Neuroscience for Kids
http://faculty.washington.edu/chudler/neurok.html

Our Sense of Hearing

Student Guide

How do our ears tell us the direction from which a sound is coming?

It had been a great day of hiking in the Southwest; now Sam and Derek and their dads were ready for a good sleep under the stars. As darkness fell over the friends in their sleeping bags, Sam's Dad asked, "Hey, did you guys seal up all the food so mice won't get into it tonight?" "Uh, I think so," replied Sam. "Well, what's that rustling I hear?" continued his Dad. "I hear it, too," said Derek. "Where is it coming from?" Everyone stopped moving and strained to hear the faint sounds. "Over there by the rocks, where we ate dinner," said Derek. "Oooh, I think spilled some granola over there," reported Sam. "Well, at least they're not chewing into our main supplies," said his Dad with relief.

"H'mmm," said Derek, "We didn't even have to use our eyes to figure out where the mice were. I wonder how our ears do that." "Yeah," said Sam. "I noticed that after I first heard the sound, I kept turning my head a bit each time I heard it. That seemed to pin down where it was coming from."

Have you ever noticed what you do when you hear a new sound in your surroundings? Most people turn toward the source of the sound. This is our body's way of using senses to find out about things in the environment. One of our senses picks up the first signal that something is happening, and we then use other senses to further investigate the area we have been alerted to. Turning toward the source of a sound lets us direct our eyes to that area. In the dark, however, we rely completely on our hearing.

How do our ears detect sound? How do our brains interpret it? Your teacher will discuss the parts of the hearing or **auditory** system and how they work. This system includes the **outer, middle, and inner ears**, and special **receptor cells** in the inner ear, called **hair cells**. The hair cells detect vibrations and pass this information on to nerve cells, which send messages to **auditory areas of the brain** through long extensions called **axons**.

After your class discussion and experiment, use what you have learned to explain how our sense of hearing allows us to locate sound sources.

Name:_____ Date:_____

What's that Noise?

CLASS EXPERIMENT

LAB QUESTION

PREDICTIONS

SUPPLIES

8 identical noise makers, such as pairs of pencils, chopsticks or "clickers," one for each Noisemaker (person) in your group
Post-it notes numbered 1 through 8
Blindfolds
Diagram of locations of Listeners and Noisemakers, below
Data charts for Recorder - get these from your teacher.

PROCEDURE

1. Write the **Lab Question** and then write your prediction in the boxes above.

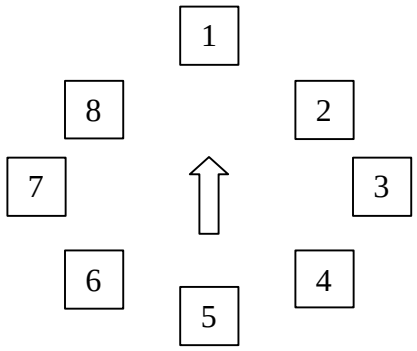
2. Follow all **safety procedures** your teacher recommends.

3. Your teacher will help organize groups and set up the circle of Noisemakers. Let your teacher know if you do not want to be a Listener.

4. Each group will consist of a Listener, eight Noisemakers, and a Pointer/Data Recorder. (Your teacher may decide to modify this arrangement.)

5. Set your group up as shown in the diagram below.

POSITIONS OF LISTENER AND NOISEMAKERS



KEY: ARROW = LISTENER, FACING DIRECTION INDICATED

NUMBERS = NOISEMAKERS

1.	DIRECTLY IN FRONT OF THE LISTENER
3.	DIRECTLY TO THE RIGHT OF THE LISTENER
5	DIRECTLY BEHIND THE LISTENER
7.	DIRECTLY TO THE LEFT OF THE LISTENER
2, 4, 6, 8:	EQUIDISTANT BETWEEN THE ABOVE NUMBERS

6. Each Noisemaker should wear a post-it note number badge that corresponds to his or her place in the circle. Each person should be at least one meter from the Listener, and all people should be the same distance away.

7. The Listener sits on a chair in the middle of the circle and wears a blindfold.

8. The Pointer randomly points at one of the Noisemakers to make a sound with clickers or chopsticks. The Noisemakers should each **make several clicks:** for example, click your pencils together 10 times in about 5 seconds.

9. Noisemakers try to make all their sounds **identical**.

10. **Without moving his or her head**, the Listener points in the direction the sound seems to come from.

11. The Pointer/Data Recorder records whether the Listener pointed correctly on the data sheet (your teacher will supply data sheets). Use + for correct and – for incorrect.

12. The Pointer continues pointing to Noisemakers randomly and recording the correct and incorrect answers. You should do five or more rounds—where one round gives each Noisemaker a chance to make a sound.

