THE ROBOT ZOO

EDUCATOR'S GUIDE

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The Robot Zoo Book

Conceived, edited and designed by

Marshall Editions, London, England

The Robot Zoo Exhibit

Produced by BBH Exhibits, Inc., San Antonio, Texas

with support from Silicon Graphics, Inc.

and TIME magazine

The Robot Zoo: A Teacher's Guide

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Introduction

Welcome to the wonders of Robot Zoo, a traveling exhibit based on the book by the same name and developed by BBH Exhibits, Inc., in San Antonio, Texas, with sponsorship from Silicon Graphics, Inc., in Mountain View, California, and Time magazine, New York.

Robot Zoo is a study of the form and function of real animals through their biomechanical counterparts—robots. The history of robots is fairly recent. Robots are machines with programmable computers. The word "robot" came from the Czech author Karel Capek in his play R.U.R., written in 1920. In the play, non-human workers were called robots. The first "real" robots appeared in the 1930s. Electro and his dog Sparko, the earliest electric-powered robots, were created in 1939 for the New York World's Fair.

In Robot Zoo the "animals" are mechanical, programmable robots displayed in the context of their habitats. On display you'll see a bat, chameleon, giraffe, grasshopper, house fly, platypus, rhino and giant squid. The robots in Robot Zoo show the amazing mechanics of living things (called biomechanics). From Robot Zoo you and your students can explore ecology, biology and the branches of physics and engineering which comprise mechanics. The purpose of this Teacher's Guide is to enhance your class' visit to Robot Zoo. The activities are multidisciplinary and can easily be integrated into your curriculum to enhance and enliven your current lesson plans.

To help guide you we have placed preparatory or pre-visit activities early in this guide. We've also included one activity that focuses on some of the animals on display in Robot Zoo. You can use these as part of pre-visit or post-visit lessons. Activities that require a bit more knowledge or that can be used to assess students' learning have been placed at the end of this guide. You can follow this sequence or just use the activities that fit your students and your needs. The glossary and list of references at the back of the book may be helpful when planning your Robot Zoo adventure.

Enjoy!

Suggested Pre-Visit Activities

Animal Shapes

life sciences,
language arts

SUBJECTS

3 - 8

GRADES

life's diversity

CONCEPTS

one class period

DURATION

OBJECTIVE

Students will learn that... living things have different structures to support their bodies.

Background Information

Almost all animals have a skeleton, the organ system that supports the body, provides shape and helps animals move. But not all skeletal systems are similar. Some animals have a hard skeleton inside their bodies (e.g., the bones of fish, frogs, dogs and humans).

Other animals have hard skeletons on the outside (e.g., the cuticle of a grasshopper), or produce a structure to protect the body (e.g., the shell of a clam). Some skeletons aren't hard, they're hydrostatic—formed from sacs of fluid (e.g., in earthworms and sea anemones).

Skeletal systems are so important that scientists classify animals by their type of skeleton. Animals classified as vertebrates have internal skeletal systems made of bone or cartilage. Animals classified as invertebrates have solid, external skeletons or hydrostatic skeletons.

Because each species has a unique skeleton, you can use skeletal structure to identify animals. For example, you can tell a bird skeleton by its hollow bones. Features such as wing bone length and beak shape help you decide which species of bird the skeleton belonged to. Paleontologists identify fossils by examining skeletons and other hard parts such as shells left behind by once-living animals.

This activity gives your students a closer look at the structures that give animals shape and lets them compare the similarities and differences between vertebrates and invertebrates.

Activity

Materials

- Pictures or mounted reproductions of whole animals. Invertebrates (animals without backbones) include: snail, giant squid, grasshopper, earthworm, starfish. Vertebrates (animals with backbones) include: frog, fish, bird and small mammal.
- Prepared or fabricated snail shell, starfish test (body) and grasshopper cuticle (outer skeleton).
- Prepared or fabricated skeletons of frog, fish, bird and small mammal.

QUESTIONS TO BEGIN

Touch your arm. What do you feel inside it?
(That's a bone. Bones make up your skeleton inside your body.)

Can you think of another animal that has a skeleton in its body?

Can you think of any animals that have skeletons outside their bodies?

Procedure

1. Place around the classroom pictures or mounted reproductions of whole animals. Use vertebrates and invertebrates (see list under Materials).
2. Have your students walk around the room in pairs or small groups and sketch each specimen.
3. Have them write (or discuss) their thoughts about each animal's skeleton. Do they think it's the same as their own skeletons or different?
4. Bring the class back together.
5. Using pictures or fabricated shells and skeletons, discuss each specimen, emphasizing the differences between the skeletal systems of vertebrates and invertebrates.

QUESTIONS TO CLOSE

What do you think you would be like without your skeleton?
How does a skeleton help an animal?

Adapted from
Science: Model Curriculum Guide, Kindergarten Through Grade Eight. Sacramento: California State Department of Education, 1987.

Additional Sources
Arms, Karen and Pamela S. Camp. Biology. Philadelphia: Saunders College Publishing, 1987.
Burnie, David. How Nature Works. Pleasantville, NY: Reader's Digest Association, Inc., 1991.

How Do They Move?

life sciences, physical education

SUBJECTS

K - 8

GRADES

life's diversity, adaptations

CONCEPTS

one class period

DURATION

OBJECTIVE

Students will learn that...animals move in different ways depending on how they've adapted to where they live.

Background Information

Animals move in different ways. Bats fly, chameleons crawl, grasshoppers hop and rhinos run. The way an animal moves is related to the environment it lives in—its habitat. Imagine a rhino flying or a grasshopper swimming. Neither would get very far. In fact, a grasshopper falling in a pond would make easy pickings for a hungry fish. How an animal moves is one way it has adapted to its habitat.

This role play allows your students to "feel" what it's like to be an animal on the move, and to appreciate each animal's adaptations for moving.

Activity

Materials

- Large box or paper bag.
- Magazine cutouts of each animal. Choose a variety of animals that move in different ways: walking (humans or rhino), flying (house fly or bat), swimming (platypus), hopping (grasshopper) and jet propulsion (giant squid).

QUESTIONS TO BEGIN

How do you move? What parts of your body do you use to walk? What parts do you use to wave hello or good-bye?

What are the different ways that you can move?

Procedure

1. Place magazine pictures in a box or large paper bag.
2. Have students form a circle with the box or bag in the center.
3. Choose a student to reach into the box or bag and pull out one picture.
4. Ask the student to look closely at the animal and its body parts and identify the way the animal moves.
5. Have the student move as the animal would move.
6. Have the rest of the class repeat the movements.
7. Repeat until everyone has had a chance to choose an animal and lead the class.

QUESTIONS TO CLOSE

Do all animals move the same way?

How many different ways of moving can you name?

Which movement did you like? Why?

Which movements didn't you like? Why?

Adapted from

Mystic Marine Life Aquarium Education Dept. Pre-, During and Post Activity Kits. Mystic, CT, Sea Research Foundation, 1992.

Additional Sources

Cooke, John. The Restless Kingdom: An exploration of animal movement. New York: Facts On File, 1991.

Mouths And Meals

life sciences, language arts

SUBJECTS

K - 8

GRADES

life's diversity, jaws and teeth as adaptations

CONCEPTS

one class period

DURATION

OBJECTIVE

Students will learn to…tell what an animal eats by looking at jaws and teeth.

Background Information

To help animals meet their survival needs, animals have developed special body parts, called adaptations. One body part that helps animals get food is the mouth. You can tell a lot about what an animal eats just by looking at its jaws and teeth. Animals that eat meat (carnivores) have pointed teeth that bite and rip their food. Animals that eat plants (herbivores) have flattened teeth that grind up plant material. Omnivores, which eat meat and plants, have teeth that rip and teeth that grind.

Compare a rhino, a chameleon and a fly, and you'll notice they have different mouths. That's because they eat different foods. With fleshy lips and grinding teeth, the rhino's mouth is designed for cropping and chewing tough grasses or leaves. A chameleon, by comparison, eats insects. It doesn't need lips that crop or teeth that grind. Instead, it has a long, sticky tongue that snares insects from a distance. The fly approaches eating in a completely different way. It spits on its food to turn it into a mush, then sucks up the mush through its tube-shaped mouth. The rhino's lips and molars, the chameleon's sticky tongue and the fly's tube mouth are adaptations that help each survive.

This activity gives your students a closer look at jaws and teeth: how animals use them and what they can tell you about what an animal eats.

Activity

Materials

- Pictures or fabricated sets of teeth: human, cat, rabbit, raccoon, horse, shark.

QUESTIONS TO BEGIN

Feel your teeth with your tongue. Which ones do you use to take bites out of food? Which ones do you use to mash your food?

Do you think all animals have teeth like yours?

Procedure

Read the descriptions below to your students and have them decide who each set of teeth belongs to. Or print these descriptions on paper. Have students read the descriptions and examine the sets of teeth. Have them record their answers. After everyone has had a chance to complete the activity discuss the results.

Match each set of teeth with its owner.

I'm a meat eater (carnivore). I don't chew my food. I just take big bites, then swallow. I have long, sharp front teeth for catching prey. My back teeth are sharp and short for slicing big chunks of meat. Who am I? ______________________

I'm a plant eater (omnivore). I nibble on grasses and other plants all day. I have flat teeth with hard ridges for grinding the food I eat. Plants are tough and could easily wear down a good set of teeth. But my teeth never stop growing.
Who am I? ______________________

I'll eat just about anything (omnivore). Sometimes I bite into meat so I need sharp teeth for that job. Other times I eat seeds or vegetables so I need flat teeth for that job. My teeth work well on just about anything I eat. Who am I? ______________________

I'm a meat eater (carnivore), but I prefer to eat what's swimming nearby. I have a big mouth and take big bites. My teeth are very sharp and they grow in rows. Like a conveyor belt, the rows keep moving forward so as older teeth fall out they're replaced by newer ones. Who am I? ______________________

ANSWERS ***cat*** ***horse or rabbit*** ***human or raccoon*** ***shark***

QUESTIONS TO CLOSE

Which jaw and set of teeth do you think works best?

Which animals have teeth that keep growing?
What would it be like if your teeth continued to grow as you got older?

What would happen to you if your teeth were designed for eating only one type of food and you couldn't find that food? Do you know any wild animals that face that problem?

Extensions/Variations

Research how each of the Robot Zoo animals eats. Write (or tell) a story about how each animal uses its mouth to obtain food. Include in the story a description of the jaw, teeth and mouth, where the animal finds its food and how it eats.

