AUDITORY SYSTEM

ECE 331 – INTRODUCTION TO BIOMEDICAL ENGINEERING

Monday, October 15, 2025

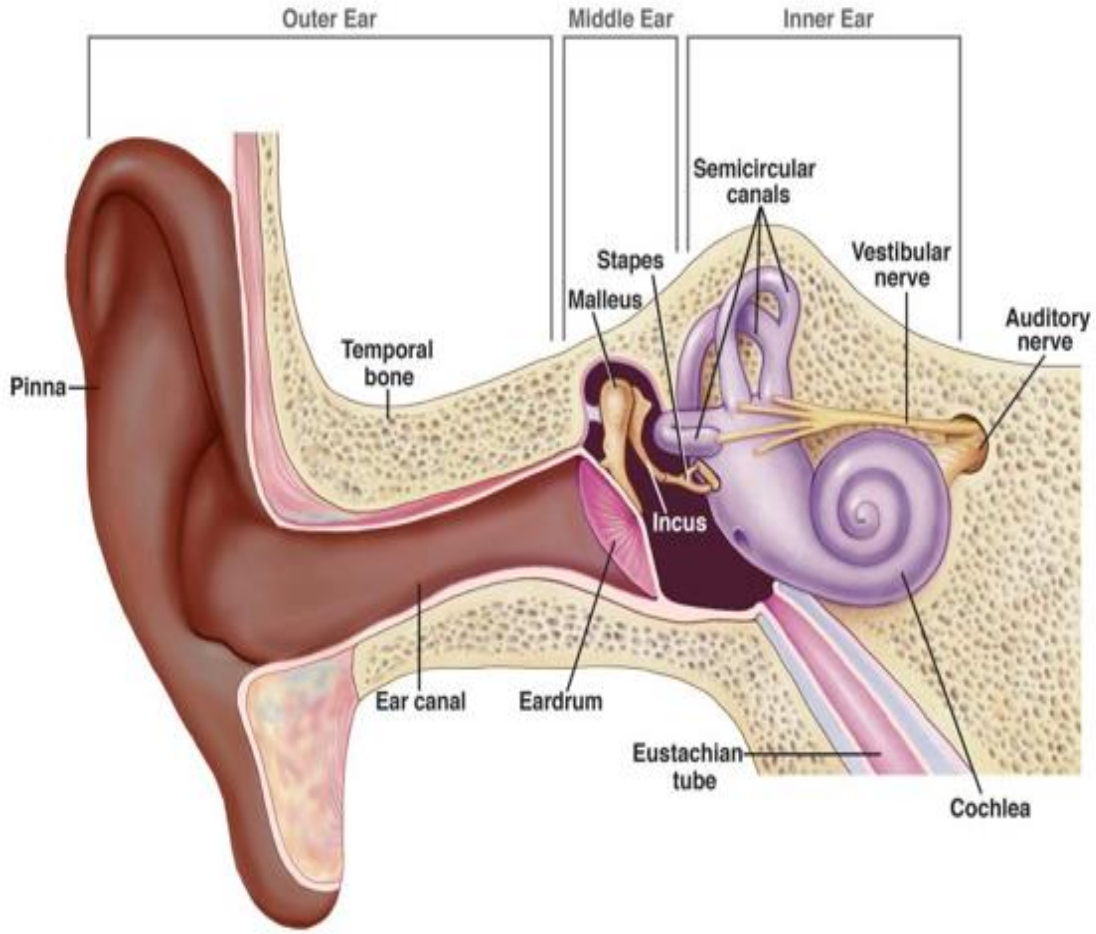
WHAT IS THE AUDITORY SYSTEM?