13. **Repeat** the procedure, but this time let the Listener **move his or her head** while Noisemakers make their sounds.

14. **Repeat** the entire procedure with **different Listeners**.

15. Tally the correct and incorrect responses (on the Data Recording Sheet) for each Listener for each position, without moving head and with moving head.

DATA AND OBSERVATIONS

- Each group should calculate the **average** number of correct and incorrect responses for all Listeners they tested.

- Your teacher will ask someone in your group to write your results in a class chart.

- **Calculate the entire class average** for correct and incorrect answers for results without moving the head and with moving the head.

- Write down any other interesting things you noticed while doing this experiment.

ANALYSIS: THINK ABOUT IT!

1. Were sounds from certain locations always more difficult to point to than others were when Subjects were not allowed to move their heads? Which locations? What is the explanation for this?

2. Were results of Listeners very different from one another, or all quite similar? What could be some reasons for differences?

3. How does information from the ear get to the brain? Illustrate with a simple diagram.

4. What does the brain do with signals from the ears to let us tell where a sound is coming from?

5. How does moving your head let you tell where a sound is coming from?

CONCLUSIONS

How was the Lab Question answered in your experiment?

List three findings you think are important from today's experiment. Were you surprised by anything you found?

How could you improve this experiment?

OUR SENSE OF HEARING

WHAT ELSE CAN WE FIND OUT ABOUT THE SENSE OF HEARING?

EXPERIMENTS

You can use what you have learned about the hearing system to develop your own experiment. **Explore** the materials your teacher makes available and think of some things you can investigate. Here are some ideas to begin with.

1. Continue the experiments on **locating a sound source**. Could you have the Listener do something else? Can you change what the Noisemakers do?

2. Do animals with **outer ears** different from ours hear things differently? How could you get an idea of what hearing is like for another animal?

3. **Ear safety**: Do most people know how to avoid damaging their hearing? How can you get some **quantitative** information on what people know? Your teacher can help you find Internet resources that tell you how to take care of your hearing.

4. **Sound intensity:** How loud must words be for a person to understand them?. How loud do you have to turn the volume on a recording before a Subject can repeat words on a tape recording? Can you figure out how to quantify this—that is, how to assign number values to the loudness?

5. **Decoding the sounds of speech**: How well do people hear when someone's voice is muffled? How can you make this into an experiment, with a prediction and something to measure and analyze?

HOW TO DESIGN A GOOD EXPERIMENT

In designing experiments to answer questions like these, keep in mind what a **successful investigator** must do:

- Ask a **very specific question**: not, for example, "Can people tell what someone is saying if the speech is muffled?" but rather, "How many layers of cloth over a speaker's mouth will prevent listeners from understanding a familiar phrase?"
- Be sure you understand the **control condition** for your experiment, and then **change only one thing, or variable,** in the experiment. For example, if you do an "animal ear" test, what would your control experiment be? What would your variable be? Researchers try to change only one variable in an experiment. Sometimes this is difficult, but at least they must be aware of other variables, write them down, and think about what effects they might have.

- Make a guess or **prediction** about what will happen in your experiment. If you want to find out what people know about ear safety, you could make a list of questions and predict which ones people will answer correctly or incorrectly.

- Keep good **records** of everything you do.

- **Think** about your results—did you get the information you need, or was there a flaw in your experiment?

- **Write** down your conclusions and suggest plans for the next experiment you could do.

PROJECTS

Some activities are not experiments but rather demonstrations, surveys, or library research projects. For instance, you may decide to investigate American Sign Language, or you may find out something about hearing loss. Here are some ideas for projects.

1. **American Sign Language:** learn the ASL alphabet or some common words and show them to your class; or, ask a hearing interpreter of ALS to talk to the class.

2. **Investigate** owl hearing or bat hearing in your library or on the WWW. How do their hearing abilities differ from humans? What special uses do they make of what they hear?

3. **What is the meaning** of different sounds to humans? buzz, rustle, growl, chirp, laughing, words…. How do our reactions to different sounds reflect our survival, our needs, or our evolution?

4. **List the sounds** you hear in 5 min, while sitting in the cafeteria, the bus, study hall---somewhere that you go regularly. **Next day**, close your eyes and make a list in the same place (you need to quickly open eyes to write, then close again.) Compare the lists. Do you find that you hear more sounds in one case or the other?

NAME:_____DATE:_____

What's that Noise?

TRY YOUR OWN EXPERIMENT

LAB QUESTION

PREDICTIONS

PROCEDURE (Use as many steps as needed.)