Adapted from

Ontario Science Centre. Foodworks: Over 100 science activities and fascinating facts that explore the magic of food. Reading, MA: Addison-Wesley Publishing Company, 1987.
Mystic Marine Life Aquarium Education Dept. Pre-, During and Post Activity Kits. Mystic, CT, Sea Research Foundation, 1992.

Additional Sources

Burnie, David. How Nature Works. Pleasantville, NY: Reader's Digest Association, Inc., 1991.

Hide or Show

life sciences,
art

SUBJECTS

K - 8

GRADES

color as an adaptation

CONCEPTS

one or two class periods

DURATION

OBJECTIVE

Students will learn how...animals use color to help them survive.

Background Information

For many animals, being seen means being eaten. To escape notice, many animals conceal themselves by looking like something else in their environment. Their bodies take on the shapes and colors of plants and they sit very still so they're not noticed. This is called camouflage. Some animals, such as chameleon and giant squid, can change body colors and patterns to match their surroundings.

Other animals want to get noticed and are brightly colored. But why? Won't they get eaten? It's not that they have a death wish. They're brightly colored as a warning, like a stop sign, to teach predators to recognize them and leave them alone. These animals have warning colors that tell predators that they taste bad or are deadly to eat. Poison arrow frogs and monarch butterflies are poisonous to eat and use color to stand out so they don't get eaten.

Colors also appear on some animals during certain times of year. Robins and other birds get more colorful in the spring. This is to attract the attention of potential mates. Bright colors are supposed to signal that the animal is healthy and should make a good partner.

This activity gives your students a closer look at the value of a color in the natural world, especially colors that camouflage.

Activity

Materials

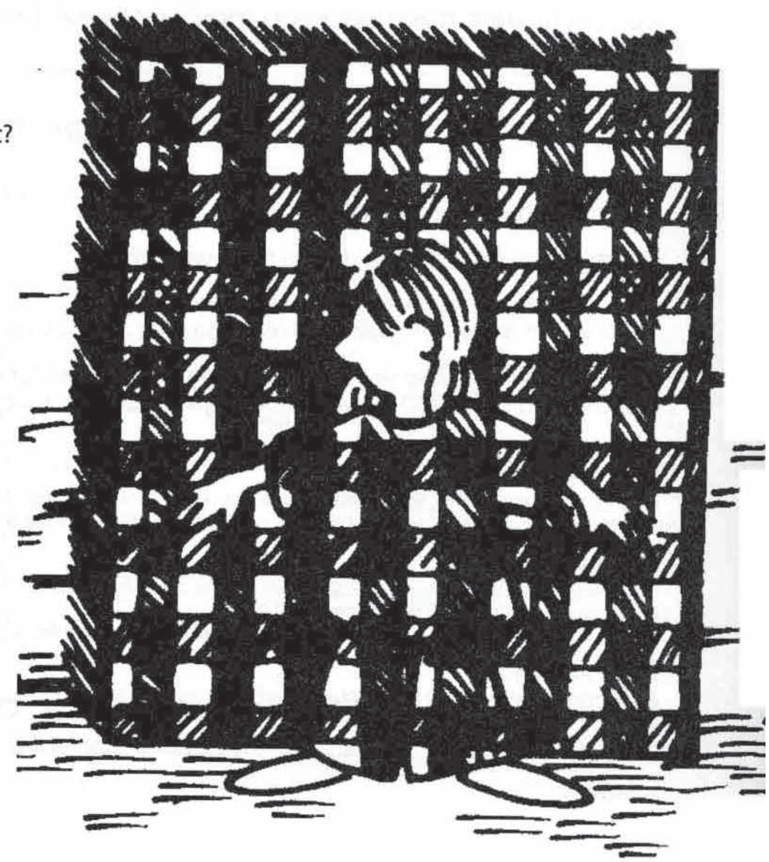
- None.

QUESTIONS TO BEGIN

Are humans camouflaged? Why or why not?

What do you need to be camouflaged?

Why is camouflage useful?



Procedure

1. Have your students come to school camouflaged. Suggest they choose clothing colors and patterns that match the colors and shades of the classroom or schoolyard. They should also wear clothes that are loose or bulky to break up body outlines.

2. See who blends in best in the classroom and in the schoolyard. Have students sit still in the open and have a team of judges decide who is hardest to find (best camouflaged).

QUESTIONS TO CLOSE

Is it easy or difficult to camouflage yourself?

When you're camouflaged, what happens when you move?
Are there things you can do to help you hide (sit still, sit close to a tree, hug the ground, etc.)?

What are the advantages and disadvantages of camouflage?

Extensions/Variations

Have your students come to school dressed to stand out. Suggest they choose clothing colors or patterns that contrast with the colors and shades of the classroom or schoolyard. Have a team of judges decide who is easiest to find (stands out the most). Using photos or other visual materials, show animals that are brightly colored because they're deadly to eat (poison arrow frogs) or brightly colored to attract attention (cardinal or robin in spring). Discuss the advantages and disadvantages of being colorful.

Adapted from

Duensing, E. and A. B. Millmass. Backyard and Beyond. Golden, CO, Fulcrum Publishing, 1992.

Additional Sources

Burnie, David. How Nature Works. Pleasantville, NY: Reader's Digest Association, Inc., 1991.

Robot Zoo

Animal Activities

Bats And Echoes

life sciences,
physical sciences,
language arts

SUBJECTS

K - 8

GRADES

sound production and receiving as an adaptation

CONCEPTS

one or two class periods

DURATION

OBJECTIVE

Students will learn to…make and listen to echoes like a bat.

Background Information

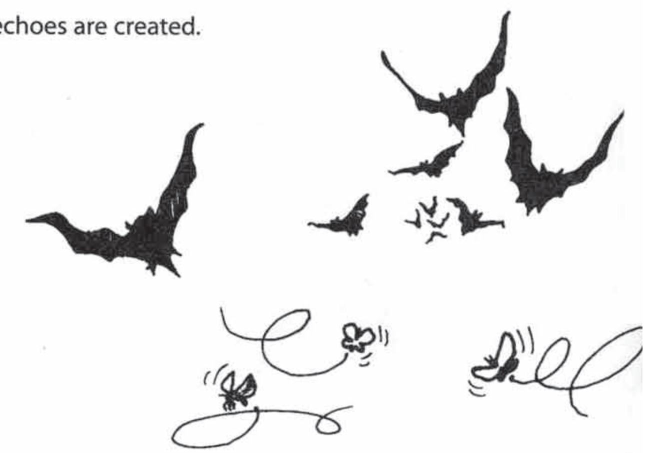
Sounds are created when something vibrates and your ears pick up the vibrations. Many animals are much better than humans are at hearing sounds, and a few animals hear so well that they can "see" in the dark.

Bats are probably the best at using sounds to see. They hunt at night and most hunt for flying insects. To find food, bats use echoes. An echo is a sound that's repeated as the sound waves reflect off a surface. A bat's echolocation system produces a burst of high-pitched sounds as the bat flies. Those sounds bounce off objects and from the returning sounds (echoes) a bat can tell if the object is a rock or a moth, how big it is and how far away. Take a look at most bats and you'll probably find big ears for receiving echoes.

Humans developed something like echolocation when they created sonar during World War II. Sonar is an apparatus that transmits high-frequency sound waves through water and registers the vibrations reflected back from an object, such as a submarine or the ocean bottom.

This activity gives your students a closer look at how echoes are created.

Activity



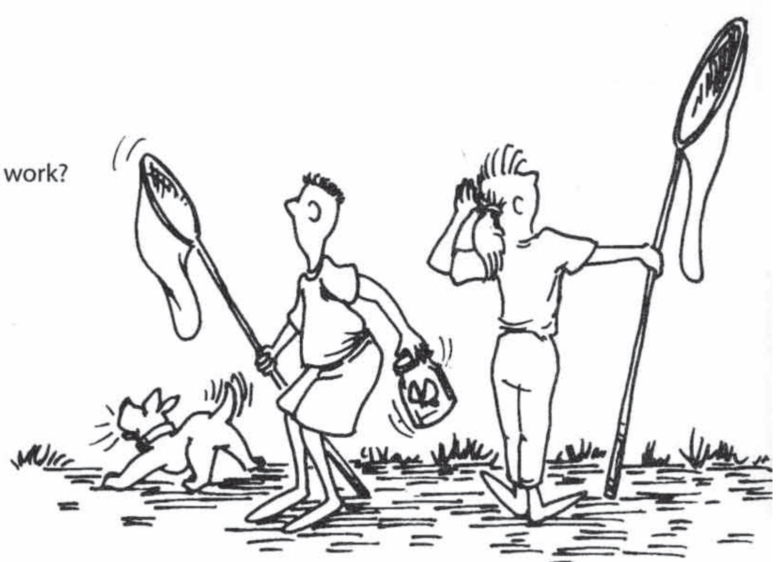
Materials
For each pair of students:

- A watch that ticks.
- A large piece of cardboard or hardboard.
- Two paper towel tubes.
- Other objects that make soft sounds:
  a chime, a baby rattle, clicking fingers, a whisper.
  Be creative.

QUESTIONS TO BEGIN

Where do sounds come from?

What do you hear with? How do your ears work?



Procedure

1. Have students get into teams of two.
2. Give each pair a piece of strong cardboard or hardboard, a ticking watch and two paper towel tubes. The cardboard will be used to "bounce" the sounds of a ticking watch.
3. Start by having students listen through a tube to the ticking watch. Have them record what they hear.
4. Have one partner hold the watch at one end of a paper tube as he or she directs the other end of the tube toward the sounding board (cardboard).
5. Have the other partner cover one ear and hold a paper towel tube up to the other ear. Direct the open end of the tube toward the sounding board.
6. Experiment with different positions of the tubes.
7. Experiment with different objects that make soft sounds.
8. Have students write down their observations.

QUESTIONS TO CLOSE

When you first listened to the watch, what effect did the paper tubing have on the sound of the watch?

What happened to the sounds when you directed the paper tube at the sounding board and listened to the board? Did it sound the same as when you listened to the watch through the tube?

What is an echo? How are echoes created? Do you think the sounds bouncing off the sounding board are echos?

How do bats use sounds to hunt in the dark? (They use echoes.) Why do they have such large ears?

How does bat echolocation work? How does sonar work? What are the similarities and differences between echolocation and sonar?

Extensions/Variations

Have your students practice pinpointing the location of sounds. Have a student sit in a chair in the middle of the classroom and blindfold him or her. Have other students quietly sit in a circle around the chair, but at different distances. Point to one of the students in the circle and have him or her snap fingers. Have the student in the chair point to the location of the sound and tell you if the sound is close or far away. Try a few more times. Then change students.

