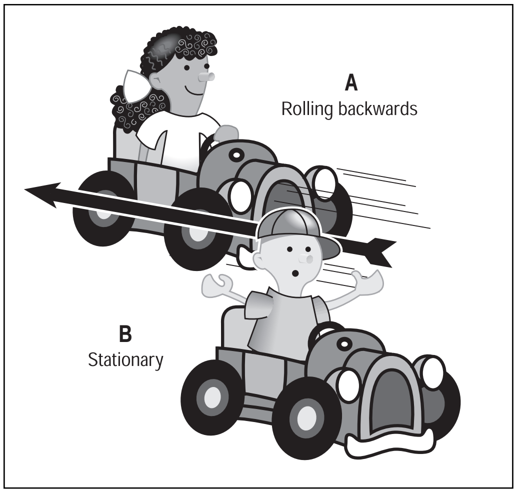

Figure 40 *Diagram of vection.*

Vection is the illusion that the body is moving in a circle (circular vection) or in a line (linear vection) when, in fact, external visual cues are moving relative to the body. For example, vection occurs while we are sitting in a parked car, reading, or looking ahead. We sometimes "feel" as though the car is rolling, when, in reality, the vehicle next to the car has started moving (Figure 40). Visual cues, especially those located in the periphery of one's vision (things a person can see out of the corner of his or her eye) strongly affect sense of movement, even without any sensations in the inner ear vestibular system, and without any actual movement of the body.

LEARNING ACTIVITY I:
Visualizing How the Vestibular System Works

OVERVIEW

In this activity, students will learn about the effects of different types of motion on the hairs suspended in fluid in the inner ear.

SCIENCE & MATHEMATICS SKILLS

Observing, collecting and recording quantitative data, measuring angles of rotation, calculating averages, creating charts, creating models, drawing conclusions

PREPARATION TIME

15 minutes (at least one day before the activity)

CLASS TIME

50 minutes

MATERIALS

Each group of 3 – 4 students will need:

- One tube of super glue (should be water resistant and adhere to glass and hair-like fibers) OR a hot glue gun and glue sticks
- Automatic turntable (such as for pottery class), centrifuge, or other rotating device (such as a Lazy Susan or old record player)

MAJOR CONCEPTS

- Hair cells within the vestibular system are affected by movement of the head in different directions.
- Movement causes fluid in the inner ear to shift, bending the hairs attached to the hair cells.
- Hair cells send messages to the brain indicating the direction of movement.
- Hair cells specifically are sensitive to changes in the speed or direction of motion.

MATERIALS (*cont.*)

- Set of false eyelashes or strands of another fuzzy or wispy material
- Clear glass jar or cylinder with lid
- Water
- Watch
- Note pad
- Pen or pencil

BACKGROUND

In this activity, students create a model that permits them to visualize the movement of fluid and bending of hairs in the inner ear in response to motion. It also demonstrates how the vestibular system maintains or restores equilibrium despite movement.

The vestibular system is key to our senses of balance and self-motion.

Located in the inner ear, the vestibular apparatus is comprised of three canals containing fluid and receptor cells, called hair cells. Long hairs extend from the hair cells into the canals and are embedded in the cupula. Motion of the head causes the fluid in the canals to shift or move, which in turn, causes the hairs to bend. The direction of the movement determines the direction in which the hairs are bent. When motion ceases, the vestibular system reacts in the opposite direction until equilibrium is reached again and the hairs are motionless.

In this activity, students will observe the importance of acceleration and deceleration in producing movement of hairs suspended in fluid. Students will be able to see how water within a rotating cylinder first accelerates, and then decelerates, as the movement stops. Because the speed is constantly changing during this movement, hairs within the cylinder will be bent to different degrees. While accelerating, they bend more; while decelerating, they straighten. If rotation continues at a constant speed in a constant direction, the hairs remain in a stable unbent position.

In this exercise, students can observe and compare how the "hairs" move as a container of fluid is rotated in different directions, with acceleration and deceleration, and at a constant speed. These observations can then be compared to the way in which the vestibular organs respond to different types of head movements. Students can measure and compare the amount of time it takes to restore equilibrium with different degrees of motion and acceleration.

