



## Outreach Lesson Plan

### 1. Pet Rescue

Help rescue a beloved pet trapped in a pipe! In this design challenge activity students will explore how structure relates to function as they design devices to save Fido.

**Grade Levels:** 4-8

#### Educational Outcomes:

1. Students will understand how “form” relates to “function” in nature, in their created devices, and how the two are similar. In particular, students will relate “form and function” of their device to things found in everyday life, from bones and muscles to construction equipment.
2. Students will gain hands-on experience with the process of design including the stages of investigation, creation, and reflection.
3. Students will be able to articulate the steps in their design process, identify the challenges presented by their designs, and how they met and ultimately solved those challenges.

**Estimated Time:** ~ 60 minutes (**note:** timing may be extended, depending on age of students and complexity of solutions)

- Introduction and Materials 10 minutes
- Class brainstorm 5 minutes
- Design Challenge
  - Building 20 minutes
  - Sharing 10 minutes
- Discussion 10 minutes
- Clean-up & Evaluations 5 minutes

**\* It is highly encouraged, when time permits, to allow students the opportunity to redesign their devices (perhaps the following day).**

#### California State Science Standards Connections:

**Grade 7 – Life Science:**

##### Structure and Function in Living Systems

- Students know how bones and muscles work together to provide a structural framework for movement.

##### Physical Principles in Living Systems

- Students know how to compare joints in the body (wrist, shoulder, thigh) with structures used in machines and simple devices (hinge, ball-and-socket, and sliding joints).
- Students know how levers confer mechanical advantage and how the application of this principle applies to the musculoskeletal system.

**All grades – Investigation and Experimentation:** Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations.

#### ITEA (International Technology Education Association) Standards Connections:

##### Design:

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

##### Abilities of a Technological World:

- Standard 11: Students will develop abilities to apply the design process.

##### The Designed World:

- Standard 20: Students will develop an understanding of and be able to select and use construction technologies.

#### The Tech Museum Connections:

**Communication Gallery** - Home Again Recovery System (<http://www.SPAH.com>)

**Life Tech Gallery – Med Tech:** Keyhole Surgery (<http://www.thetech.org/exhibits/subgallery.cfm?id=54>);

**The Transparent Body:** Visible Human (<http://www.thetech.org/exhibits/subgallery.cfm?id=55>)

**IMAX Films** - Human Body and Space Station (<http://www.thetech.org/imax/#HB>)



## 2. MATERIALS AND SET-UP

### Student teams

Students will work in teams of 2-4.

### Design Challenge materials for pet retrieval:

*Note:* This list is not meant to be exhaustive. The goal is to provide students with a variety of materials with which to construct their devices.

Tape	Basswood	Clothespins
Hot glue	Sticks/strips	Spools
Craft glue	Pipe cleaners	Foam Core
Brads	Strawberry baskets	Binder clips (all sizes)
String	Plastic/paper cups	Paper clips
Rope	Plastic bags	Rubber bands
Wire	Plastic spoons	Clay or play-dough
Craft sticks	Springs	
Dowels	Foam pieces	

### Tools:

Scissors	Craft knife
Glue guns (set up a glue station?)	Cutting mat
Craft stick punch	Masonite board
Saws	

### Materials for Design Challenge scenario (pet in pipe)

Pet: squeaky dog toy, 4-6 inch stuffed animal, something along those lines

Pipe: big cardboard tube (at least 5-7 inches in diameter—large enough for animal)

Flashlight to see into the pipe

### Student Research Station & Demo Station:

Beach toys, buckets and shovels.

Supply models of joints, arms, legs, hands, and other body parts for students to construct analogies to living systems.

Robot arms

Skeleton

Construction equipment toys

Toys that help you reach things – i.e., a grabber

Provide pictures of animals (or other examples found in nature) that relate form to function. For example the giraffe's long neck means they can eat leaves high in the canopy and birds' beak shape relates to what they eat.

### Visual aids:

Elaborate on the "lost pet" scenario. Before class put up "lost pet" posters with pictures and vital information about the pet. Include information about size, color, gender, etc. without students seeing and handling the pet first-hand while they are building.