Adapted from

Vivian, C. Science Experiments and Amusements for Children. New York, Dover Publications, Inc., 1963.

Additional Sources

Parker, Steve. How the Body Works. Pleasantville, NY: Reader's Digest, 1994.

Chameleon Eyes

life sciences,
physical sciences
SUBJECTS

2 - 8
GRADES

adaptations
CONCEPTS

one class period
DURATION

OBJECTIVE

Students will learn how...two eyes working together judge distance better than one eye working alone.

Background Information

Did you ever wonder why you have two eyes that face forward? Why don't people have two eyes at the sides of their head or on top? One reason is that two eyes facing forward help you see depth.

Our eyes are set apart from each other and so see everything from slightly different angles. The images your brain gets from each eye are a little different from one another. By comparing the images, your brain can give you a three-dimensional picture that helps you judge distances. This is called stereoscopic vision. When you cover one eye, you no longer have stereoscopic vision and you see things in two dimensions, that is, the world looks more like a photograph. This makes judging distance much more difficult, although not impossible.

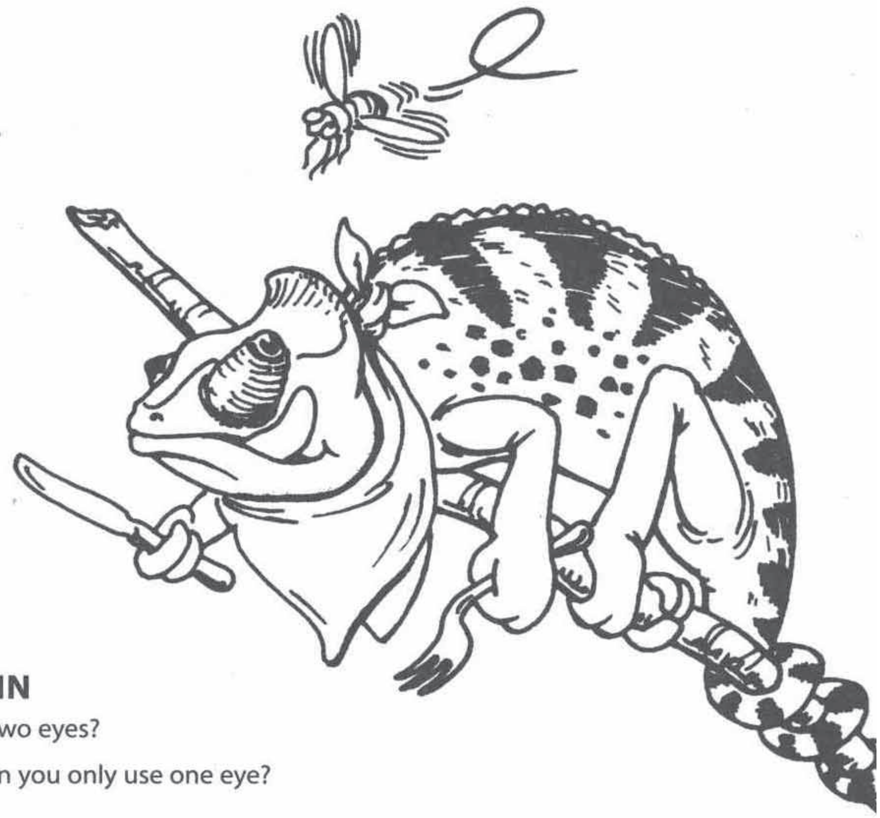
A chameleon has two eyes that can work independently. One eye can be looking backward and the other eye forward at the same time. But when the chameleon spots something to eat, both eyes focus on the target. This gives the chameleon the stereoscopic vision it needs to judge distance before it strikes with its sticky tongue.

This activity gives your students a closer look at how two eyes work together to give you stereoscopic vision.

Activity

Materials
For each student team:

- A cup.
- A penny.



QUESTIONS TO BEGIN

Why do you think you have two eyes?

Do things look different when you only use one eye?

Procedure

1. Divide your class into teams of two students.
2. Have Student 1 put the cup on a desk or table and hold the penny at arm's length above the cup, but slightly in front of it.
3. Have Student 2 stand about 9 feet away, facing the cup and Student 1.
4. With both eyes on the cup and the penny, have Student 2 tell Student 1 where to move his or her arm so that the penny will fall into the cup when it's dropped.
5. When ready, have Student 2 tell Student 1 to drop the penny and see if it lands in the cup.
6. Have students record what happens.
7. Repeat the activity, only this time have Student 2 cover one eye.
8. Have students record what happens.
9. Have the students repeat the activity a second time with one eye covered and record the results.
10. Then have Student 1 and Student 2 switch roles and follow the same procedure.
11. Have students record what happens and possible reasons why.

QUESTIONS TO CLOSE

Was it easier to hit the cup with both eyes open or one eye covered? Why?

Did you get better the second time you tried with one eye covered? Why?

Why do you think a chameleon focuses both eyes forward when it aims?

Can you think of other animals that have forward-facing eyes? How does that help them?

Can you think of any animals that have eyes on the sides of their head instead of facing forward? What do you think the advantages of that are?

Adapted from
Ontario Science Centre. Scienceworks. Reading, MA: Addison-Wesley Publishing Co., Inc., 1986.

Additional Sources
Parker, Steve. How the Body Works. Pleasantville, NY: Reader's Digest, 1994.

Insect Investigation

OBJECTIVE

Students will learn…the basic body plan of insects.

life sciences,
art,
language arts

SUBJECTS

2 - 8

GRADES

adaptations

CONCEPTS

several class periods

DURATION

Background Information

The body of an insect, such as a grasshopper or fly, has three distinct parts. These are the head, the thorax (the middle part) and the abdomen (the rear section). All three sections are covered with a hard substance called a cuticle.

On the head, most insects have a large pair of eyes and a pair of delicate "feelers" called antennae. The mouth parts are just at the bottom of the insect's head, opposite the eyes.

Attached to the thorax are three pairs of legs and usually two pairs of wings. On grasshoppers the first two pairs of legs are for walking and the third pair of legs are for jumping. The wings are under cover. The first pair are long, narrow and rather stiff. The lower wings are delicate, transparent and fanlike.

On house flies, all the legs are for walking. The first pair of wings are for flying. The second pair have been modified and help provide balance when the fly is flying.

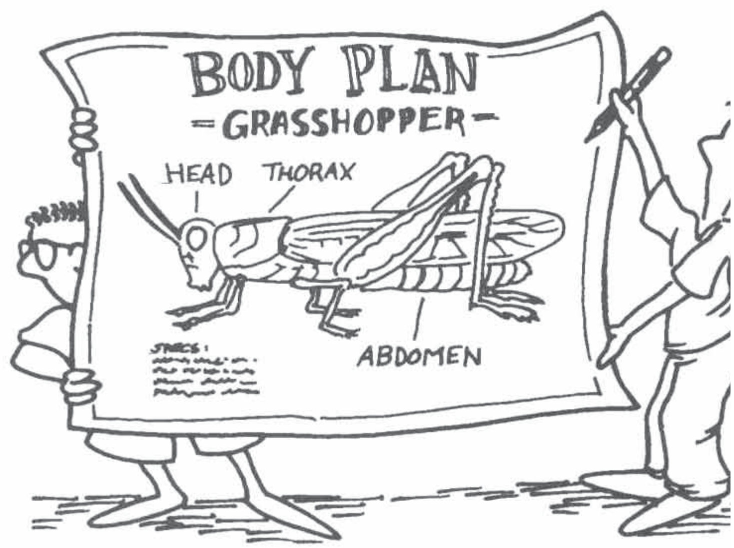
The abdomen is made of many sections (segments) and each segment has many tiny openings. These openings exist in pairs, one on each side of the segment. The openings are called spiracles, and it is through these that the grasshopper breathes.

This activity gives your students a closer look at insects.

Activity

Materials:

- A large jar.
- A square of cheesecloth.
- A rubber band.
- One or more grasshoppers.



QUESTIONS TO BEGIN

What is an insect? What makes it different from a dog or a human?

How does an insect live? What does an insect need to survive?

Procedure

1. Place the grasshopper in a large jar with fresh grass and twigs.
2. Note: as the grass dies, add fresh grass with drops of water on it. Grass growing in a little piece of dirt stays fresher longer.
3. Cover the jar with a piece of cheesecloth secured by a rubber band
4. Have students use a hand lens to examine the grasshopper in the jar.
5. Have them identify the body parts and draw what they see.
6. Have them write down the behaviors of the grasshopper that they observe.
7. Collect or purchase other insects (house fly, cricket, etc.) and have students compare observations of the new insects to their grasshopper observations.

QUESTIONS TO CLOSE

How is an insect different from people?

How does a grasshopper differ from a house fly?

Adapted from

Hanauer, E. Biology Experiments for Children. New York, Dover Publications, Inc., 1962.

Additional Sources

O'Toole, Christopher. Alien Empire. 1st ed., New York: HarperCollins, 1995.

House Fly Reaction Tim

life sciences, mathematics

SUBJECTS

3 - 8

GRADES

adaptations

CONCEPTS

one class period

DURATION

OBJECTIVE

Students will learn about…their abilities to respond (reaction time).

Background Information

If someone throws something at you without telling you, you immediately make a choice: to catch object or get out of the way. If you catch the object in time, or move and it misses you, your reac time is quick.

But no matter how fast you are, you're not as quick as a house fly. A house fly reacts 12 times fa than humans. A fly's reaction time is about one fiftieth of a second; yours is one fourth. The insect's large eyes, called compound eyes, are very sensitive to movement. Any tiny motion in its direction, the fly zips away.

This activity gives your students a closer look at how quickly they react (reaction time).