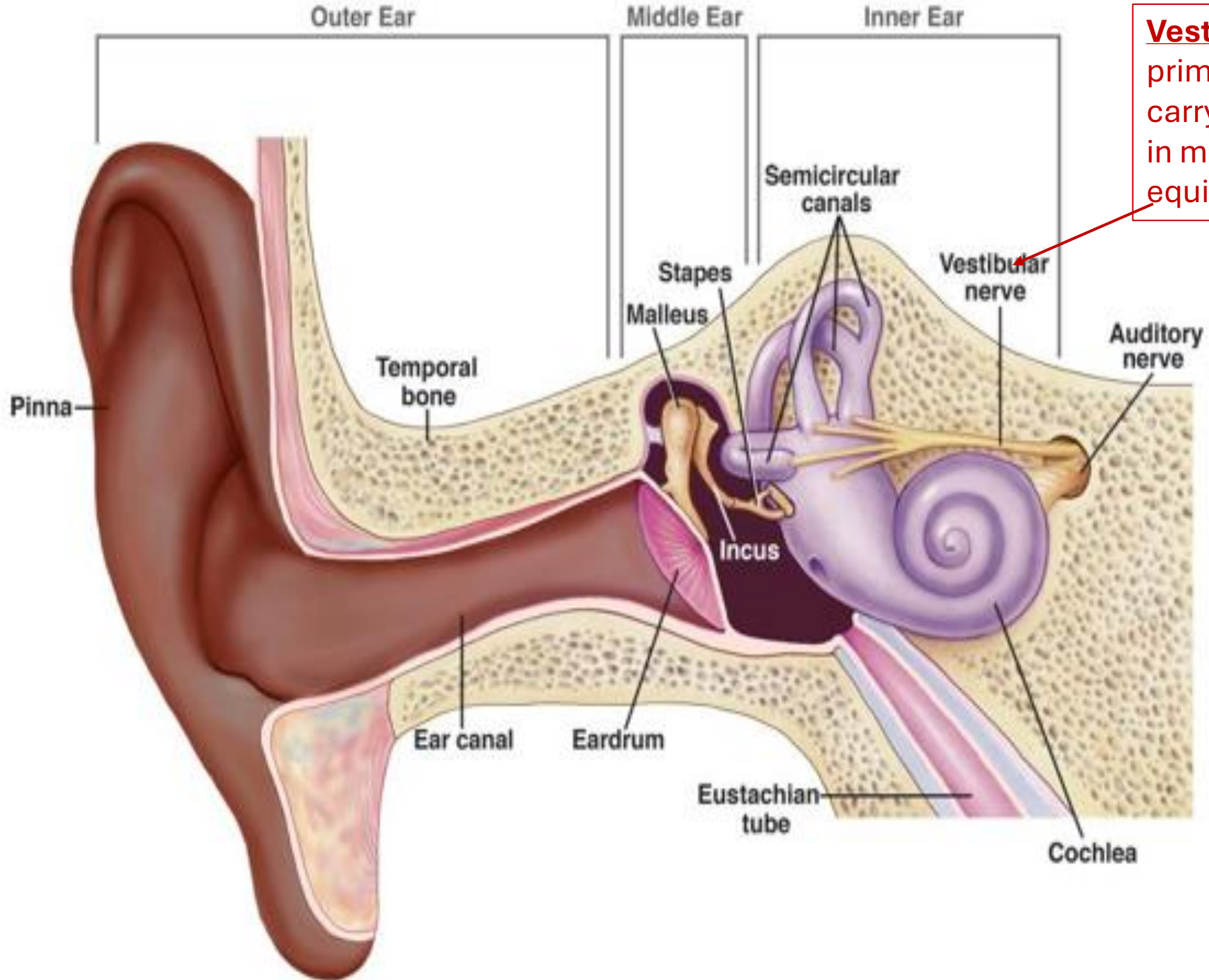
1. **Auditory system** consists of:
   a) Two ears, located on the left and right sides of the head,
   b) Vestibulocochlear nerve
   c) Central auditory nervous system (CANS)
2. **The main functions of the auditory system** are:
   a) Perception of speech and other acoustic events
   b) 360° spatial detection and localization of sound sources.
3. The act or process of hearing is called **audition**.
4. The anatomical structure processing incoming acoustic stimuli is called **auditory system.**

ANATOMY OF THE EAR

Human ear consists of:

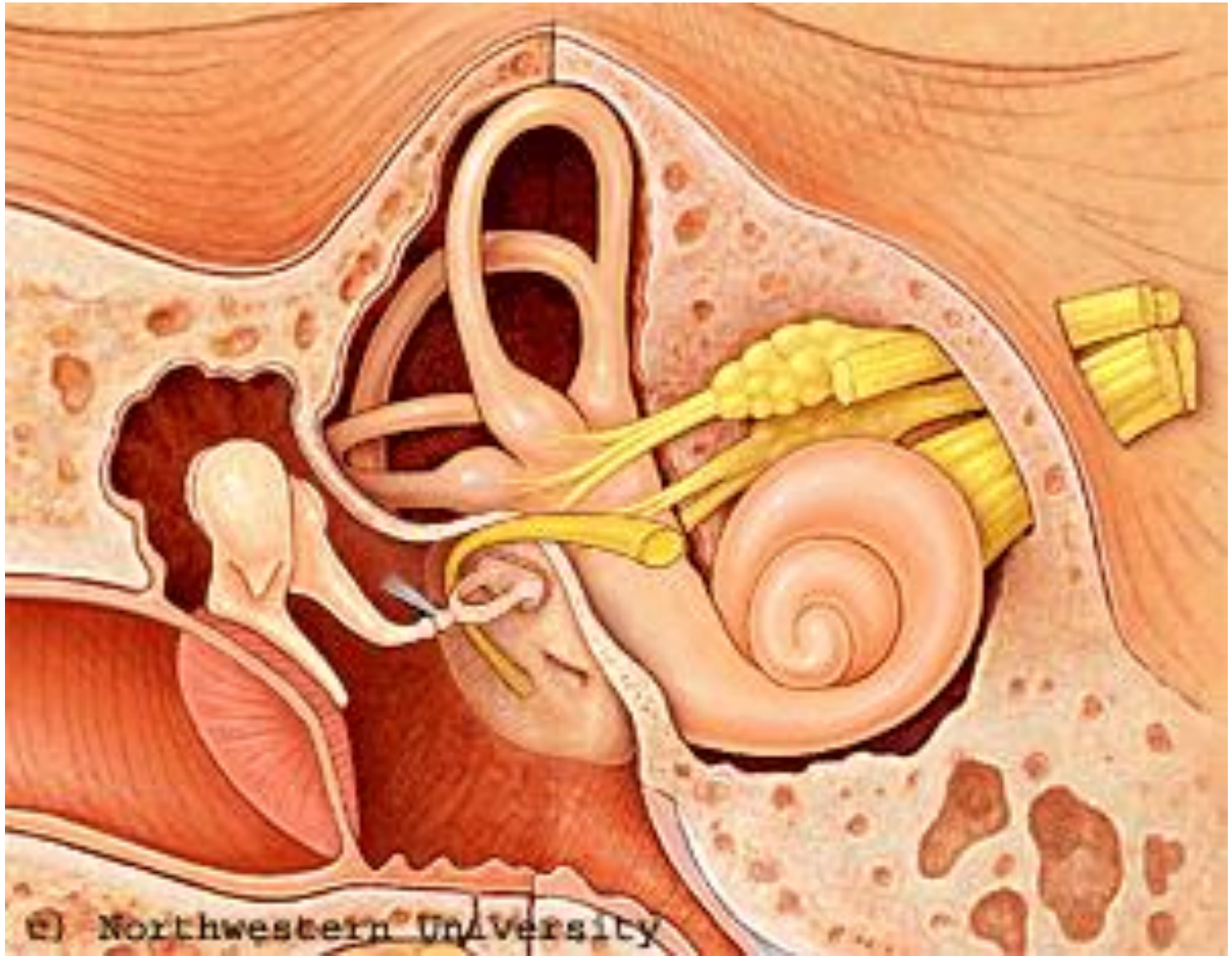
1. **Outer ear** collects sound waves and channels them into the ear canal (external auditory meatus), where the sound is amplified.
2. **Middle ear** contains three ossicles (malleus, incus, and stapes), which transfer the vibrations of the eardrum into waves in the fluid and membranes of the inner ear.
3. **Inner ear** has two functions, ie
   a) converts the sound waves into electrical signals
   b) helps the body maintain balance
4. **Central auditory nervous system** encode sound frequency, attenuation, and spatial



