The Barany Chair

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The Barany Chair experiment illustrates the ability of the inner ear's vestibular apparatus to detect changes in rotational motion.

Image Reference

A Training Device

STS-40 Space Shuttle astronauts conduct rotating (Barany) chair investigations.

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A Training Device

The Barany Chair is a training device used to prepare pilots and astronauts for flight situations in which their senses may be hindered.

Image Reference

National Aeronautics and Space Administration. Barany chair investigation. Retrieved 1-13-10, from http://www.nasa.gov/multimedia/imagegallery/index.html.

Our Senses

- How many senses do humans have?
  - The common answer is “five” (sight, taste, hearing, touch, smell).
  - In fact, there are other senses, such as the ability to sense your body’s movement or a change in motion.
- Senses sometimes can send false information, which can affect decision making while operating aircraft or other vehicles, or while carrying out other activities.

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Our Senses

The five classic senses of sight, taste, sound, touch, and smell are well known, but did you know that we possesses other senses, too? For example, proprioperception is the sense of knowing where your body is in regard to the external environment. This sense allows a person to point to his or her nose or other body part, even when his/her eyes are closed.

Gravity and other forces act on sensors in our bodies that inform the brain about our body position. Certain flight conditions (e.g., cloudy, dark, microgravity) can compromise a pilot’s ability to sense motion, thereby impeding his or her ability to operate the aircraft safely.

Sensing Yaw Motion

- The rider (in the Barany chair) is blindfolded and wears sound deadening ear protectors to isolate the vestibular sense.
- The chair is spun uniformly and smoothly.
- The rider is asked to indicate the direction in which he or she is moving by pointing his or her thumbs.

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Sensing Yaw Motion

Make clear to participants that they are to use their thumbs to indicate the direction in which they feel they are moving while in the Barany chair (either left or right). To denote no movement, they should point their thumbs straight upwards. If a rider feels a change in motion while spinning, he or she should indicate this shift with his/her thumbs.

Strap the participant securely into the Barany chair. Provide a blindfold and ear protectors to block out stimuli that may interfere with the vestibular sense. To achieve further sense isolation, you may ask the participant to close his/her eyes and instruct others close by to remain as quiet as possible.

Spin the chair around uniformly and smoothly.

Image Reference

Vogt, G.L. (2009). *The Barany Chair*. Center for Educational Outreach. Houston, TX: Baylor College of Medicine.

What Happened?

Occular Nystagmus

- Rhythmic, oscillating motions of the eye caused by a sudden stop in angular motion.
- The continued motion of the endolymph fluid in the semicircular canal “tricks” the brain into believing that the body is still moving.
- The rider’s eyes shift to track objects in the room, even though the motion has stopped.

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What Happened?

Even after the chair has come to a full stop, fluid within the ear continues to move, and the participant may feel he/she is still spinning. This ongoing sense of motion may lead to occular nystagmus, an oscillating motion of the eye. Even though the body is not moving, sensors in the brain indicate that it is still spinning. To compensate, the eyes attempt to fix on stationary objects to stabilize themselves.

Sensing Roll Motion

- In a second test, the volunteer bends over to position his or her head close to his/her knees.
- The chair is pushed uniformly and smoothly.
- After the chair has stopped moving, the volunteer sits up straight with his or her eyes open.

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Sensing Roll Motion

In a second test, the participant is once again strapped securely into the Barany chair. Have the participant bend over to position his or her head above his/her knees. Spin the chair uniformly and smoothly, making the sure the participant remains in the original (bent) position. When the chair has come to a stop, have the participant sit up straight and open his/her eyes.

Image References

Vogt, G.L. (2009). *The Barany Chair*. Center for Educational Outreach. Houston, TX: Baylor College of Medicine.

What Happened?

- When the person in the Barany chair sits straight up, he or she experiences a powerful cartwheeling sensation to the left or right.
- Because the person's head was tilted forward, the roll axis in the semicircular canal was brought into the same plane of rotation as the chair. When the chair stopped and the head was returned to a vertical position, the fluid in the canal continued to move, which caused a sensation of tumbling.