Activity

Materials

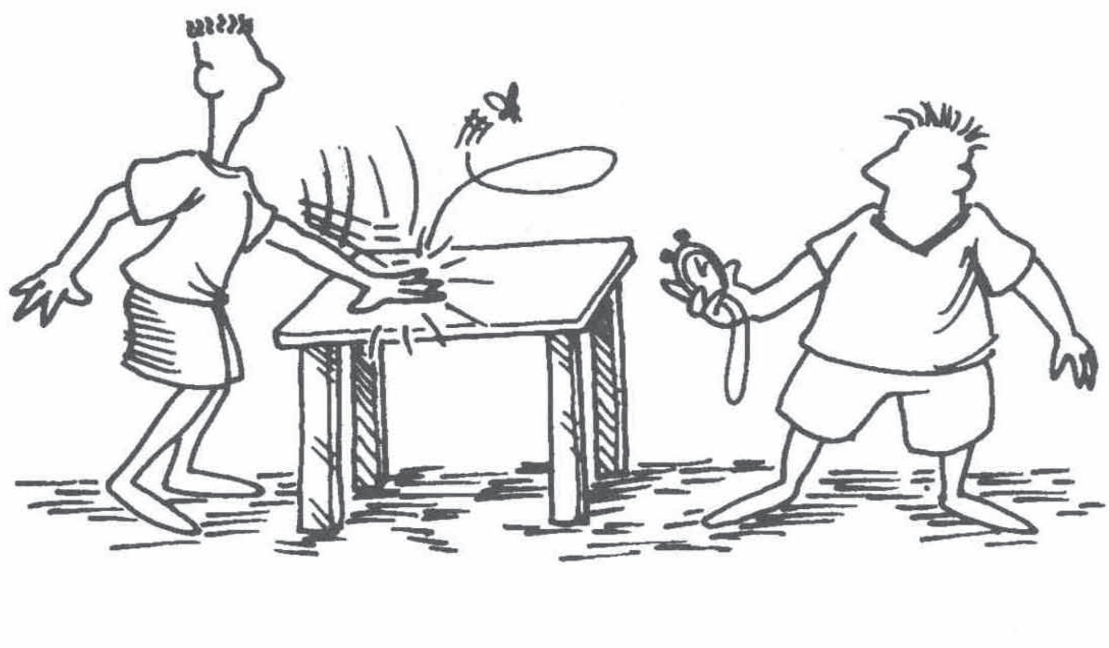
For each student team:

- A yardstick.
- Chart to record reactions.

QUESTIONS TO BEGIN

What's the fastest animal you can think of? Why is it so fast?

What is reaction time? How would you measure the quickness of someone's reactions?



Procedure

1. Divide your class into teams with three students in each team.
2. Have Student 1 extend a hand with the thumb and forefinger separated.
3. Have Student 2 hold a yardstick at one end so that the other end of the stick is between Student 1's thumb and forefinger.
4. Have Student 1 watch the bottom end of the stick and when ready tell Student 2 to release the top end. Student 1 tries to catch the stick between the thumb and forefinger.
5. The distance that the stick falls before it's caught gives a measure of the reaction time.
6. Have the Student 3 record the distance the stick drops before being caught.
7. Repeat the procedure a couple of times.
8. Have the three students switch roles.

QUESTIONS TO CLOSE

Who was the fastest in each group? What does that say about reaction time?

Did any of the students get faster after they tried a couple of times to grab the stick? What does that say about reaction time?

Adapted from

Abruscato, Joe and Jack Hassard. The Whole Cosmos. Santa Monica, CA: Goodyear Publishing Co., 1977.

Additional Sources

Mound, Laurence. Insect. Eyewitness Books, New York: Alfred A. Knopf, 1990.
O'Toole, Christopher. Alien Empire. 1st ed., New York: Harper Collins, 1995.

Platypus Touch

life sciences

SUBJECTS

3 - 8

GRADES

adaptations

CONCEPTS

one class period

DURATION

OBJECTIVE

Students will learn about…their abilities to respond to touch.

Background Information

Platypus hunt under water for snails, shrimp and other animals they find along stream bottoms. To find food in murky waters, they have a special organ—their duckbill. On a platypus bill are two kinds of sensitive receptors. One feels by touch, the other picks up minute electrical signals given off by the contracting muscles of its prey.

This activity gives your students a closer look at how the sense of touch provides clues to what's around them.

Activity

Materials:

- Blindfold.
- 6 strips of balsa wood (1 inch by 2 inch strips, approximately 4 inches long).
- Straight pins.
- Ruler.
- Paper and pencil.

QUESTIONS TO BEGIN

Why do we have the sense of touch?

How is it useful?

Procedure

1. Carefully push two pins through each of the balsa wood strips. Position the pins in the following ways:
   - Strip A: 1 inch apart
   - Strip B: 3/4 inch apart
   - Strip C: 3/5 inch apart
   - Strip D: 2/5 inch apart
   - Strip E: 1/5 inch apart
   - Strip F: 1/10 inch apart
2. Blindfold Student 1 and give Student 2 the strips of wood.
3. Have the Student 2 lightly touch the back of Student 1's forearm, starting with the pins on Strip A.
4. Ask Student 1 how many pins he or she feels.
5. Have Student 2 record the results.
6. Repeat steps 3 and 4 with the other strips until Student 1 feels only one pin. Record the results each time.
7. Try this on the inside of the forearm. Record any differences.
8. Have students switch roles and repeat the experiment.

QUESTIONS TO CLOSE

Was it hard or easy to tell what you were feeling? What made it hard? What made it easy?

Was the skin on the back of your arm and the inside equally sensitive?
Can you think of any reasons they might be different?

How important is a good sense of touch?
Do you think it's more important to some animals than others? Why?

Which animals have a good sense of touch? Where do they live? How do they use that sense?

Adapted from
Burnie, David. How Nature Works. Pleasantville, NY: Reader's Digest Association, Inc., 1991.

Additional Sources
Whitfield, Philip, ed. The Human Body Explained. First ed., New York: Henry Holt and Company, 1995.

Rhino Senses

life sciences,
physical sciences,
language arts

SUBJECTS

2 - 8

GRADES

senses of hearing and smell as adaptations

CONCEPTS

one or two class periods

DURATION

OBJECTIVE

Students will learn about...
their abilities to respond to sounds and smells.

Background Information

Rhinos have terrible eyesight. But they make up for it with a great sense of hearing and sense of smell. Along with its nose, a rhino's ears keep it informed of which animals are coming, which are going, and if humans are nearby. Pivoting like a sonar dish listening for enemy sounds, the cup-shaped ears collect and funnel sounds to the inner ear, which sends nerve impulses to the brain for interpretation.

Sounds a rhino might hear that cause alarm are the squeaking of a calf in distress or the alarm calls of birds. Reassuring sounds the rhino might hear are the pant of a nearby rhino calf.

The rhino's nose is a powerful smell receptor. In the roof of each nasal cavity is a button-sized patch of cells. In each patch, millions of tall, slim cells are clustered together. Some of the cells sense scents. When chemical molecules drift into the nose, they stimulate these smell receptors, which send impulses to the brain. The brain interprets the impulses as smells.

This activity gives your students a closer look at how ears and noses work to provide clues to what's around them.

Activity 1

Materials:

- None.

QUESTIONS TO START

Why do we have the sense of hearing?
How is it useful?

Procedure:

RHINO EARS

1. In the classroom have each student listen carefully to the sounds around him or her. Have each student record the sounds that he or she hears.
2. Have students cup their hands behind their ears to increase their sound collecting abilities.
3. Have them listen quietly to the sounds around them again.
4. Have them record what they hear.
5. Have your students try changing the shape of their cupped hands. What seems to make the surrounding sounds louder? Have them record the differences.
6. Have your students try opening their mouths slightly with their ears cupped. Does this help? Have them record the differences.
7. Try the same activity outdoors. Have students record what they hear.

QUESTIONS TO CLOSE

Did your hearing ability change when you cupped your hands over your ears? Did you hear the same sounds or more sounds? Were the sounds louder or quieter?

How important is a good sense of hearing? Do you think it's more important to some animals than others? Why?

Which animals have a good sense of hearing? Where do they live? How do they use that sense?

Adapted from

Duensing, E. and A. B. Millmass. Backyard and Beyond. Golden, CO, Fulcrum Publishing, 1992.

Additional Sources

Estes, Richard Despard. The Behavior Guide to African Mammals. Berkeley, CA: The University of California Press, 1992.

Activity 2

Materials

- Film canisters.
- A pin to make holes in the canister tops.
- Cotton balls.
- Scents: vanilla extract, chocolate, coffee, various spices, orange peel, or any other object with a scent.

QUESTIONS TO BEGIN

Why do we have a sense of smell?
How is it useful?

Procedure

1. Put scented objects into the canisters. To use extracts, put a drop on a cotton ball and place inside the canister. Poke holes in the lid of the canister.
2. Tell the children that they are going to be smelling a hidden object. Ask them not to talk and definitely not to say aloud what they think they are smelling.
3. Take one canister and allow each child a turn to smell it.
4. Ask the children to describe the smell without telling what it is. After each child has the chance to come up with his/her own description, ask the students if the smell was sweet or sour, heavy or light, and strong or faint. Ask them to come up with their own descriptive paired words. Ask them to describe how the smell makes them feel.
5. Ask the students what the smell reminded them of. Allow them to guess at what the object actually was.
6. Go through the same process with each of the other smells.

QUESTIONS TO CLOSE

Was it hard or easy to tell what you were smelling? What made it hard? What made it easy?

Which smells did you like? What did you like about them?

Close your eyes for a minute and smell the air. Describe the smells. Where do you think the smells are coming from? Did you sense just one smell, or could you separate different smells?

When do you think it would be good to have a strong sense of smell?

What animals have a good sense of smell? How do they use their sense of smell?

Adapted from
Olitsky, Stacy. Science for Little Children. The Academy of Natural Sciences Education Handbook, Philadelphia: The Academy of Natural Sciences, 1996.

Additional Sources
Whitfield, Philip, ed. The Human Body Explained. First ed., New York: Henry Holt and Company, 1995.

Giant Squid Jets

life sciences,
physical sciences,
art
SUBJECTS

3 - 8
GRADES

adaptations
CONCEPTS

one class period
DURATION

OBJECTIVE

Students will learn how…jet propulsion works by making a biomechanical model.

Background Information

Imagine you're sitting on a chair that has wheels, and you're facing a wall. If you lift your feet and push against the wall, the wall exerts a force that pushes you backward. Push softly and you'll roll back a short distance slowly. Push harder, you'll jet backward faster and farther. This illustrates Newton's Third Law of Motion: for every action there is an equal and opposite reaction.

Giant squids and balloons put Newton's Third Law of Motion to use. When a balloon is blown up, the air inside pushes on the rubber, and the rubber pushes back. As long as the balloon is closed tight, nothing happens. But if you let air out of the balloon, the rubber pushes on the air inside and the air rushes out. When it does, the force of the escaping air pushes the balloon in the opposite direction.

A giant squid's body is like a balloon. Its outer skin is like the rubber of a balloon. Between the outer skin (called the mantle) and its organs is a space, called the mantle cavity. One end of the space opens and closes like a gate; at the other is a funnel, similar to the open end of a balloon. A giant squid pumps water through the gate, closes the gate, then squeezes the water out of the funnel. Like the balloon, the escaping water pushes the giant squid forward in the opposite direction, and the giant squid jets away.

This activity gives your students a closer look at how a giant squid uses jet propulsion to swim.