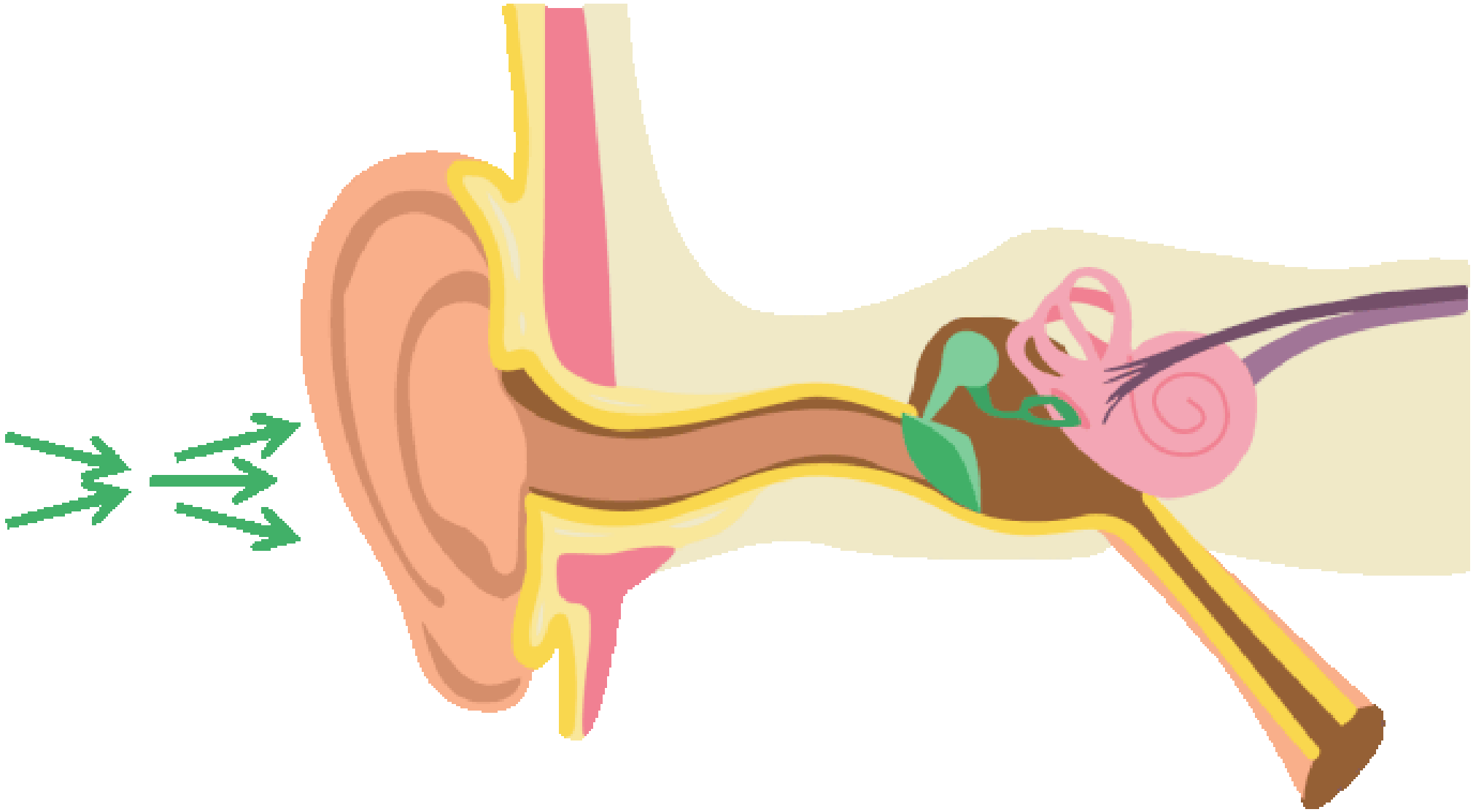


Vestibular nerve is primarily responsible for carrying impulses involved in maintaining balance and equilibrium.