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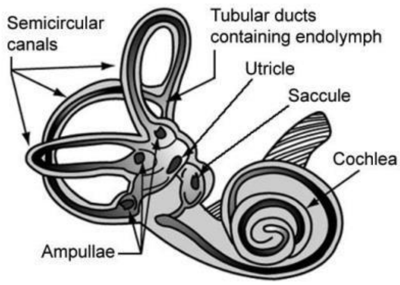
What Happened?

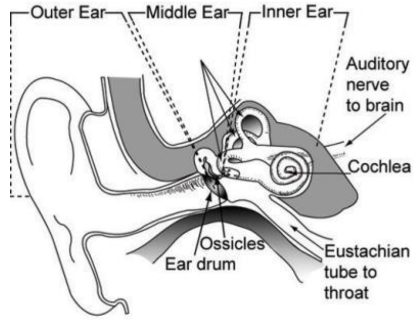
After sitting up, the participant may feel as if he or she is performing a cartwheel. His or her body may attempt to "correct" itself by moving in the direction opposite of the cartwheel sensation (so be sure participants are strapped in properly). While the participant was bent over, fluid within the ear was on the same plane as the chair. After the participant sat straight up, the fluid continued moving, and this caused the cartwheel sensation.

Semicircular Canals

Motion-changing sensors inside our ears.



The Vestibular System
semicircular canals and otolith organs



The Outer, Middle, and Inner Ear

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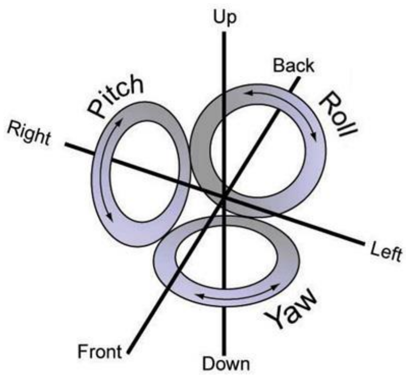
Semicircular Canals

Within our ears are three semicircular canals, which are situated at right angles to each other and connected to the brain via bundles of nerves. The three canals sense changes in body motion, with each canal detecting motion on a different plane.

Image Reference

Coulter, G., Vogt, G. (2009). *The outer, middle, and inner ear: The effects of space flight on the human vestibular system*. Retrieved 1-14-2010, from http://weboflife.nasa.gov/learningResources/vestibularbrief.htm.

The Vestibular System



The semicircular canals are oriented along the following three planes in the inner ear.

- Pitch: up and down
- Roll: left to right
- Yaw: lateral movement left to right

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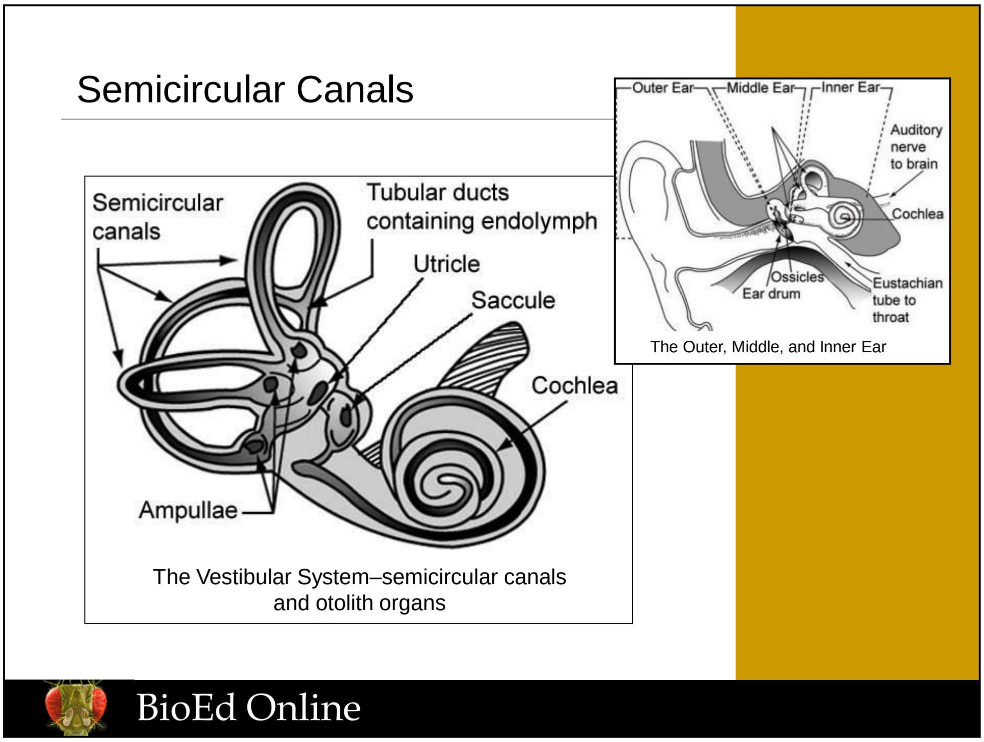
The Vestibular System