Activity

Materials
For each student:

- A balloon.
- A paper clip or twist tie.

Also:

- Tape.
- Streamers.
- Markers.

QUESTIONS TO BEGIN

What parts of your body do you use to move across the room?

If the room was filled with water, would you move the same way as you do when you walk? Why or why not?

Procedure

1. Show students a video or pictures of giant squid swimming through the water.
2. Give each student a balloon for making a giant squid.
3. Have students use markers to add eyes to their giant squid balloons (the giant squid's eyes and head are near the opening of the balloon).
4. Have students blow up a balloon fully and close securely with a twist tie.
5. While balloon is still inflated have students attach streamers (for giant squid arms and tentacles) with tape near the tied end of the balloon.
6. When all the giant squids are complete, have students, one at a time, demonstrate giant squid jet propulsion by removing the twist ties and watching the giant squid shoot through the air.

QUESTIONS TO CLOSE

What do the models show us about how a giant squid moves?
Why do you think it moves differently than you do?

Do you think real giant squids use air to swim or something else?
What do you think they use to power their jets in the water?

Adapted from

Mystic Marine Life Aquarium Education Dept. Pre-, During and Post Activity Kits. Mystic, CT, Sea Research Foundation, 1992.

Additional Sources

Gates, Phil. Nature Got There First: Inventions inspired by nature. New York: Kingfisher, 1995.

Squid Sucker Power

life sciences, physical sciences

SUBJECTS

3 - 8

GRADES

adaptations

CONCEPTS

one class period

DURATION

OBJECTIVE

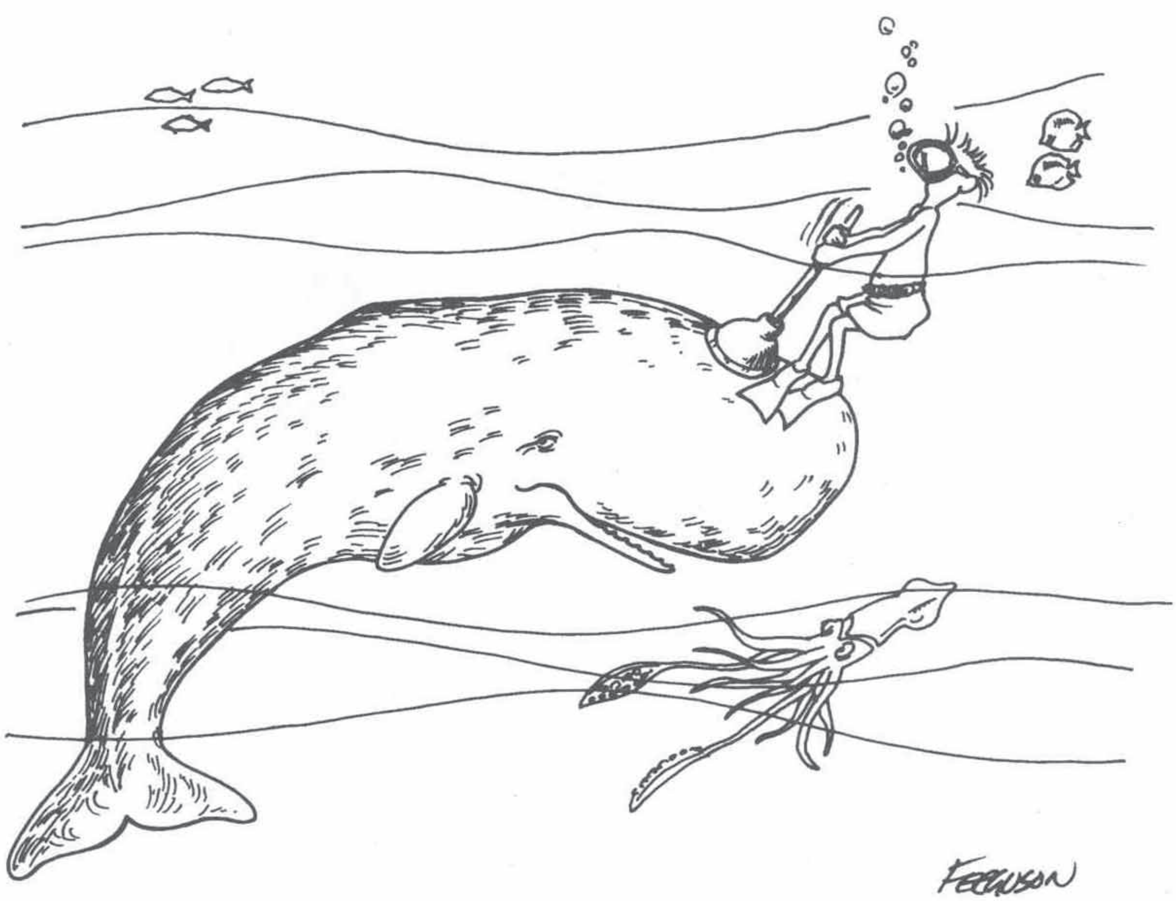
Students will learn...to stick to a surface like a giant squid sucker. How a sucker works by making a biomechanical model.

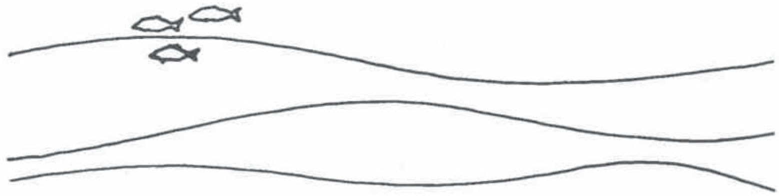
Background Information

At sea level the atmosphere presses down on objects at 14.7 pounds per square inch of pressure. In the ocean, water presses down on objects with even more pressure. The deeper you go, the greater the pressure. Where giant squid roam, water pressures can reach thousands of pounds per square inch.

Water pressure helps a giant squid attach its suckers onto objects, like the skin of prey or its predator, the sperm whale. When a giant squid first places its sucker on a whale's skin, the water pressure inside the sucker is the same as it is outside the sucker. But then the giant squid seals off the outer edge of the sucker and pulls the center of the sucker away from the whale. This creates a kind of vacuum: the water pressure inside the sucker becomes much less than that outside of it. Higher water pressure outside the sucker keeps the sucker attached, as long as the seal stays intact.

This activity gives your students a closer look at how giant squid suckers work. Keep in mind that you're using air pressure instead of water pressure to create the suction. But the principle is the same.





Activity

Materials

- A plumber's suction cup.
- A smooth surface, such as a plastic table top.
- A pin.

QUESTIONS TO BEGIN

How do you hold onto objects?
How would you hold on if you couldn't use your fingers?

Procedure

1. Moisten the suction cup and the surface on which it is to be placed.
2. Have a student press the cup down on the smooth surface, then try to pull it away.
3. Place a small hole in the suction cup. Repeat steps 1 and 2. It should be easy to pull the cup away from the table top.
4. Have a student hold a finger over the hole on the next try.
5. It should be difficult, if not impossible, to pull the cup from the surface.
6. Explain that although we don't notice it, the atmosphere pushes down at about 14.7 pounds per square inch. If the suction cup encloses an area of 16 square inches, the force required to pull it loose from the smooth surface could be more than 200 pounds. This represents the pressure of the atmosphere on the top of the rubber cup. Under water, a giant squid uses the pressure of the water to help it stick tight to food it catches.

QUESTIONS TO CLOSE

How does a giant squid hold on to something?

How do suction cups compare to fingers in how well they hold on?

Adapted from

Brown, R. J. 333 More Science Tricks and Experiments. Blue Ridge Summit, PA, Tab Books, 1984.
Vivian, C. Science Experiments and Amusements for Children. New York, Dover Publications, Inc., 1963.

Additional Sources

Gates, Phil. Nature Got There First: Inventions inspired by nature. New York: Kingfisher, 1995.

Suggested Post Exhibit Activities

Join Two Bones

life sciences,

physical sciences (biomechanics)

SUBJECTS

3 - 8

GRADES

biomechanics

CONCEPTS

one class period

DURATION

OBJECTIVE

Students will learn how…hinge joints work by building a biomechanical model.

How the backbone (vertebrae) work together by building a biomechanical model.

Background Information

Your students can see the principles behind the body's joints by making wooden models. The hingelike elbow joint connects the humerus of the upper arm and the paired radius and the ulna of the lower arm. The elbow joint can only move in one plane.

Your backbone (vertebrae) is a series of bones joined together. Each bone (vertebra) is separated by a pad of cartilage and held in place by strong muscles and ligaments. Each joint moves a small amount, but there are many joints so your spine can bend.

This activity gives your students a closer look at how joints (the area where bones meet) work.

Activity

Materials

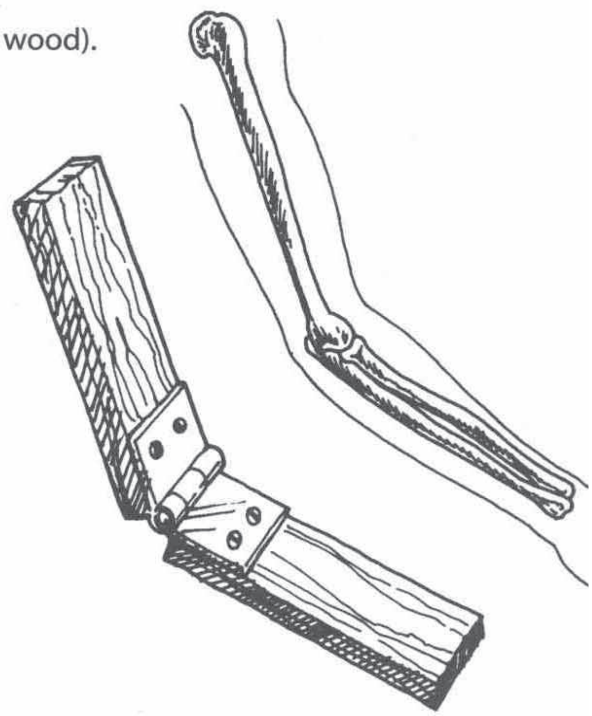
For each team of students:

Procedure A:

- Wood (2 equal length pieces of 1 inch by 2 inch board).
- Hinge (choose a size that fits the pieces of wood).
- Screws (for the hinge).
- Screwdriver.
- Rubber bands.
- Dishwashing sponge.