### 3. LESSON PLAN

#### Introduction to Concept

Today we're going to be talking about "form and function". That is, how things are designed, made or evolve is important to determining how they are used. This is an important concept in both the designed and natural worlds. (*Use toys as examples, maybe construction equipment or "grabber, and then make shift to body parts. What is your hand used for?*) Are there "neat" design features that you can recognize that make those functions easier?

Today you are going to design a device to help solve a problem. As you work on this problem keep an eye out for how form and function work together.

#### Design Challenge

**Scenario:** Your beloved pet (cat, dog, snake, etc.) has escaped from your house and has been missing all afternoon. You've looked in all her favorite hiding spots – under the house, in the neighbor's garage, in the bushes behind your house – and you still can't find her. Dejected, you wander through the neighborhood hoping against all hope that you'll find her. Suddenly you hear her small, soft voice (meow, bark, hiss, etc.??). After looking around frantically, you realize she has fallen into, and is trapped inside, a pipe. You try with all your might, but you can't reach her!

**Challenge:** Create a device that you can use to rescue your pet from the pipe.

#### Constraints

- The device must be able to gently remove the animal from the pipe. You wouldn't want a device that would injure the animal!
- You may not damage the stuffed animal during the rescue (i.e., no skewered pets!).
- You may not destroy the pipe – it must remain intact.
- When you demonstrate your device to the class (and rescue the pet!), you will be asked to make analogies between the design of your device and designs found in nature (body parts, joints, methods and structures related to carrying and lifting, etc.)
- You may only use the materials available.
- A minimum of two team members must work together during the operation of the device.
- The team members operating the device must stand at least 3 ft. away from the pipe (outside the safety perimeter).

#### Modifications for younger kids

- First stage: let them stand right next to the pipe. When they successfully remove the pet, ask students to modify their device so that they can stand further away.

#### Testing

You will **not** be allowed to test your device on the actual stranded pet until the appointed rescue opportunity.

#### Notes for Teacher/Facilitator

- **Functions of bones and the skeletal system** - give structure and shape to the body, point of attachment for muscles/ligaments, protect internal organs, store minerals (such as calcium), and produce blood cells.
- The shapes of different bones are related to the amount of force they must withstand. For example, the bones of the lower extremities are the heaviest, largest, and strongest bones in the body because they must bear the entire weight of the body when a person is standing in the upright position.
- The place where two bones meet is called a **joint**.
- Types of **moving joints**: hinge joint and ball and socket joint.
- **Hinge joint**: like the hinges on a door; found in elbows and knees, also found in fingers and toes. Can only move in one direction.



## Teaching Points to guide Facilitator's Questions:

Content: Structure and Function in Living Systems

- Bones (or our skeletal system) are the structural supports for our bodies.
- Joints can move our bones in a variety of directions, depending on their structure.
- Muscles are important for moving our bones.
- Muscles can only pull; they cannot push.
- The shapes of different bones are related to the amount of force they must withstand.
- You can also discuss other structures/"forms" and their related function that is similar to the body.

## Facilitators' Questions

- Which parts of your device provide support for another part of the device?
- What would your device look like without the structural support?
- Which parts of your device move? How are they attached to the structural (support) parts?
- How many directions can your moving parts turn, twist, bend, or move?
- Which parts of your body does your device mimic as it is used to reach the pet? Are there parts that extend or reach? Parts that rotate? Parts that bend? Parts that swivel?
- Are there any parts that act in ways that your body cannot? How do they work?
- How did you design the part of the device used to retrieve the pet? What were the things you considered in the design?

## Demonstration

Students will "try out" their device. If students have not completed their device, ask them *how the device would have worked*.

- When you demonstrate your device to the class (and rescue the pet!), you will be asked to make analogies between the design of your device and designs found in nature (body parts, joints, methods and structures related to carrying/lifting, etc.)
- A minimum of two team members must work together during the operation of the device.
- The team members operating the device must stand at least (to be determined by instructor) ft. away from the pipe (outside the safety perimeter).

## Reflection (see also Facilitator questions above)

- Would you be able to use this device on a live animal? Why or why not? If not, what types of changes would you need to make?
- If you were going to build a robot that could rescue pets from a pipe, what things would you consider? What types of things would you want to include? What forms would you design for the associated functions?
- If we wanted to classify (organize) all the devices that the class made, how would you group them? What are some features that many devices have in common? What are features that make them different? How are different combinations of all these "forms" used for the same ultimate "function" (rescuing the pet)?

