and wash their hands thoroughly with soap and hot water after having touched raw chicken. Even if students wear gloves, they should wash their hands thoroughly after discarding the gloves. Students should also wash their hands thoroughly before they record their observations in their science notebooks. Circulate around the room with a large garbage bag to remove the chicken wings when students finish their observations.

Dissecting tools and trays should be thoroughly washed in hot soapy water and then disinfected for about 5 min in a solution of 1/4 cup bleach per gallon of lukewarm water.

Dissection scissors are sharp and must be used with caution. Standard scissors, especially small ones, may be used instead of dissection scissors, but the dissection will be more challenging.

## TEACHING SUMMARY

#### GET STARTED

1. Students consider different engineering approaches.
   a. Ask students what they think inspires people to create new designs.
   b. Tell students that they will dissect chicken wings in this activity as a model of human movement.

#### DO THE ACTIVITY

2. Students conduct the dissection of a chicken wing.
   a. Review the safety precautions for this activity.
   b. In Part A, provide an opportunity for students to identify parts of the wing.
   c. In Part B, support students in dissecting the wing.
   d. Students continue to explore the wing as they complete the Procedure.
   e. Clean up the dissection.

#### BUILD UNDERSTANDING

3. Students draw conclusions about opposing muscle groups.
   a. Help students figure out the biomechanical motion of the wing.
   b. (MOD ASSESSMENT) Review students' diagrams of the chicken wing.
   c. Leverage student's prior knowledge and experiences related to the phenomena of biomechanics.
   d. Relate the activity results to the biomechanics of all vertebrates.

# TEACHING STEPS

## GET STARTED

1. Students consider different engineering approaches.
   a. Ask students what they think inspires people to create new designs.

      After providing a few minutes for students to jot down their own ideas in a notebook, brainstorm with the class a list of motivations for engineers trying to create a new design. Accept all responses. Make sure that the discussion includes the following drivers:

Helping others

Lowering costs

Improving performance

Overcoming challenges

Making money

Finding new solutions

Improving efficiency

Ask students to think about how they might go about coming up with new ideas to solve a problem. One way is to look at the structure and function of what they are designing. Sometimes engineers use an approach to design called *biomimicry*. In biomimicry, designers are inspired by the natural structures they see around them, and they use those principles to develop new designs. A simple example is novel adhesives modeled after the grippy fingers of geckos.

b. Tell students that they will dissect chicken wings in this activity as a model of human movement.

The forearms of birds and humans evolved from a common ancestor and share many structural features, although each has evolved for its own particular functions. Explain that by figuring out how the parts of a bird's wing move relative to each other, students will better understand the biomechanics of motion, which will help them in their final design project. If appropriate, discuss how the tissues that make up the system in the wing are specialized for particular body functions.

*Teacher's Note:* This activity helps students connect the process of design to the life science content in the SEPUP middle school unit *Body Systems*. See this unit for more activities on body systems.

## DO THE ACTIVITY

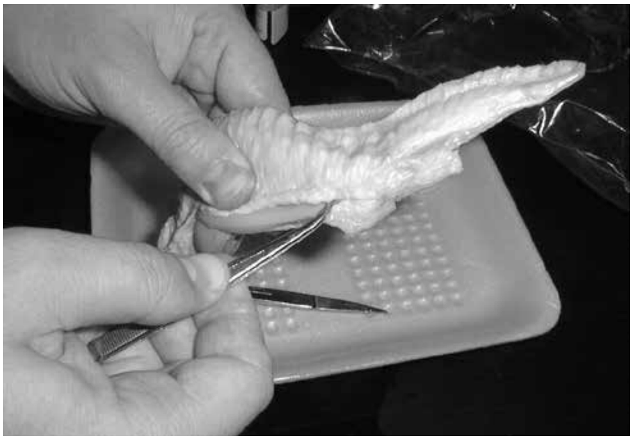
2. Students conduct the dissection of a chicken wing.

a. Review the safety precautions for this activity.