Procedure B:

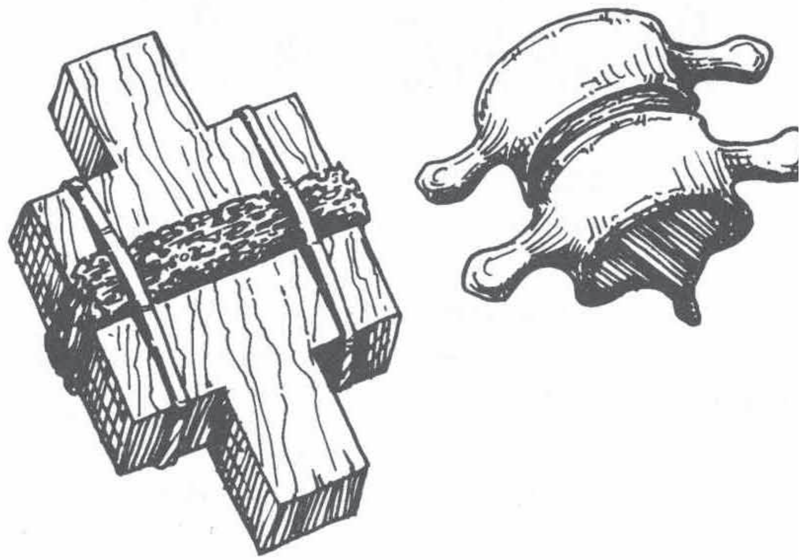
- Wood (2 T-shaped pieces, see illustration).
- Rubber bands.
- Dishwashing sponge.



QUESTIONS TO BEGIN

Bend your elbow. How does it work?

Stand up and bend at the waist.
How do you think your backbone (vertebrae) works?



Procedure A

1. Take two pieces of wood of equal size.
2. Use a hinge to join the two ends.
3. You now have an elbow joint. The hinge at this joint can fully close to allow the mechanical arm to bend inward. The hinge can open up to 180° but no farther, just like your elbow.

Procedure B

1. Take two pieces of T-shaped wood. Place the Ts opposite one another (see diagram).
2. Between the Ts add a piece of sponge.
3. Place a rubber band around the Ts to hold the sponge in place. The Ts are vertebra. The sponge is cartilage and the rubber bands are ligaments.

QUESTIONS TO CLOSE

Compare the movement in the mechanical elbow with the mechanical backbone (vertebrae). What are the similarities? What are the differences?

Compare the movement in the mechanical elbow and backbone (vertebrae) to your elbow and backbone. What are the similarities? What are the differences?

Are bones joined together differently? Why?

How does creating a biomechanical model help you understand what's going on inside you?

Adapted from
Burnie, David. How Nature Works. Pleasantville, NY: Reader's Digest Association, Inc., 1991.

Additional Sources
Whitfield, Philip, ed. The Human Body Explained. First ed., New York: Henry Holt and Company, 1995.

Make A Muscle

life sciences,

physical sciences (biomechanics)

SUBJECTS

3 - 8

GRADES

biomechanics

CONCEPTS

one class period

DURATION

OBJECTIVE

Students will learn how…muscles work by building a biomechanical model.

Background Information

Muscles can pull, but they can't push. To make your limbs move, your muscles are arranged in "antagonistic" pairs or sets. One muscle—the flexor—bends up the joint, while another muscle—the extensor—straightens it out. In the model below, springs take the place of muscles, and pieces of string make up the tendons that attach the muscles to the skeleton.

This activity gives your students a closer look at how muscles work in pairs to help the body move.

Activity

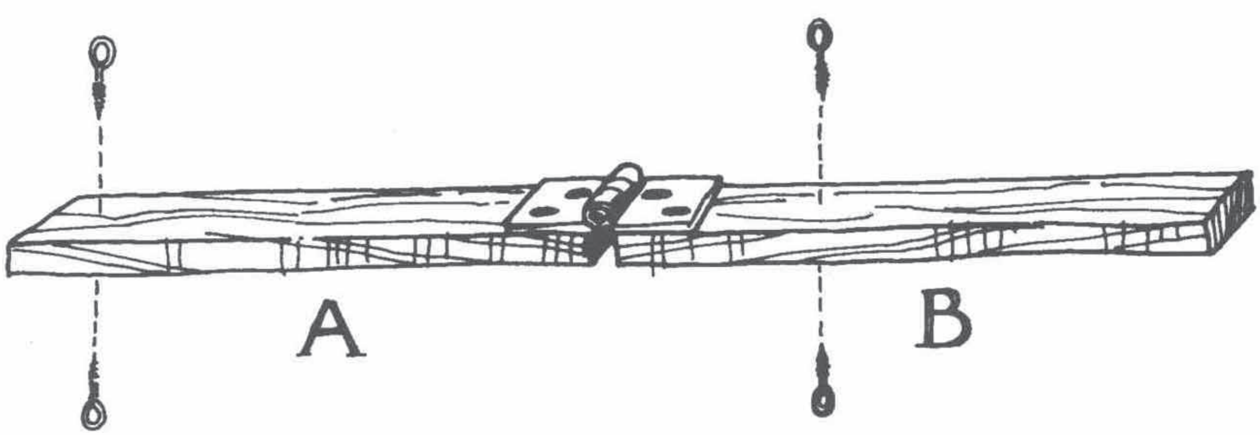
Materials

For each team of students:

- Hinge.
- 4 cup hooks.
- 4 screws.
- 2 springs.
- String.
- Wood (2 equal-length pieces of 1 inch by 2 inch board).

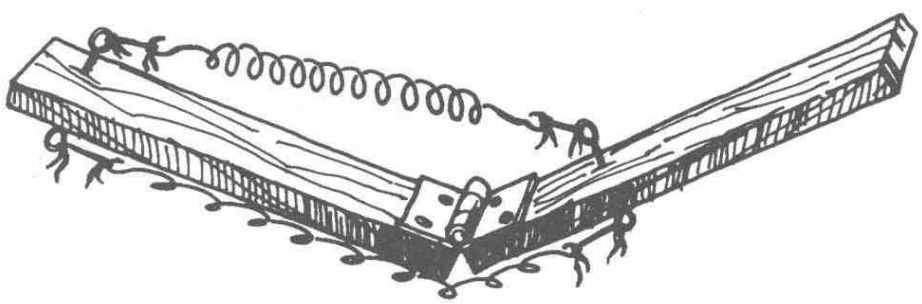
QUESTIONS TO BEGIN

Bend your elbow or knee. Feel the muscles as you bend. What do you feel?
Can you feel one muscle stretching and another one shortening?



Procedure

1. Hinge the two pieces of wood together (see Join Two Bones activity).
2. Take 2 cup hooks and screw one into Piece A about an inch from the unhinged end and screw the second hook on the same side into Piece B about two inches past the joint linking A and B.
3. Take 2 more cup hooks and screw one into Piece A directly opposite the first cup hook. On the same side, screw the second hook into piece B just past the joint linking A and B, directly opposite the second cup hook (see diagram).
4. Use one-inch pieces of string to tie the ends of the springs to each set of cup hooks (see diagram).
5. You now have an upper and lower arm with muscles attached.



QUESTIONS TO CLOSE

Bend the pieces of wood at the joint. What happens to the springs?

Straighten the wood pieces. What happens to the springs?

How does this compare to how your muscles move when you bend a joint?

How does creating a biomechanical model help you understand what's going on inside you?

Adapted from

Burnie, David. How Nature Works. Pleasantville, NY: Reader's Digest Association, Inc., 1991.

Additional Sources

Whitfield, Philip, ed. The Human Body Explained. First ed., New York: Henry Holt and Company, 1995.

Make Lungs

life sciences,

physical sciences (biomechanics)

SUBJECTS

3 - 8

GRADES

biomechanics

CONCEPTS

one class period

DURATION

OBJECTIVE

Students will learn how...a lung works by making a biomechanical model.

Background Information

To breathe, your lungs work together with your diaphragm. When you breathe in, muscles attached to your rib cage and diaphragm work together to draw air through your windpipe into your lungs. When you breathe out, most of the rib cage and diaphragm muscles relax and your lungs deflate.

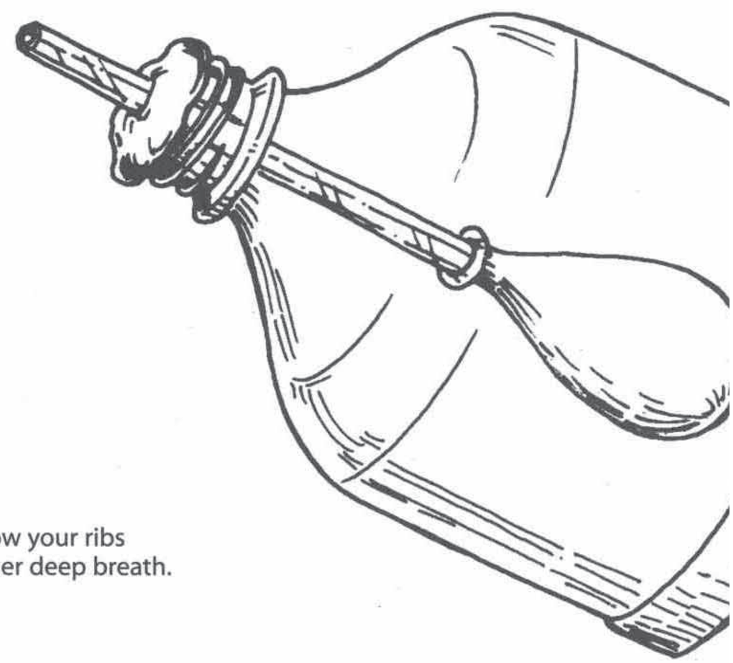
This activity gives your students a closer look at how your diaphragm and lungs work together when you breathe.

Activity

Materials

For each team of students:

- Top half of a plastic soda bottle.
- Ballpoint pen barrel.
- 2 balloons.
- Rubber bands.
- String.
- Modeling clay.
- Tape.
- Scissors.



QUESTIONS TO BEGIN

Watch your chest as you take a deep breath.

Place your hands on your abdomen just below your ribs and feel what happens when you take another deep breath. What did you feel?

How does your body breathe?

Procedure

1. With a rubber band, fasten a balloon to the end of the ballpoint pen barrel. This is the "lung."
2. Position the tube in the neck of the bottle, and make an airtight seal with modeling clay.
3. Cut across the other balloon and use it to seal the bottom of the bottle. This is the "diaphragm."
4. Fasten the string to the balloon with the tape.
5. When you pull gently on the string, the air pressure inside the bottle falls. Air from the outside then flows into the intact balloon and it begins to inflate. This is just what happens to your lungs when your diaphragm contracts.
6. If you let go of the string, air pressure inside the bottle rises. Air is forced out of the balloon. It quickly deflates, just as your lungs do when you breathe out.