1. After you **explore** materials and **brainstorm** ideas for your experiment, each group should agree upon and **write a Lab Question** in the box above.
2. **Write a prediction** for the answer to your question in the box above.
3. **List the steps** you will take to perform your experiment. Include a list of supplies.
4. Figure out what the **control conditions** for your experiment will be, and whether your experiment is one that sets control conditions, or one that tests a new variable, or both.
5. Try to change only one **variable.**
6. Design a **data sheet** or table to record your results.
7. Get your **teacher's OK** before beginning your experiment.
8. **Clean up** your area when you finish.

DATA AND OBSERVATIONS

Your teacher will give you **supplies** for your new experiment.

Record your data, such as how Listeners scored in your test, or the type of animal ears you used and how this affected hearing.

Write down observations on what worked well and what didn't, problems with supplies, or disagreements people had in their groups.

ANALYSIS: THINK ABOUT IT!

1. What is the control condition for your experiment?

2. What did you change or add for your variable? Did you change only one variable?

3. If you investigated animal hearing, what were your results? How do outer ear shapes, sizes, and motility change the way animals hear?

4. Describe any other experiments you did and what you found out.

CONCLUSIONS

How did your results answer your Lab Question?

How certain are you of your conclusions? Would you need more evidence to convince yourself or others that your conclusions are right?

What are some other ideas for experiments on the sense of hearing?

MORE *SENSE OF HEARING* ACTIVITIES

- Do some animals have better hearing than we do? What gives them this acute hearing? How do they make use of it? Check on barn owls or bats.

- Can loud noises permanently damage your hearing? What can you do to protect your hearing?

- What are some hearing problems that people have?

To answer these questions, try looking for some of the following terms in your library or on the World Wide Web:

Conductive hearing loss
Nerve deafness or sensorineural deafness
Cochlear implant
Noise-induced hearing loss
Phantom hearing
Ear infections
Owl ears
Bat ears

HERE ARE SOME **WEB SITES** TO VISIT FOR AUDITORY SYSTEM INFORMATION. GET HELP FROM YOUR TEACHER TO FIND THE BEST SITE FOR YOUR PROJECT.

http://www.nidcd.nih.gov/health/kids/index.htm - National Institute of Deafness and Communication Disorders (NIDCD) – this is the teacher and student site; you can go to the general NIDCD site by clicking on "home" (works best with Shockwave)

http://www.nidcd.nih.gov/health/kids/owlgame/owl.html#8 - hearing quiz at the above site

http://www.nidcd.nih.gov/health/pubs_hb/presbycusis.htm - National Institutes of Health site on age-related hearing loss

http://www.nidcd.nih.gov/health/pubs_hb/noise.htm - National Institutes of Health site on noise-induced hearing loss

http://faculty.washington.edu/chudler/chhearing.html - more experiments to investigate the sense of hearing (from Neuroscience for Kids)

http://ctl.augie.edu/perry/ear/hearmech.htm - "virtual tour of the ear". Click on Outer Ear, Middle Ear, or Inner Ear.

http://medic.med.uth.tmc.edu/Lecture/Main/ear.htm - this is the site that the Virtual Tour of the Ear uses under its Inner Ear heading: good diagrams

http://www.cscd.nwu.edu/public/ears/hearloss.html - excellent discussion of types of hearing loss (conductive vs. sensorineural); from Northwestern University

http://www.sfn.org/briefings/hearing.html - Society for Neuroscience (SFN) brain briefings: restoring hearing with cochlear implants

http://www.sfn.org/briefings/deafness.html - SFN brain briefings: deafness genes

http://www.sfn.org/briefings/hair_cell.html - SFN brain briefings: hair cell regeneration

http://kidshealth.org/kid/body/ear_SW.html - information for late elementary to middle school students

http://kidshealth.org/kid/stay_healthy/body/ear_care.html - same web site as above, but links you to tips on taking care of your hearing.

www.iurc.montp.inserm.fr/cric/audition/english - "promenade around the cochlea" good pictures

http://www.discover.com/search/index.html - blind people do have better hearing

http://www.discover.com/feb_99/breakpinna.html - folds of the pinna give each person an individual auditory map

http://www.sissa.it/bp/Cochlea/index.html - Fabio Mammano's page on the cochlea; see a traveling wave on the basilar membrane!

http://www.sissa.it/bp/Cochlea/utils/basilar.htm - from same site as above, a drawing of basilar membrane

http://www.hhmi.org/senses/c/c110.htm - Howard Hughes Medical Institute site. Hair cell mechanisms; owls' location of prey in the dark—see: Locating a Mouse by its Sound.

http://146.139.100.40/webpages/askasci/phy99/phy99405.htm - decibel levels