The three planes on which motion can be detected are known as yaw, pitch, and roll. Pitch refers to the "up and down" plane; roll to the "left and right" plane; and yaw to the "lateral left and right" plane.

Image Reference

Vogt, G.L. (2009). *The Barany Chair*. Center for Educational Outreach. Houston, TX: Baylor College of Medicine.

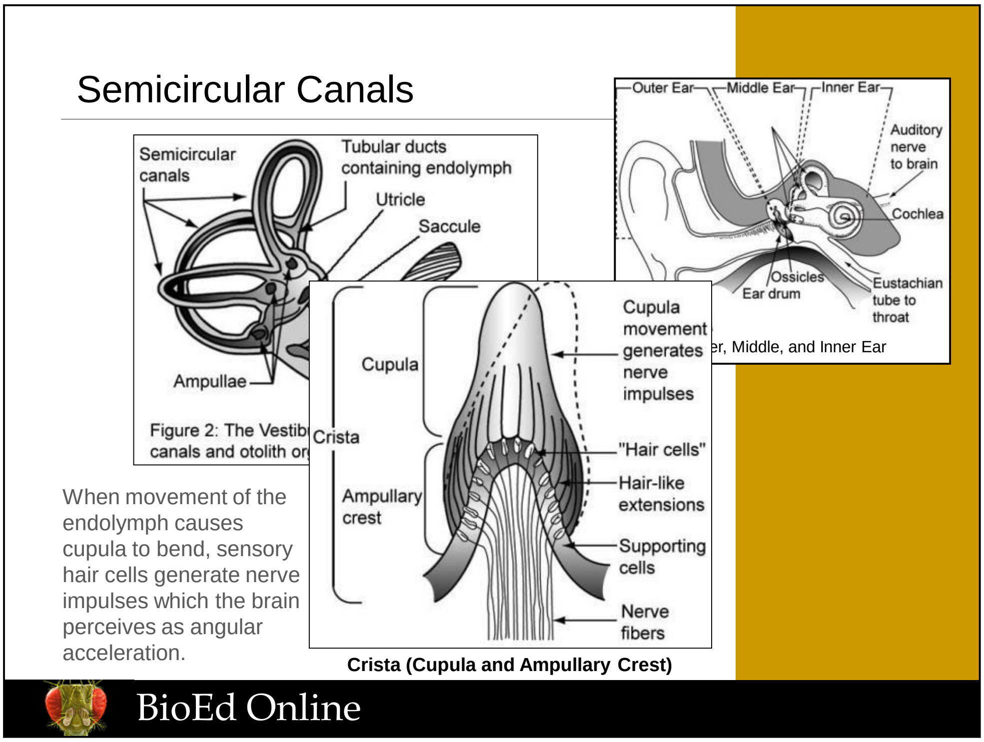


Semicircular Canals

Protruding structures inside the ear, called the ampullae, contain sensory hair cells surrounded by endolymph fluid. As the body moves, the fluid within the ear moves as well. Due to inertia, however, the fluid moves more slowly than the body does. When we move very rapidly, there may be a small delay as the fluid "catches up" with the body.

