Teacher Guide

Balance: The Ears Have It

Lesson Summary: The vestibular system controls our balance, providing information on spatial orientation for head position and posture. Spinning a student around in a chair demonstrates how the vestibular system senses different types of circular motion. Using these observations, students will design and conduct experiments to explore vestibular function.

Grade Level 5-8

Lesson Length
1 class period

Standards Alignment

Next Generation Science Standards

- MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
- 4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.
- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- **Framework for K-12 Science Education**: Science & Engineering Practices 3,4,6,7,8

National Science Standards – Project 2061: Atlas of Science Literacy reference

a) Systems – boundaries and interacting parts (p. 133, Atlas Vol. 1)
Research on student learning: "Research done in connection with SCIS (Science Curriculum Improvement Study) indicates elementary students may believe that a system of objects must be doing something (interacting) in order to be a system or that a system that loses a part of itself is still the same system." (p.132, Atlas Vol. 1)

b) Scientific inquiry: Evidence and reasoning in inquiry – observations and evidence (p.17, Atlas Vol. 1)
Research on student learning: "Middle-school students tend to invoke personal experiences as evidence to justify a particular hypothesis. They seem to think of evidence as selected from what is already known or from personal experience or second-hand sources, not as information produced by experiment." (p.16, Atlas Vol. 1)

Objectives—Students will be able to

- describe the processes at work in the vestibular system when the human body responds to circular motion.
- describe the role of the vestibular system when the human body responds to circular motion.
- design and conduct an experiment to learn more about how the vestibular system is affected.

Assessment Options

- Grade students' written or drawn and labeled description of the processes at work in the vestibular system when the human body responds to circular motion.
- Grade students' written or drawn and labeled description of the role of the vestibular system when the human body responds to circular motion.
- Collect and grade lab report of student-designed and conducted experiment.

Terms are important vocabulary that can strengthen the lesson. Select terms according to the needs and abilities of your students. Visit the Neuroscience Glossary on the website for additional terms and definitions.

- Vestibular system – the system found in the inner ear that helps maintain balance and judge a person's position in space, even with the eyes shut.
- Nystagmus – an involuntary rhythmic eye movement that occurs when a person is spun around and then suddenly stops
- Inertia - the tendency of a body to remain in a state of rest or uniform motion unless acted upon by an external force

Teacher Notes — Visit BrainU.org to download background information on the Vestibular System, Science Standards Alignment, and Hair Cell Model templates and assembly instructions on the Balance: The Ears Have It lesson page**.**

Materials

- 4 feet of 3cm wide masking tape
- 1 spinning chair per group of 4 students

SAFETY NOTES

- Some students may experience nausea while spinning and should be excused from the role of *spinnee*.
- Everyone should watch carefully and be prepared to stabilize the individual who is spinning during the explore phases.
- Spinning should be done in an open area, away from tables, lockers, or any other objects. If done indoors, you may wish to lay athletic mats on the floor in case a student falls.

Engage – Walking the Line

1. Place a 7-foot strip of wide masking tape on the center of a hallway floor or open space.
2. Ask a student volunteer to be spun (the *spinnee*). The teacher will be the *spinner* and will spin the student.
3. Line up the rest of the class about 3 feet away from either side of the tape.
4. Tell the *spinnee* to face the line and to shut his/her eyes.
5. Instruct the *spinnee* to keep his/her arms by his/her side during spinning. The teacher will spin the *spinnee* 5 times from behind and stop the *spinnee* so that s/he faces the line and is perpendicular to it.
6. Then ask the *spinnee* to open his/her eyes and immediately "walk the line."
7. All students should write down their observations.

Explore – Eye Tracking

1. Divide students into groups of four. Give each group an office chair or some other chair that will spin around.
2. In each group, students pick one person to be the *spinnee*, two others to be the *spinners*, and one person to observe and record what happens.
3. Ask the *spinners* to stand behind the chair and the observer to stand a little bit to the front while the *spinnee* sits in the chair. Do not let students start spinning yet. Tell the *spinnees* to keep their eyes closed and arms down by their sides for the whole spinning time.
4. Both *spinners* should start spinning the chair at a medium speed, taking care that the *spinnee* doesn't fall off the chair.
5. After 5-10 spins, the *spinners* should stop the chair when the *spinnee* is facing the observer.
6. Once the *spinnee* has come to a complete stop, s/he should immediately OPEN HIS/HER EYES.
7. The observer records the eye movement of the *spinnee*.
8. Each group will develop an explanation for their observations. If time permits, repeat the procedure with another person in the group as the *spinnee*.
9. Ask the groups to share their observations and explanations with the class.

Make sure students understand the major concepts in this activity before designing experiments on their own. If you are concerned that students do not understand what is occurring, you may want to use one of the following suggested strategies:

- After students share their observations and explanations, they should be able to see for themselves what issues they understand and where they need further assistance.
- Form a group of Teacher Assistants and let those students answer questions within groups. The teacher can determine who the assistants should be by developing a set of questions to ask each member of a group orally. Based on the answers, you can determine which students understand the concept and can help other groups clear up misunderstandings. If those questioned do not understand, the teacher can give them additional questions and repeat the process with another group to identify teacher assistants.

Develop Questions

1. In groups, request that students develop a scientific question that tests an effect on the vestibular system.
2. As a class, students will share the questions they developed.
3. Direct the class to identify questions that are testable. Discuss if all questions can be feasibly tested and re-write any questions that are not testable.

Explore – Student Tests

1. In the same groups, have students design and conduct their experiment.
2. Students should develop their own predictions and procedures.
3. Once students conduct their experiments, they should analyze their data and then share their results with the class.

Explain

- After students have shared their experimental results, as a class, determine which tested **variables** affect the vestibular system and which variables do not.
- Allow time for students to discuss why they think certain variables affect or don't affect the vestibular system.

Expand (Optional)

- Students may write a lab report for their experiment.
- Students could design an experiment using *C. elegans* that tests something other than worm preference.

Suggested Reading

- Goldberg, M.E., Eggers, H.M. & Gouras, P. (1991). **The Ocular Motor System**. In E.R. Kandel, J.H. Schwartz & T.M. Jessell (Eds.), Principles of neural science (pp. 660–678). New York: Elsevier Science Publishing Company. Kelly, J.P. (1991).
- **The Sense of Balance**. In E.R. Kandel, J.H. Schwartz & T.M. Jessell (Eds.), Principles of neural science (pp. 500–511). New York: Elsevier Science Publishing Company.

This document adapted with permission from **Neuroscience Laboratory and Classroom Activities (1996): What Else do Ears do?** pp. 37-58 -- a publication developed by the National Association of Biology Teachers and Society for Neuroscience, with funding from the National Institutes of Health available at https://nabt.org/files/galleries/04NLCAchp2.pdf. Additional background derived from Balance Disorders: NIH Publication No. 00-4374, January 2000, retrieved 3 July 2003 from the National Institute on Deafness and Other Communication Disorders website.