PROCEDURE

1. At least one day before actually performing the activity, glue (or have the students glue) the false eyelashes or strands of other fuzzy material to the inside of the beakers, jars or glass cylinders. Attach to the side of the cylinder (not the bottom).
2. Organize students into pairs or groups of 3 – 4, depending on the amount of materials available.
3. Have one student from each group fill the cylinder with water. Let the water settle until it is motionless.
4. Direct the students to rotate the cylinder quickly 90 degrees to the right (maintaining the vertical position of the cylinder) and observe what happens to the hairs on the eyelashes (Figure 41B).
5. Have the students rotate the cylinder 90 degrees in the other direction and record observations.
6. After the motion stops, have students quickly rotate the cylinder 180 degrees to the right, this time using a watch to measure the amount of time required for the hairs to return to the straight position. Have students record the time (Figure 41D).
7. Direct the students to repeat this procedure, with each student taking a turn rotating the cylinder, observing the watch, and recording the time. Have them record the name of the person who rotated the cylinder and the person who observed the watch beside the measured time.
8. Have the students calculate the average time required for the hairs to come to rest after rotating the cylinder, and to record their calculations.
9. Have students quickly rotate the cylinder 90 degrees to the right and then immediately rotate 180 degrees to the left, measuring the time required for the hairs to stop moving. Have them record their observations.

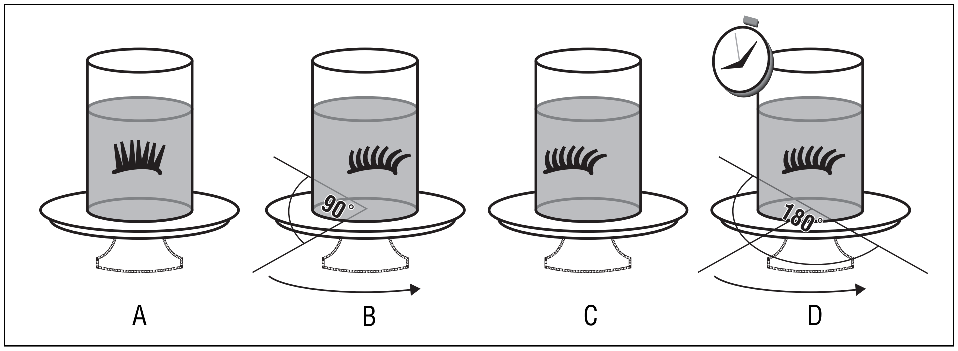

Figure 41 *Diagram of furry or wispy material or false eyelash in motion.*

Figure 41A *at rest.* Figure 41B 90° *rotation.* Figure 41C *motionless.* Figure 41D 180° *rotation.*

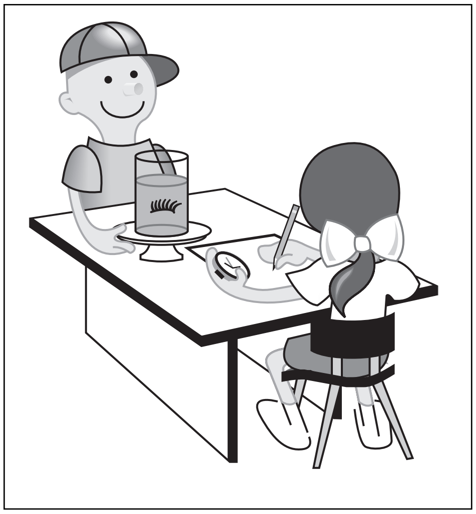

Figure 42 *Diagram of students observing fuzzy material in action.*

10. Have students present their data from steps 7, 8 and 9 in tabular format (Figure 43).

11. If a rotating device or turntable is available, have students place the cylinder on the device and rotate slowly (so as not to splash or dislodge the eyelashes) at an even rate for one minute (Figure 42). Have them time one minute using the watch. Ask the students to observe what happens to the hairs as they continue to spin, and after rotation is stopped. Have them record their observations.

90 degrees (observations)	180 degrees (time)	90/180 degrees (time)	1 minute rotation (observations)	Person rotating	Person w/stopwatch

Figure 43 *Example of chart to record motion observations.*

EVALUATION

At this point, students should understand how rotation of varying direction and magnitude affects the motion of hairs suspended in fluid.

REVIEW QUESTIONS

1. **How did the direction of rotation affect the direction in which the hairs bent?**
   The hairs bent in the opposite direction of the rotation.

2. **Was there a difference in the time required for the hairs to stop moving after the 90 degree and 180 degree rotations? How do you explain this?**
   Students' answers will vary. There should be no difference in the time because both stops were sudden and the movement was not continuous.

3. **What happened to the hairs when the rotation was continuous for one minute? What happened to the hairs when the rotation suddenly stopped? What do you think happens to our vestibular system when we spin continuously for a period of time? What happens when we stop suddenly?**
   The water and hair cells moved together which allowed the hair cells to straighten out when the motion was constant for one minute. When

the hairs suddenly stopped, the water caused them to move forward. The hair cells move in the direction of the spinning. When suddenly stopped, we fall forward and if we try to stand up we experience dizziness.