## Notes for Teacher/Facilitator

- **Ball and socket joint:** One bone has a round end that fits into a cup-like structure in the second bone of the joint. Found in shoulders and hips; can move in all directions.
- **Muscles** help you move. Muscles can only pull, not push; they often work in pairs so they can pull in opposite directions.
- Muscles are connected to bones by **tendons**.
- Ligaments connect bones to each other.



## Closure

### Discussion:

Review what was learned. Mention that scientists and engineers go through this Design Challenge process on a daily basis, learning from their mistakes and reflecting and improving upon what they have already designed.

Specifically, review form and function and how they are related. Tell students to keep a close watch for design ideas – why do you think things are built/made/designed/evolve the way they are? There's probably a good reason – and it has to do with function!

### Cleanup

Reduce! Reuse! Recycle! Anything we can re-use, please put back in the appropriate basket or tub. Students may keep their devices (with teacher's permission). If not, disassemble the devices and recycle as many of the materials as possible.

### Evaluations for classroom design challenge(s):

**Rubric:** We recommend the use of rubrics in evaluating Design Challenge. Before you do this challenge, design a rubric and share the elements with your students. You may already be using rubrics as a grading method, or you may be new to this method of evaluation. In either case, the Rubistar website (<http://rubistar.4teachers.org>) is a wonderful resource and tool for all teachers implementing rubrics.

**Student self-reflection:** To gain insight into each student's sense of how his or her team solved the problem, ask individual students to write a reflection from his or her perspective on the experience. Sample writing prompts that could be asked are:

- What was your role in the project?
- How did your team come up with its solution?
- What was something that challenged your team?
- How did you overcome this challenge?
- If you had more time, what changes would you make in your design?

**Peer assessment:** Have students write a short assessment of their peers' projects based on the rubric that you design.



## 4. INSTRUCTOR RESOURCES

### Glossary & Concepts

- **Functions of bones/skeletal system:** give structure and shape to the body, point of attachment for muscles and ligaments, protect internal organs, store minerals such as calcium, and produce blood cells.
- The shapes of different bones are related to the amount of force they must withstand. For example, the bones of the lower extremities are the heaviest, largest, and strongest bones in the body because they must bear the entire weight of the body when a person is standing in the upright position.
- The place where two bones meet is called a **joint**.
- Types of moving joints: hinge joint, ball and socket joint.
- **Hinge joint:** like the hinges on a door; found in elbows and knees, also found in fingers and toes. Can only move in one direction.
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- **Muscles** help you move. Muscles can only pull, not push; they often work in pairs so they can pull in opposite directions.
- Muscles are connected to bones by **tendons**.
- Ligaments connect bones to each other.

### Resources

- Real-life connections for the rescue: July 2002 miners trapped in a mine in PA.
- Information about lost pets (<http://www.petrescue.com/library/find-pet.pdf>), especially safety concerns about posting announcements, as well as potential “scams”
- Human Body IMAX film teacher’s guide  
<http://www.thehumanbodyfilm.com/teachers/teachers.html>
- The Human Body Module from FOSS

### Content Background Information (when needed)

- Make it work: Body by Andrew Haslam. World Book, Inc., Chicago, IL (1997). A visually appealing book about systems in the body, including fun pages on the skeleton, joints, and muscles, among others.
- Quick facts about the skeletal system:  
(<http://yucky.kids.discovery.com/flash/body/pg000124.html>)
- Quick facts about the muscular system:  
(<http://yucky.kids.discovery.com/flash/body/pg000123.html>)
- General information on the skeletal system:  
(<http://emuseum.mnsu.edu/biology/humananatomy/skeletal/skeletalsystem.html>)
- Space Station Extravehicular Activity: Robotic arms and more!  
(<http://spaceflight.nasa.gov/station/eva/robotics.html>)
- Weekly updates from the International Space Station  
(<http://spaceflight.nasa.gov/spaceneeds/reports/issreports/2002/index.html>)
- Effects of space flight and/or long-term stays in space on the musculoskeletal system.  
(<http://www.marsacademy.com/med1.htm>)

### Post Activities

Travel Brochure of the Body Systems from Access Excellence  
<http://www.accessexcellence.org/MTC/96PT/Share/cascio.html>  
Geared toward older grades, but easily adaptable to middle school.