FUNCTION OF THE EAR – ANIMATION /01



FUNCTION OF THE EAR – ANIMATION /02



OUTER EAR

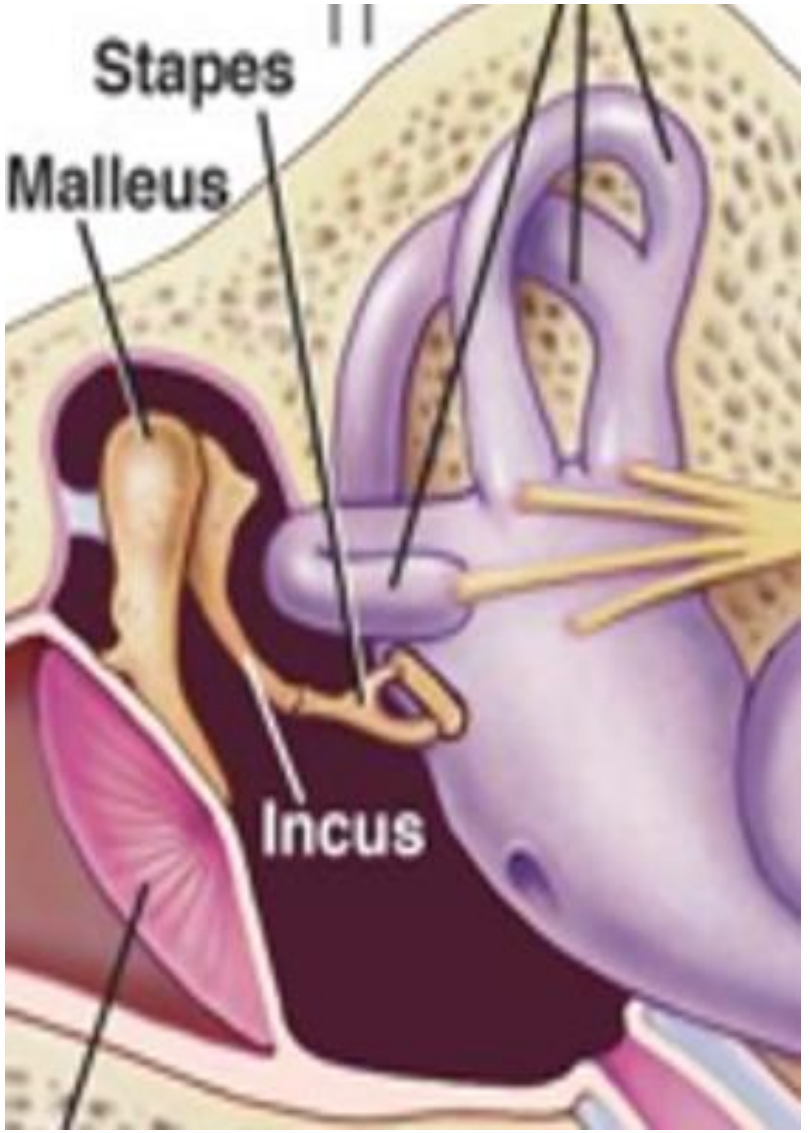
1. The external ear also referred to as the outer ear is composed of
2. an external cartilaginous skin covered structure, called the **pinna**
3. the **ear canal** or external auditory canal.
4. The **shape of the Pinna** helps to collect and converge the sound waves into the external auditory canal.
5. **Hair and wax** present in the external auditory canal help to trap dust particles present in the air within the ear.

EAR DRUM

1. **Ear drum** is about the size of a dime and is the **same size in the newborn baby as in the adult**.
2. The medical term for the ear drum is the tympanic membrane.
3. The ear drum is a **transparent gray membrane**.
4. Attached to the center part of the drum is the **middle ear bone (the malleus)**.
5. The main function of the ear drum is to **transmit the external sound waves in into the malleus ossicle of the middle ear.**

MIDDLE EAR

1. **Middle ear** is in the form of a chamber and lies inner to the outer ear.
2. It is **filled with air**.
3. The air pressure in the middle ear is maintained in equilibrium with the atmospheric air pressure through a tube known as the **eustachian tube** that opens in the nasopharynx.
4. Middle ear is made up of **three bone ossicles** named on basis of their shapes as:
   a) **Malleus (hammer)**
   b) **Incus (anvil)**
   c) **Stapes (stirrups)**
5. The bones of the middle ear **transmit the sound energy to the inner ear**.