Use the Safety Note in this Teacher Edition and in the Student Book to instruct student behavior during the dissection. Remind them that only one student should be engaged in cutting at any one point. The other partner should be watching, making observations, or recording evidence.

b. In Part A, provide an opportunity for students to identify parts of the wing.

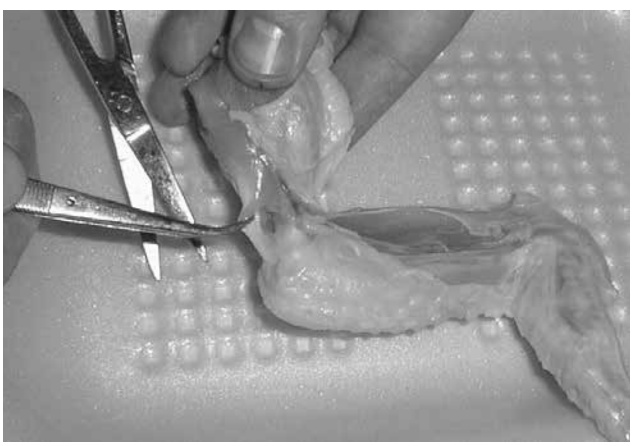
Before they begin cutting, students should examine the wing to identify how it moves. Encourage them to discuss how the wing and the arm are similar and different.



*Pulling on this tendon moves the "hand" in the opposite direction as the tendon.*

c. In Part B, support students in dissecting the wing.

The photos in the Student Book show the location of the tendons that students are likely to locate. The first is the tendon opposing the "wrist" tendon; the other two are the opposing tendons located at the "elbow" joint, as shown in the following photos.



*Pulling on this tendon moves the "hand" in the opposite direction from the tendon.*

As students perform Procedure Step 7, point out that letting go of the tendon does not cause the wing to straighten out. Instead, students must pull on the tendon attached to the opposing muscle to get the wing to become straight. Help students understand that vertebrates' motion is accomplished by opposing muscles attached to the bones by tendons. For example, the biceps muscle moves the arm in one direction, and the triceps muscle moves it in exactly the opposite direction. You may also wish to have students dissect the skin away from the elbow joint and then try to twist the joint between the upper and lower wing. They will notice that a piece of white tissue, called a *ligament*, attaches the bones at the joint. Lastly, it may be useful to suggest that students compare the range of motion of the parts of the chicken wing to the range of motion of their own arms. This investigation of the motion of the wing supports the crosscutting concept of *structure and function*.

d. Students continue to explore the wing as they complete the Procedure.

As needed, assist students in breaking the bone. They may use pliers, if their fingers are not strong enough. As they probe the matrix-like structure of the marrow inside the bone with a toothpick, explain that the marrow is a soft, fatty tissue that contains developing blood cells. If hand lenses are available, students can use them to magnify the interior of the bone.

e. Clean up the dissection.

Make sure that students complete the dissection and clean up before recording their observations in their science notebooks. Collect the discarded dissected parts, and securely close the bag.

## BUILD UNDERSTANDING

3. Students draw conclusions about opposing muscle groups.

a. Help students figure out the biomechanical motion of the wing.

Have students share their observations from the dissection. Allow students to work in small groups to make sense of and summarize their findings. Students should report that pulling on tendons engaged the muscle on that side of the bone. The tendon, however, could not be pushed back out. Instead, the opposing tendon and muscle group on the other side of the bone had to be pulled. Students may have also observed that the range of motion of the parts of the chicken wing was similar to the range of motion of their own arms.

b. (MOD ASSESSMENT) Review students' models of the chicken wing.

Teacher Resources

SEPUP Scoring Guides

Analysis item 2 in this activity can be assessed using the DEVELOPING AND USING MODELS (MOD) Scoring Guide. Students' diagrams of how forces on the chicken wing tendons contribute to wing motion is a biomechanical model. A sample Level 4 response is provided in Sample Responses to Analysis.

c. Leverage student's prior knowledge and experiences related to the phenomena of biomechanics.

