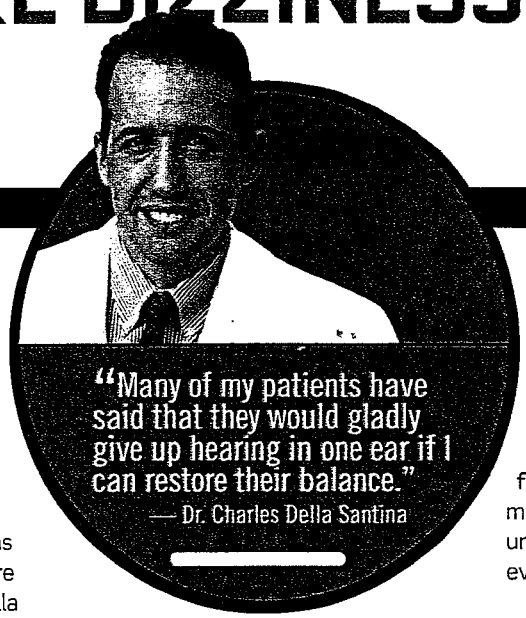
SUPERB TECHNOLOGY

A GYROSCOPE EAR IMPLANT MAY CURE DIZZINESS

Many Americans suffer from blurred vision and crippling dizziness because the balance organ in their inner ear has been destroyed. Help may be on the way as Johns Hopkins University researchers work to develop a device that can restore balance to such patients.



The mechanisms that control balance reside in the inner ear, tracking movement and orientation in space. People scarcely think about balance from day to day, but when it fails, it's sorely missed, and a damaged inner ear can lead to blurred vision and a feeling of walking on moving ground. Researchers at Johns Hopkins University School of Medicine in Baltimore are working on a solution. Dr. Charles Della Santina, professor of otolaryngology and biomedical engineering, and his team are working on an implantable prosthesis that could restore patients' sense of balance.

Behind the eardrum, inside the ear, two structures sit side by side: the snail-shaped cochlea, which is responsible for hearing, and a three-branched organ called the vestibular labyrinth, which deals with balance. It consists, in part, of three tubes filled with liquid, each one situated at a right angle to the other two, so that they extend left to right, front to back and up and down, respectively. The vestibular labyrinth has two functions. First, it tracks up-and-down movement and which way the body is moving, which is crucial for standing and walking. Its second function is to monitor which way the head is moving, necessary for clear vision — it's this function that the new treatment hopes to restore.

In order to be able to see clearly while the head is moving, the vestibular labyrinth causes the eyes to rotate in the opposite direction from the head itself, and at precisely the same speed. When the head moves in a certain direction, the liquid in the appropriate semicircular canal pushes up against a membrane, the cupula, which is covered with tiny hair cells. These hair cells are connected to nerves that send electrical information to the brain, which then orders the eyes to move, keeping vision sharp and aligned with head movement.

Hair cells in the vestibular labyrinth can be damaged by meningitis and various viral infections or by the treatment for meningitis, an antibiotic called gentamicin.

THE BODY'S BALANCE REFLEX

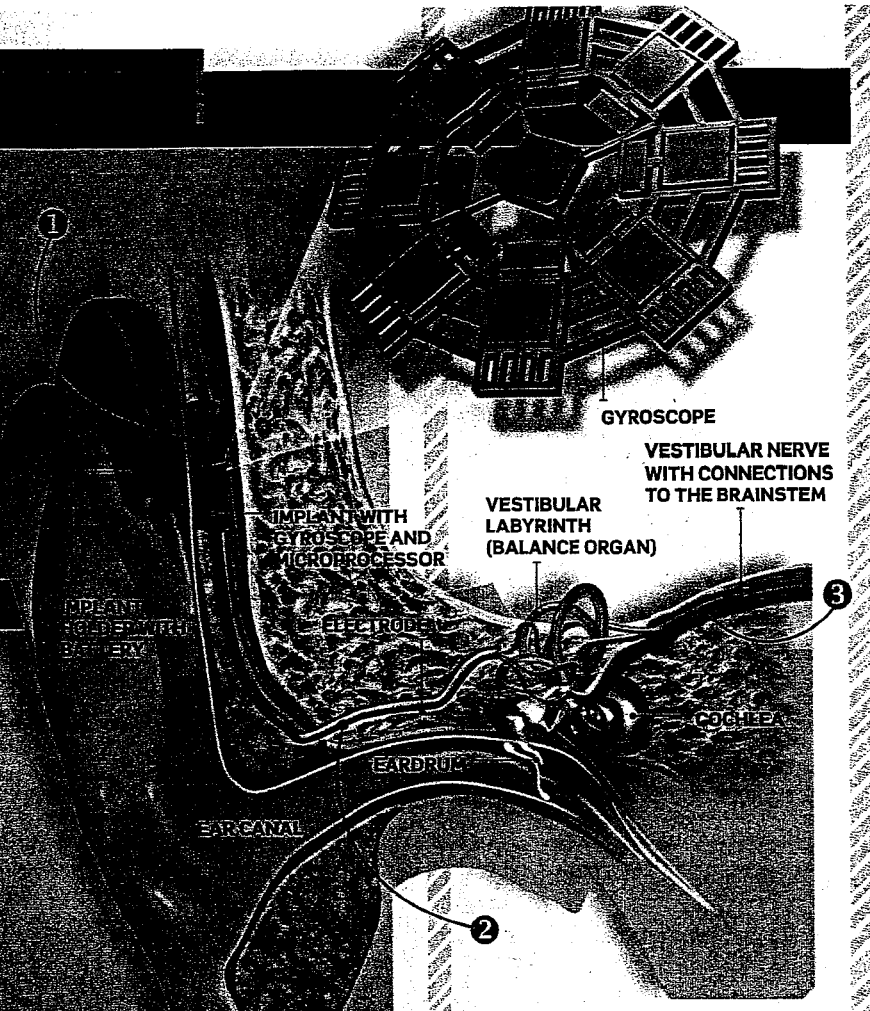
When the balance reflex functions like it should, it is incredibly fast. If it is not functioning, movements become disoriented, and vision is akin to watching a film shot with a handheld video camera. Della Santina estimates that in the United States alone there are about 30,000 people disabled by dizziness resulting from damage to their balance organs. They have lost the ability to see clearly when their heads are moving or to walk securely, especially in the dark or over uneven terrain. They often fall, and nausea and headaches are common side effects. Many of them become unable to move around — by walking, or even on a bike or in a car.