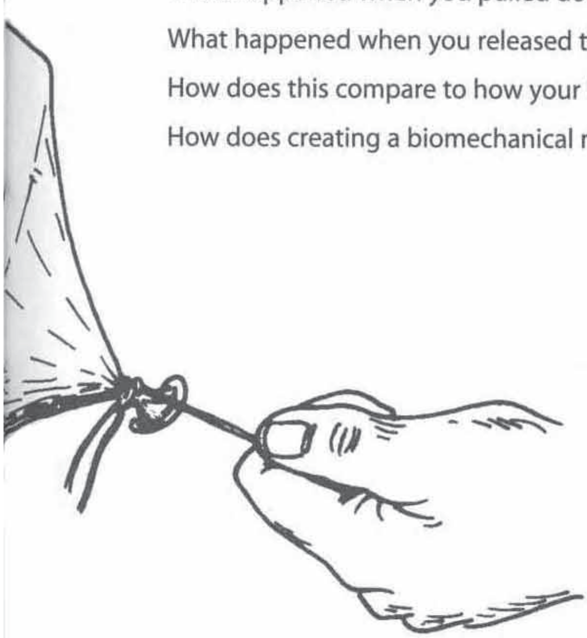
QUESTIONS TO CLOSE

What happened when you pulled down on the diaphragm?

What happened when you released the string and let go of the diaphragm?

How does this compare to how your lungs and diaphragm work together?

How does creating a biomechanical model help you understand what's going on inside you?



Adapted from

Burnie, David. How Nature Works. Pleasantville, NY: Reader's Digest Association, Inc., 1991.

Additional Sources

Whitfield, Philip, ed. The Human Body Explained. First ed., New York: Henry Holt and Company, 1995.

Build A Beast

life sciences,

physical sciences (biomechanics),

art

SUBJECTS

3 - 8

GRADES

biomechanics

CONCEPTS

one or more class periods

DURATION

OBJECTIVE

Students will learn about...animal adaptations by building a biomechanical model.

Background Information

To survive, all animals need food, water, shelter and space. Look at any animal, and you can find special anatomical features that help the animal get all it needs. A special feature that helps an animal survive is called an adaptation. An elephant's trunk, a bat's sonar, a giant squid's tentacles and a grasshopper's leaping legs are all adaptations.

Not all animals have the same adaptations. That's because they eat different foods and find their water and shelter in different ways. The environment where an animal finds food, water and shelter is called its habitat. Each animal's unique set of physical and behavioral adaptations help it survive in its habitat.

This activity gives your students a closer look at animal adaptations by designing and building an animal that is equipped for survival.

Activity

Materials

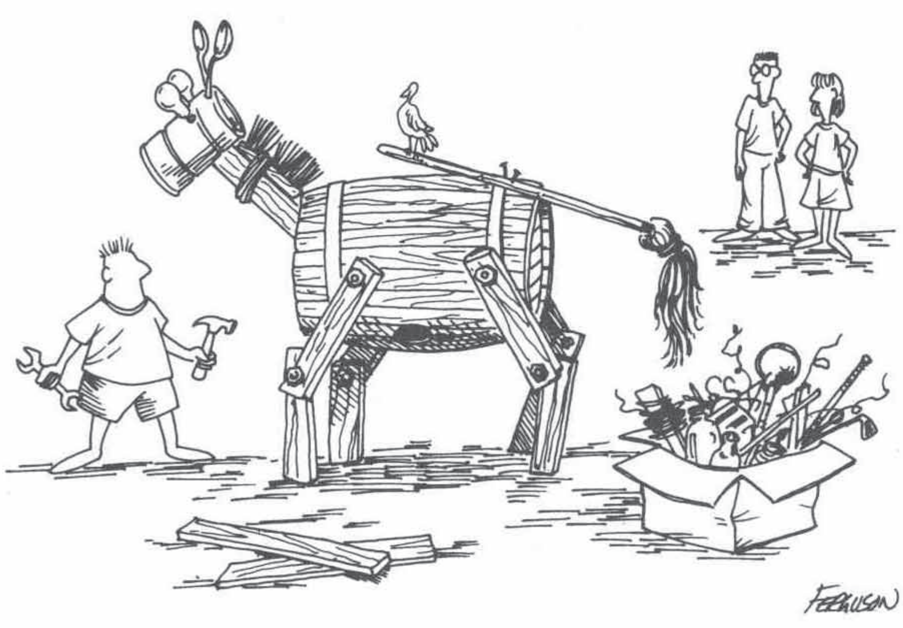
- Magazine cutouts of animals.
- Crayons or colored pencils.
- Cardboard.
- Scissors.

OR

- LEGO Technic Sets.

QUESTIONS TO BEGIN

What's your favorite animal? Where does it live?
What does it need (body parts, behaviors) to survive in its environment?



Procedure

1. Explain to the class (or student teams) that they are going to design their own animal. Some students may want to assemble a recognized animal; others may want to create a fantasy animal. To get them started, discuss one aspect of animal anatomy, such as jaws and teeth, and the ways that they might be different on different animals.

2. Pass out crayons, scissors, cardboard and paper. Have students use any natural materials they have (potatoes, marshmallows, etc., for bodies; sticks, toothpicks, tape, rubber bands, string, yarn, clay, cotton, pipe cleaners, paper, or whatever for adaptations; paints to camouflage or advertise the animals).

OR

1. Use LEGO Technic sets or other construction sets to make animal models with motors, gears and control systems.

2. Ask the students to write a description of the animal and the different adaptations that it has. Students can write a story about the animal.

3. Have each student (or student team) present their animal to the rest of the class, and explain their animal's habitat (home), adaptations and life.

QUESTIONS TO CLOSE

How are animals adapted to find food and shelter in their environments? Pick an animal and describe its adaptations.

How does creating a biomechanical model help you understand what an animal needs to live in its environment?

Adapted from

Olitsky, Stacy. Science for Little Children. The Academy of Natural Sciences Education Handbook, Philadelphia: The Academy of Natural Sciences, 1996.

Additional Sources

Burnie, David. How Nature Works. Pleasantville, NY: Reader's Digest Association, Inc., 1991.
Gates, Phil. Nature Got There First: Inventions inspired by nature. New York: Kingfisher, 1995.

Robot Zoo Word World

life sciences,
language arts

SUBJECTS

3 - 8

GRADES

biomechanics

CONCEPTS

one class period

DURATION

OBJECTIVE

Students will learn to...identify Robot Zoo animals and the parts that make them work.

Background Information

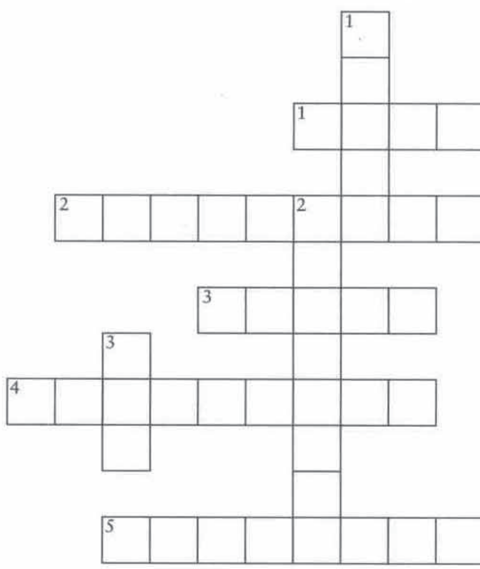
This activity gives your students practice naming the Robot Zoo animals and their biomechanical body parts.

Activity

Materials

- Copies of the following crossword puzzles and word searches.

Who lives in The Robot Zoo?



DOWN

1. Second largest land animal
2. Insect found in house that spits on food
3. Flying mammal that can see with sound

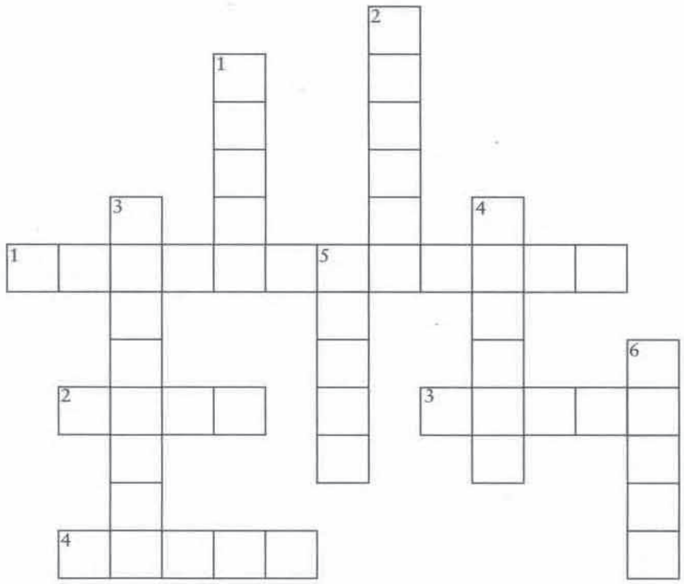
ACROSS

1. Tallest animal on earth
2. Grass-munching, high-jumping insect
3. Large, deep-sea creature with 8 tentacles and 2 arms
4. Color-changing lizard with a sure grip
5. Duckbilled, shallow-water hunter from Australia

What's it take to make Robot Zoo anima

INSTRUCTIONS

For each animal part, fill in the blank with the robot's biomechanical part.



DOWN

1. Nerve = ________________
2. Eye = ________________
3. Brain = ________________
4. Muscle = ________________
5. Joint = ________________
6. Bone = ________________

ACROSS

1. How animals work = ____________
2. Heart = ________________
3. Animal = ________________
4. Scales or skin = ____________

What's hiding here?

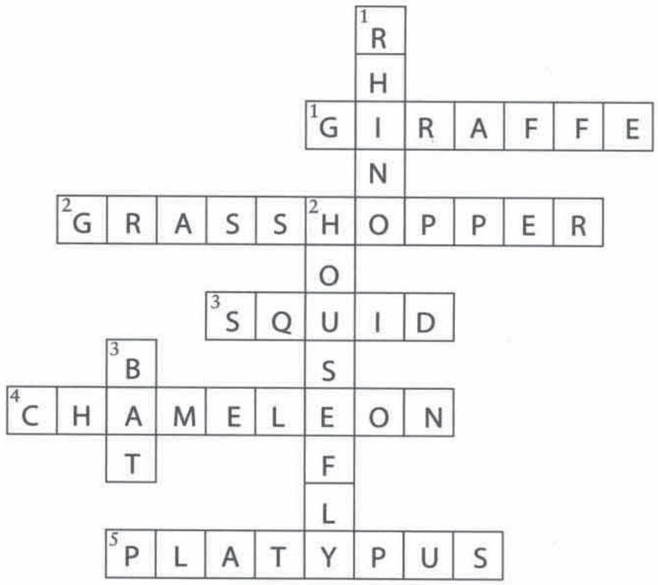
INSTRUCTIONS

Circle all the words you can find. You'll find some forward, backward, diagonally and upside-down.