Image Reference

Coulter, G., Vogt, G. (2009). *The outer, middle, and inner ear: The effects of space flight on the human vestibular system*. Retrieved 1-14-2010, from http://weboflife.nasa.gov/learningResources/vestibularbrief.htm.

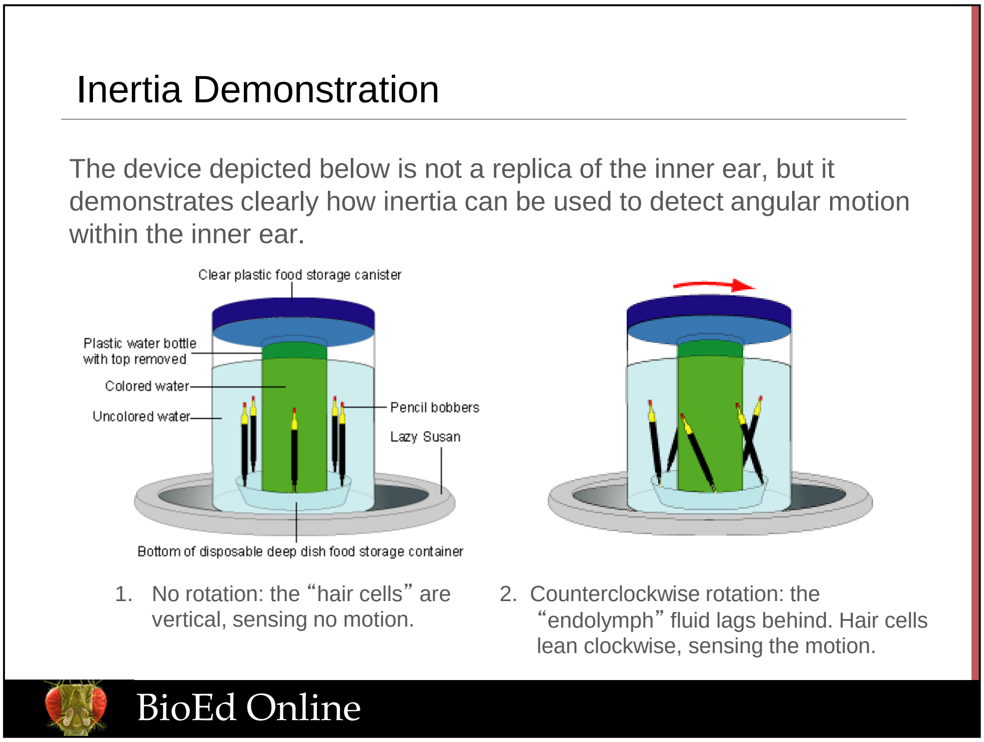


Semicircular Canals

As endolymph fluid moves, it pushes against the sensory hair cells in the ampulla, causing them to bend in one direction or another. The hairs send information regarding the body's motion and position to the brain. When the fluid comes to rest, the hair cells return to an upright position.

Image Reference

Coulter, G., Vogt, G. (2009). *The effects of space flight on the human vestibular system*. Retrieved 1-14-2010, from http://weboflife.nasa.gov/learningResources/vestibularbrief.htm.



