FEATURE: How You Keep Your Balance

VOICE: Professor, I sometimes wish I could be an astronaut. Flying in space would be exciting!

PROF.: Yes, but it would also be very disorienting. Let's talk about some of the ways that people keep their balance – in space and on Earth.

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VOICE: Professor, I just saw an interesting picture on the NASA website. It shows five astronauts upside down in the International Space Station.

The caption says, "In orbital free-fall, their topsy-turvy pose for the camera presents no problems like hairs falling out of place or blood rushing to the head."

PROF.: Yes, a "zero-gravity" environment does have some advantages. But it also gives astronauts some major inconveniences. Read what the NASA website says next.

VOICE: "Imagine waking up, startled by the bright flash of a cosmic ray inside your eyes. Groggy from sleep, you wonder, *which way is up? And where are my arms and legs?"*

PROF.: First-time space travelers often become confused about "up" and "down."

VOICE: That's not surprising. The body's balance system was designed to work in the gravitational pull that we experience on Earth.

PROF.: Yes. Dr. Geoffrey Simmons gives details: "Our balance is managed primarily by three semicircular canals, called the vestibular system, found in each ear. These fluid-filled canals are complex gyroscopes, which respond to (1) ***spinning***, (2) changes in acceleration in the ***vertical*** axis such as occur on a moving elevator, and (3) changes in acceleration in the ***horizontal*** axis such as occur during walking."

VOICE: How many of those canals do we use at the same time?

PROF.: At least two, and usually all three. They can work separately or together, and they can do their jobs with or without additional information in the form of sight or sound. Dr. Simmons says, "They give us unified, uninterrupted input for good balance and fine coordination. Without them, walking down the sidewalk would feel like walking across the deck of a rocking ship."

VOICE: So sensors in the inner ear are part of the body's balance system. They can sense the pull of gravity and signal the brain with information about our body's orientation.

PROF.: However, in space, the vestibular system doesn't sense the familiar pull of gravity. Former shuttle astronaut Robert Parker recalls, "One of the questions they asked us during our first flight was, 'Close your eyes. Now, how do you determine up?'"

With his eyes closed, his sense of up and down had vanished.

VOICE: What did the NASA website mean when it said an astronaut might awaken from sleep and wonder, "Where are my arms and legs?"

PROF.: The zero-gravity environment makes arms and legs appear ***weightless***, so sensors inside the body give astronauts the impression that their arms and legs have disappeared. One American astronaut reported, "The first night in space when I was drifting off to sleep, I suddenly realized that I had lost track of...my arms and legs. For all my mind could tell, my limbs were not there. However, with a conscious command for an arm or leg to move, it instantly reappeared – only to disappear again when I relaxed."

Another astronaut woke in the dark and saw a glowing watch looking as if it was floating in front of them. He realized later that the watch was around his own wrist.

VOICE: How does the vestibular system detect motion?

PROF.: The receptors are hair cells similar to those found in the cochlea. Each cell has between 40 and 70 smaller hairs, which are covered by a membrane. Dr. Simmons illustrates, "Picture a blanket covering the outstretched hands of hundreds of people. If some giant were to pull that blanket, every finger would sense the same motion at the same time. Each finger would also know if the pulling were to slow down, speed up, or cease."

VOICE: The same thing happens to a lesser degree when I'm driving.

PROF.: Yes. When you press down your car's accelerator, the fluid-covered horizontal membrane in each ear lags behind, bending the hairs in the opposite direction. This tells you that you are moving forward. The faster the hairs bend, the faster you know you are accelerating.

VOICE: And when I use the brakes, the membrane signals a speed change.

PROF.: Fluid in the other canals works similarly. Turn to the right and the fluid goes left; look up and the fluid goes downward. If the vehicle reaches a steady speed, the canals inform the brain, making it easy for us to ride a train or enjoy a Ferris wheel." The same mechanism tells an elderly person to use a cane or a young child to hold on to his parent's hand.

VOICE: How long does it take for the sensors to deliver their signals to the nervous system?

PROF.: The impulses from the vestibular nerve arrive at the midbrain and cerebellum in milliseconds, enabling us to adjust rapidly to most changes in position. Every move, no matter how small, is coordinated.

Dr. Simmons says, "Without these mechanisms, you might push away from the table and fall backward. If you were to roll over in bed, you might keep rolling; or if you tried to catch a ball, you would most likely miss it and injure yourself with the landing. Every car ride would cause horrid motion sickness; boat rides would be out of the question; and balancing acts unheard of."

VOICE: If the textbooks are accurate, the vestibular system isn't the only part of the body that people rely on for balance and orientation. I was reading that some specialized sensors tell where the body parts are in relationship to each other.

PROF.: Yes, they are called ***proprioceptive sensors.*** They sense which muscles and tendons are tense and which are relaxed, and in which direction they are pulling. That information helps them to know which parts of the body are in what positions and where they are moving.

VOICE: But when our various balance systems send conflicting messages, they can make us sick.

PROF.: Yes. One website explains, "Our sense of balance is so complex that even if all components are working fine – the balance organs, the feedback from our limbs, and our eyes – if there's any ***disagreement*** about what's going on, the result can be unpleasant. …Seasickness is caused when the central nervous system receives conflicting messages from these three systems."

VOICE: That happens when one system says we are right-side-up, while another says we are upside down or tilted 90 degrees to one side. Or one system says we are spinning, while another system says we are standing still.

PROF.: The ultimate test for our sense of balance is a trip into space. In fact, some specialists say that an even more difficult test is a trip on board what NASA calls "the Vomit Comet." It consists of a KC-135 airplane, flying parabolic arcs to create short periods of weightlessness. One journalist says this ride is so upsetting to the body's equilibrium that first-timers in space can sometimes end up in hospital, being fed intravenously because their stomachs cannot hold food or liquid.

VOICE: That would be a ***major*** upset of the digestive system!

PROF.: The late Dr. Paul Brand observed, "If we traced all the body signals involved in walking, we would find...a machine of unfathomable complexity. Over one hundred million sense cells in each eye compose a picture of the object he is walking toward. Stretch receptors in the neck relate the attitude of his head to the trunk and maintain appropriate muscle tension. Joint receptors fire off messages that report the angles of limb bones. The sense organs inside the ear inform the brain of the direction of gravity in the body's balance. Pressure from the ground on each toe triggers messages about the type of surface on which he is walking."

VOICE: When scientists analyze actions like walking, they realize that even activities that seem simple, are really quite complex.

PROF.: Dr. Simmons adds, "Merely turning to speak to a passenger while driving a car may seem simple, but the brain must keep track of every visual and auditory cue inside and outside the car, determine if it is safe to look right, keep track of traffic, maintain the right pressure on the accelerator, control all appropriate muscles in the head, neck, and eyes, find the words and say them, and maintain a sitting and driving balance."

VOICE: Many millions of neurons are at work. But unless some of them are injured, every movement is smooth and in unison.

PROF.: We can analyze the ability to maintain our balance into dozens of smaller steps. And these steps can be divided further. The sense of balance requires "the whole package phenomenon."

VOICE: That expression, "the whole package phenomenon" is interesting. Each part of the balance system is intricate and precise.

PROF.: But multiple systems have to work – not as separate parts – but as one "whole package."

VOICE: So, whether we're astronauts in orbit or pedestrians on Earth's surface, we're impressed by the system that enables us to keep our balance.

PROF.: The Bible book of Romans speaks of "the only wise God." As we analyze the intricate balance system that each of us has in our bodies, logic tells us that a "wise God" might be the explanation of how this system originated.

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