The new prosthesis aims to replace the balance reflex by electrical stimulation of the nerves that normally transmit signals from the vestibular labyrinth to the brain. A miniature gyroscopic sensor — a device that detects any changes from a desired orientation, often used in autopilots for planes and boats — will detect and code the head's movements and then transmit the information to the brain.

The new implant will thus sidestep the destroyed vestibular labyrinth by transmitting information directly to the balance nerves. Previous researchers created balance implants that registered head movements in a single dimension, but in order to recreate the complete sense of balance, Della Santina and his colleagues decided to develop a device that can detect the head's motion in all three dimensions. As Della Santina says, "We live and move in a three-dimensional world, so the goal of our implant is to detect movements in all three dimensions."

In 2007 and 2010, the team published

IMPLANT SIDESTEPS A DEFECTIVE BALANCE ORGAN



In order to see clearly and avoid getting dizzy — with each turn of the head, for example — a balance organ called the vestibular labyrinth must be functioning properly. It consists of three fluid-filled semicircular canals, which combine forces to detect the head's motion in all three dimensions. The canals are connected to nerves that send signals to the brain when the head moves. The brain reacts by causing the eyes to move in the opposite direction of the head at the same speed, so that we can maintain clear vision and stable balance. But if the vestibular labyrinth is damaged, the signals are interrupted with dizziness and wobbly vision resulting. In animal subjects, an implant beneath the skin has been able to send the correct signals to the brain, thereby restoring the sense of balance. Researchers hope eventually to test the device on humans.

1 The implant uses a minigyroscope that registers the head's movements. The gyroscope, contained in a little box, is shaped like an electromechanical wheel, which turns when the head moves, changing the current in the microprocessor.

2 The processor transmits a signal to electrodes that are connected to the vestibular nerves in the inner ear.

3 The electrodes trigger the nerves to send information to the brain, so that the eyes turn in the opposite direction of the head. As a result, the person has stable balance and clear vision.

ILLUSTRATIONS: CLAUS LUNAU; LEFT: JOHNS HOPKINS UNIVERSITY

results demonstrating that the device could restore the balance reflex in animals. Using chinchillas, an animal whose inner ear has been thoroughly studied, the team treated them with gentamicin, which disrupted the signals coming from the animals' vestibular labyrinth. Chinchillas then received an implanted gyroscope device in just one ear to minimize the risk of destroying function in both inner ears. Tests showed that restoring the balance reflex in just one ear was sufficient to completely restore stability.

DEVICE MAY BE READY FOR TESTS ON PATIENTS SOON

The researchers were inspired by the success of advanced cochlear implants for the deaf, and so they constructed a small battery-powered box that contains a tiny gyroscope connected to a microprocessor. The processor measures the speed of the head's movements by way of electrodes implanted in the inner ear and connected to the vestibular nerve endings. The first model was the size of a matchbox, but the team is currently working on an implant for human use that will be small and thin enough to be implanted under the skin, behind the ear.

"We have cut both power consumption and the thickness of the implant in half, so from a technology standpoint, it is ready for use in humans," Della Santina says. "But it will still take several years before it is tested and approved." SCI

Name_____Date_____Hour_____

Close and Critical Reading Questions A Gyroscope Ear Implant May Cure Dizziness

Site evidence from within the text to justify your answers for questions 1-4.

1. Describe the two parts of the inner ear in terms of structure and function.
2. How can the vestibular labyrinth be damaged? What effect does this have on the body?
3. What's a gyroscope?
4. What successes have scientists had in their testing of their device?
5. The goal of the scientists in the article is to restore balance by using a technological device implanted in the ear. To which specific characteristics of life does this article directly relate to. Explain your choice(s)
6. The scientists obviously tested their device on a group of animals. Write a possible hypothesis they used as a starting point for their investigation.