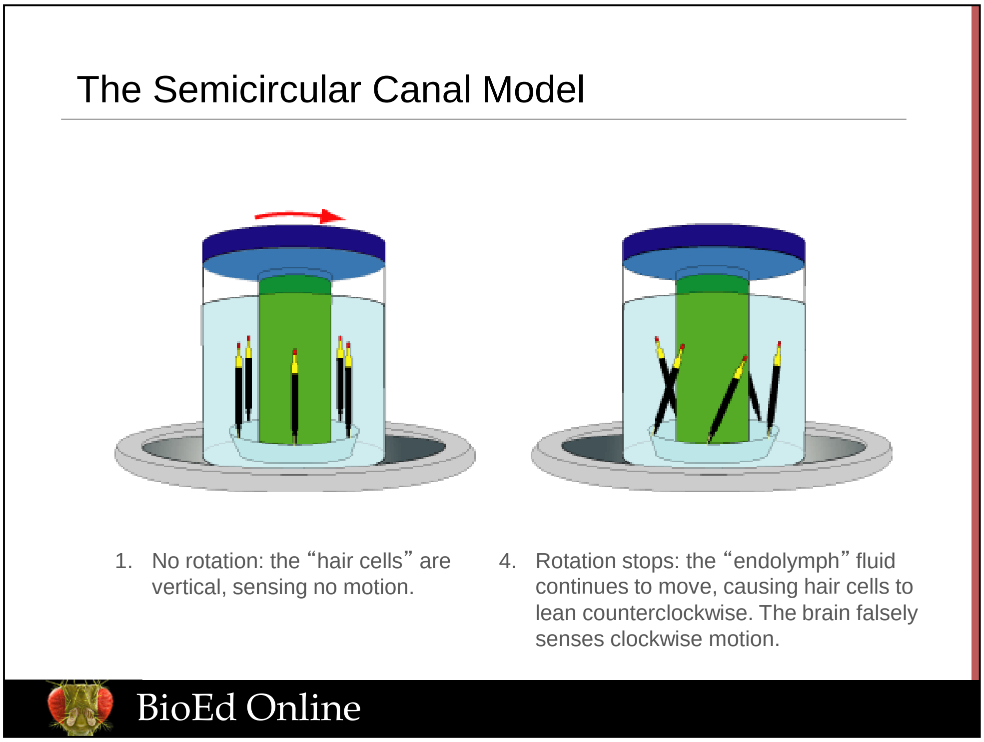
Inertia Demonstration

A simple classroom model can be built to reproduce the action of hair cells within the ear. In this model, water represents the endolymph fluid, and pencil “bobbers” represent sensory hair cells. Use string or fishing line to attach several pencil bobbers to the bottom of a food container. Make sure that the bobbers are evenly spaced and arranged so that the bottom of each bobber almost touches the rim of the container. Attach a plastic bottle with the top removed, or large diameter PVC pipe, to the center of the food container. Place the apparatus within a storage canister and fill the canister with water. Put the top on the canister and place the entire canister on a lazy susan.

First, observe the bobbers at rest (they will be vertical, detecting no motion). Then spin the canister counterclockwise. Initially, the inertia of the fluid resists the change in motion, so the bobbers will lean clockwise.

Image Reference

Vogt, G.L. (2009) *The Barany Chair*. Center for Educational Outreach. Houston, TX: Baylor College of Medicine.



The Semicircular Canal Model

As rotation continues, the fluid will "catch up" with the counterclockwise motion. After rotation stops, the fluid continues to move, causing the bobbers to lean counterclockwise. This creates a false sense of clockwise motion.

Image Reference

Vogt, G.L. (2009) *The Barany Chair*. Center for Educational Outreach. Houston, TX: Baylor College of Medicine.

Reversing the Effects of Inner Ear Fluid Movement

Reversing the Effects of the Inner Ear Fluid Movement

The effects of inner ear fluid movement can be reversed by turning in the direction opposite of the spin. This trick is used by figure skaters, who direct their heads away from the direction of their spins before landing.

Image Reference:

Karbownik, E. (2007). *Andrei Lutai*. Retrieved 1-14-10, from http://en.wikipedia.org/wiki/File:Andrei_Lutai_-_skok.JPG.

Paré, C. (2006). *Jessica Miller and Ian Moram*. Retrieved 1-14-10, from http://en.wikipedia.org/wiki/File:Jessica_Miller_%26_Ian_Moram_Throw_Jump_-_2006_Skate_Canada.jpg.