G	A	B	S	E	N	I	H	C	A	M
R	H	I	N	O	C	E	R	O	S	S
A	M	N	R	M	U	S	E	U	M	U
S	W	E	O	S	Q	U	I	D	Y	P
S	S	F	B	E	G	B	Q	L	B	Y
H	L	F	O	A	L	I	F	L	B	T
O	A	A	T	X	T	E	P	E	H	A
P	M	R	Z	F	S	A	M	V	E	L
P	I	I	O	U	H	B	W	A	X	P
E	N	G	O	N	O	A	O	R	H	S
R	A	H	Z	Y	W	T	W	T	W	C

Word World Answer Keys

Who lives in The Robot Zoo?



DOWN

1. Second largest land animal
2. Insect found in house that spits on food
3. Flying mammal that can see with sound

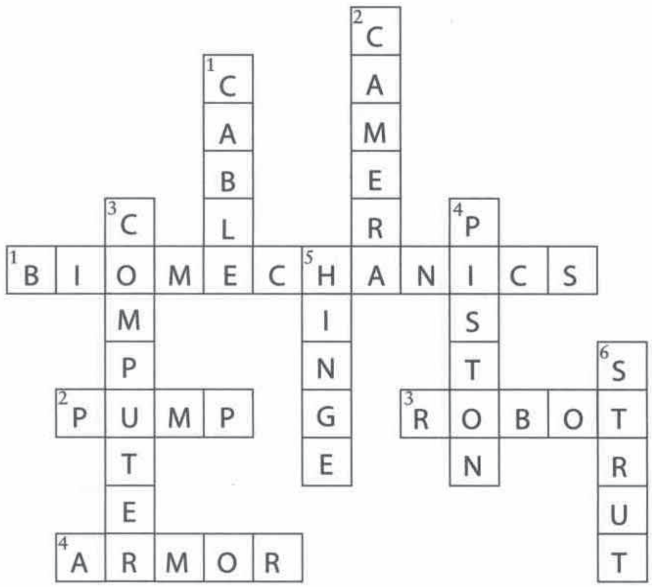
ACROSS

1. Tallest animal on earth
2. Grass-munching, high-jumping insect
3. Large, deep-sea creature with 8 tentacles and 2 arm
4. Color-changing lizard with a sure grip
5. Duckbilled, shallow-water hunter from Australia

What's it take to make Robot Zoo animals?

INSTRUCTIONS

For each animal part, fill in the blank with the robot's biomechanical part.



DOWN

1. Nerve = *Cable*
2. Eye = *Camera*
3. Brain = *Computer*
4. Muscle = *Piston*
5. Joint = *Hinge*
6. Bone = *Strut*

ACROSS

1. How animals work = *Biomechanics*
2. Heart = *Pump*
3. Animal = *Robot*
4. Scales or skin = *Armor*

What's hiding here?

INSTRUCTIONS

Circle all the words you can find. You'll find some forward, backward, diagonally and upside-down.

G	A	B	S	E	N	I	H	C	A	M
R	H	I	N	O	C	E	R	O	S	S
A	M	N	R	M	U	S	E	U	M	U
S	W	E	O	S	Q	U	I	D	Y	P
S	S	F	B	E	G	B	Q	L	B	Y
H	L	F	O	A	L	I	F	L	B	T
O	A	A	T	X	T	E	P	E	H	A
P	M	R	Z	F	S	A	M	V	E	L
P	I	I	O	U	H	B	W	A	X	P
E	N	G	O	N	O	A	O	R	H	S
R	A	H	Z	Y	W	T	W	T	W	C

ROBOT ZOO WORDS

Animals
Bat
Chameleon
Fun
Giraffe
Grasshopper
Housefly
Machines
Museum
Platypus
Rhinoceros
Robot Zoo
Show
Squid
Travel

OTHER WORDS

Ago
Amp
Bin
Boy
Fen
Foal
Fog
Fox
Need
Nor
Oft
Pig
Rah
Sue
Tag
Use
Wow

Glossary

abdomen
The rear section of a grasshopper, housefly or other insect.

adaptation
The structures or behaviors of an organism that are suited to a particular environment.

antenna
One of a pair of "feelers" on an insect's head. (plural: antennae)

anus
The opening at the end of an animal's digestive system where waste leaves the body.

backbone
A chain of small bones that run along the center of the back of a vertebrate. Also called the spine or spinal column.

biomechanical
The application of mechanics and machinery knowledge to the structure and functions of living things.

bone
The hard tissue that forms the skeleton of vertebrates.

brain
The organ in an animal's head that controls and regulates the body's activities.

calcar
A spur on the inner side of a bat's ankle that helps support the wing membrane.

camouflage
A way of hiding by blending in with the surrounding environment.

cartilage
A tough, flexible tissue that supports the fins of a platypus, as well as your nose.

chromatophores
Special skin cells that change a chameleon's color.

cloaca
An organ into which an animal's digestive, urinary and reproductive systems empty, and that opens to the anus.

cold blooded
Having a body temperature that rises or falls with the temperature of the surrounding environment.

compound eye
An eye that's made up of many tiny, simple eyes that work together to form an image.

crop
A saclike area in an insect's gut where food is stored before it's digested.

digestion
The breaking down of food into forms the body can use.

echolocation
A system that bats use to navigate and find food. They give off high-pitched sounds, then interpret the echoes.

endoskeleton
A skeleton that's inside the body (like your skeleton).

engineering
The design, construction and operation of structures and machines, using scientific principles.

esophagus
The tube that leads from the throat to the stomach or crop.

exoskeleton
The hard outer covering that makes up the skeleton of insects and some other animals.

evolution
The change in the genetic make-up of a population of organisms over time. This process of change is driven by natural selection.

feathers
A bird's body covering. Each feather is made up of a hollow rod with two rows of light, soft barbs.

femur
The third segment of an insect's leg.

fur
The hairy coat of a mammal.

ganglia
Groups of nerve cells that act as brains in insects.

gills
The breathing organs of a water-living animal. Gills exchange gases between body fluids and the surrounding water.

hair
A mammal's outermost covering, made up of threadlike growths on the skin.

horn
The hard, pointed structure that grows on the head of some animals and is used for self-defense.

humerus
The upper bone of an animal's front leg.

insect
An animal that breathes air, has an exoskeleton, three body segments, three pairs of legs, two sets of wings (usually), a pair of antennae and compound eyes.

intestines
The tubelike part of the digestive system between the stomach or crop and the cloaca or anus.

invertebrate
An animal that has no backbone.

keratin
The tough protein that makes up hair, nails, scales, horns and hooves.

labra/labia
The upper and lower plates that form insects' lips.

larynx
1. The part of the respiratory (breathing) system that contains an animal's "voice box."
2. The "voice box" of some animals.

machine
A human-made system or device made up of fixed and moving parts that perform tasks.

mammal
A warm-blooded vertebrate that grows hair on its skin and (in females) produces milk for its young.

mandible
One of a pair of jaws in insects and beaked animals, such as the giant squid.

manus
The end of a giant squid tentacle.

maxilla
One of a pair of mouthparts located just behind an insect's mandibles.

muscle
Body tissue made up of bundles of cells or fibers that move body parts by lengthening and shortening.

nerves
Long fibers or bundles of fibers that transmit messages between the brain and the rest of the body.

nervous system
The system of nerves, ganglia and (in vertebrates) the spinal cord and brain. It regulates and coordinates all the body's activities.

organism
A living being.

ovary
The organ that produces eggs in females.

pharynx
The part of the digestive tract that connects the mouth with the esophagus.

prehensile
Adapted for holding, especially by wrapping around, like a chameleon's tail.

pretarsals
The last segment of an insect's legs.

proboscis
A long, tubelike structure on an invertebrate's head.

radula
The tooth-lined tongue of a giant squid.

reptile
A cold-blooded vertebrate that lays eggs and has scales or plates on its skin.

respiration
The interchange of gases between a cell and its environment, or between an animal and its environment (known as breathing).

robot
A mechanical device that resembles a living animal and moves automatically or by remote control.

scale
One of the small, platelike structures that cover reptiles.

skeleton
A hard structure that supports and shapes an animal.

specimen
An individual in group, used as an example of the whole.

spinal cord
The central pathway of a vertebrate's nervous system, it runs from the brain through the backbone.

spiracles
The openings on an insect's sides where air enters the respiratory system.

stomach
A saclike organ that digests food.

tentacle
One of a pair of long, thin, flexible structures that giant squid use to feel and to grab food.

thorax
The middle segment of an insect, where the legs and wings attach.

tibia
The fourth segment of an insect's leg.

trachea
A tube that carries air to the lungs (in a vertebrate) or to other body tissues (in an insect).

ultrasonic
A sound frequency that's too high for humans to hear.

vertebra
One of a chain of bones that make up the backbone. (plural: vertebrae)

vertebrate
An animal that has a backbone.

warm blooded
Having a warm, constant body temperature that doesn't depend on the outside environment.

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1-800-334-5551

NASCO

Ft. Atkinson, WI and Modesto, CA
1-800-558-9595
www.nascofa.com

Ward's National Science

Establishment
Rochester, NY
1-800-962-2600

LEGO Technic Sets

The LEGO Group
Enfield, CT
1-860-749-2291
www.lego.com/products

Web Sites

American Society of Biomechanics
www.usc.edu/dept/biom/asb.html

International Society of Biomechanics

www.kin.ucalgary.ca/isb

Welcome To The Robot Zoo!

Silicon Graphics and TIME magazine are delighted to partner in presenting you a unique high-tech experience—The Robot Zoo. This adventure with a colorful chameleon, a giant squid, a rhino and other monstrous robot animals struck us as a great synthesis of science, technology and fun. We figured you would have a good time, and if you learn something, well, it's no extra charge!

Silicon Graphics is the world's leader in high-performance computing and visualization technology. TIME magazine is the premier weekly newsmagazine and a leader in new media and technology coverage. We have created this unique partnership to bring The Robot Zoo to you because we're committed to getting kids interested in the sciences—and ultimately in science and engineering careers. Innovations in medical, communication and information technologies happen when kids who think science and technology are cool become adults who make science and technology cool.