THINKING CRITICALLY

1. **In step 7, each student took a turn at each task. Were the times measured the same or different for each student? What might account for the differences in time?**

2. **If the water in the cylinders was replaced with another substance that was more dense, such as liquid detergent, or less dense, such as air, how would the movement of the hairs change?**
   What if the hairs were in a vacuum? What other factors might affect movement?
   If the hairs were placed in a dense liquid, the movement would be slower and not as obvious. If they were placed in a less dense substance, movement would be faster and more obvious. If they were placed in a vacuum, there would be no movement of the hairs.

3. **Why do patients who are bed-ridden for long periods of time often experience dizziness and difficulty standing upright?**
   These patients experience dizziness because their vestibular systems have not been required to function. Due to the lack of movement, when the patients stand, the vestibular systems are activated and their bodies have to adjust.

SKILL BUILDING

Have students pool their measurements from the different trials and calculate class averages. How much did the individual measurements vary from the class averages? What does this tell us about incorporating several trials into the design of an experiment?

STUDENT ACTIVITY SHEET
Visualizing How the Vestibular System Works

Name ______________________________ Date ______________

OBJECTIVE

To learn about the effects of different types of motion on the hairs suspended in fluid in the inner ear.

MATERIALS

- Tube of super glue
- Rotating device
- Fuzzy or wispy material
- Clear glass jar or cylinder with lid
- Water
- Watch
- Note pad
- Pen or pencil

DIRECTIONS

Work in groups of four, maximum. Your group will need all of the materials.

PROCEDURES

1. At least one day before actually performing the activity, glue the fuzzy material to the inside of the beaker or glass cylinder. Attach the fuzzy material to the side of the beaker or cylinder (not the bottom).
2. Have one member from your group fill the cylinder with water. The water should settle until it is motionless.
3. Rotate the cylinder quickly 90 degrees to the right (maintaining the vertical position of the cylinder) and observe what happens to the fuzzy material (Figure 44B).

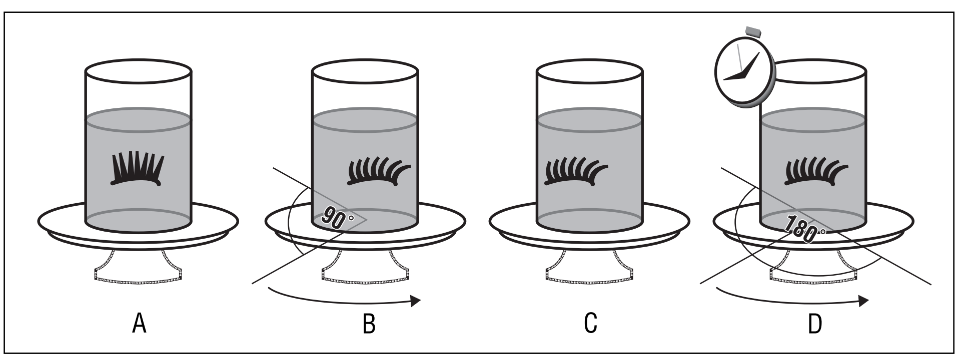

Figure 44A *at rest.* Figure 44B 90° *rotation.* Figure 44C *motionless.* Figure 44D 180° *rotation.*

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Name ______________________________ Date ______________

4. Rotate the cylinder 90 degrees in the other direction and record observations.
5. After the motion stops, quickly rotate the cylinder 180 degrees to the right, this time using a watch to measure the amount of time required for the hairs to return to the straight position (Figure 44D). Record the time.
6. Repeat the procedures, with each student in your group taking a turn rotating the cylinder, observing the watch, and recording the time. Using the chart, record the name of the person who rotated the cylinder and the person who operated the watch beside the measured time.
7. Calculate the average time required for the hairs to come to rest after rotating the cylinder, and record your calculations.
8. Quickly rotate the cylinder 90 degrees to the right and then immediately rotate 180 degrees to the left, measuring the time required for the hairs to stop moving. Record your observations.
9. Present your data from steps 6, 7, and 8 in tabular format (Figure 45).
10. If a rotating device is available, place the cylinder on the device and rotate slowly (do not splash or dislodge the fuzzy material) at an even rate for one minute. (Use the watch to time one minute.) Observe what happens to the hairs as they continue to spin, and after rotation is stopped. Record your observations.

Understanding the Vestibular System

90 degrees (observations)	180 degrees (time)	90/180 degrees (time)	1 minute rotation (observations)	Person rotating	Person w/watch

Figure 45 *Example of chart to record motion observations.*

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Name ______________________________ Date ______________

Understanding the Vestibular System

90 degrees (observations)	180 degrees (time)	90/180 degrees (time)	1 minute rotating (observations)	Person rotating	Person w/watch