Analysis item 1 asks students to use their prior knowledge and personal experiences to compare the biomechanics of a chicken wing to human arms. Analysis item 4 asks students to leverage what they learned in the dissection to their prior experience developing the model for the "Artificial Bone" activity.

d. Relate the activity results to the biomechanics of all vertebrates.

Explain to students that this biomechanical way of moving—with opposing muscles attached to bones by tendons—is the same in humans and all vertebrates. Ask students to generate an example. One is the human arm where the biceps muscle moves the arm in one direction and the triceps muscle moves it in exactly the opposite direction. Discuss how this scientific principle could limit designs of devices that imitate human movement, such as the prostheses explored earlier in the unit.

## STRATEGIES FOR TEACHING DIVERSE LEARNERS

Below are suggestions for differentiating instruction and assessment in this activity for diverse learners in your classroom:

- Students with learning disabilities: Provide a premade diagram of the chicken wing for students to label as they conduct the dissection.
- English learners: Provide a video or the LABsent video to accompany and help clarify the directions.
- Academically gifted students: Assign students the task of investigating all the opposing muscle groups in the human body.

## SAMPLE RESPONSES TO ANALYSIS

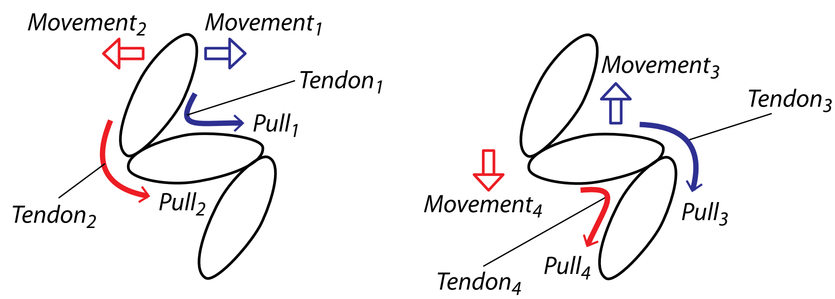
● ● 1. How are human arms and chicken wings similar? How are they different?

*Human arms are similar to chicken wings in that their parts move in two directions and they have both elbow and wrist joints. Both arms and wings use the same kind of muscle-tendon-bone system to accomplish movement of the entire structure. They are different in that chickens do not have obvious fingers but, instead, have a webbing of skin that feathers attach to.*

2. (MOD ASSESSMENT) What evidence did you find that would help to explain how birds move parts of their wings back and forth? Draw a diagram showing muscles and tendons to help explain your answer.

**SAMPLE LEVEL4 RESPONSE**

*The dissection gave evidence that the muscles are attached to bone by tendons because we could observe that. We saw that when we pulled on one tendon, the wing moved in one direction. When we pulled the tendon on the other side, the wing moved in the other direction. This is how the mechanics of the wing worked, because the tendons* *did not push the wing back. For the wing to move back, the opposing tendons had to be used. So, the motion of a wing is the result of alternating pulls on these tendons, probably by muscles.*




3. Describe how the structure of bird bones allows them to be both lightweight and strong.

   *The hard outside shell of bone paired with the light inside decreases their weight while increasing their strength. The cylindrical shape also provides strength.*

4. Now that you know the internal structures of bird bones, would you change your bone prototype from the "Artificial Bone Model" activity? If so, describe how and why. If not, explain why not.

   Students' responses will likely vary. A sample response is shown here:

   *Now that I have seen the bone marrow inside a real bone, I think I would use stuffing throughout the artificial bone prototype because our group did not use any.*

### REVISIT THE GUIDING QUESTION

How does the structure of an arm or wing affect its function?

The structure of the chicken wing completely affects its function because the structures inside the wing, such as the tendons and muscles, dictate how the wing moves. The same is true for humans: Our structure determines how the muscular system moves the body.

## ACTIVITY RESOURCES

### KEY VOCABULARY

**biomimicry**

function

structure

**tendons**