MIDDLE EAR: EUSTACHIAN TUBE

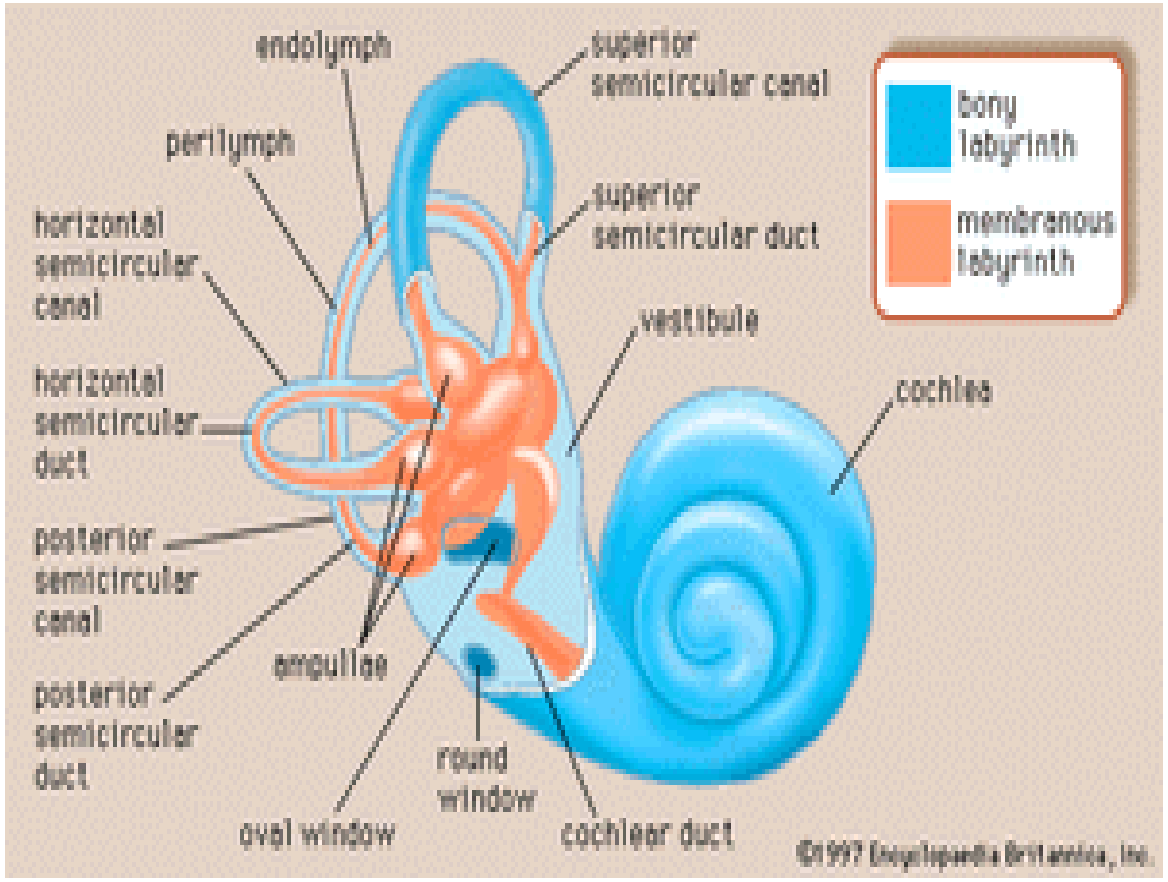
1. **Eustachian tubes** are passage ways that connect the middle ear with the nasal-sinus cavity.
2. **Function of the tubes** is to balance pressure in the middle ear (commonly felt as your ears popping)
3. **Eustachian tubes** are usually closed except for when you chew, swallow, or yawn.
4. These passageways are small in size and can get plugged for a variety of reasons.
5. **Blocked eustachian tubes** can cause pain, hearing difficulties, and a feeling of fullness in the ears.

CAUSES OF EUSTACHIAN TUBE DISFUNCTION

1. **Eustachian Tube Dysfunction** can be caused by many various different causes.
2. The most common are:
   a) Chronic sinusitis or sinus problems
   b) Nasal congestion
   c) Smoking or vaping
   d) Barotrauma related to flying or diving

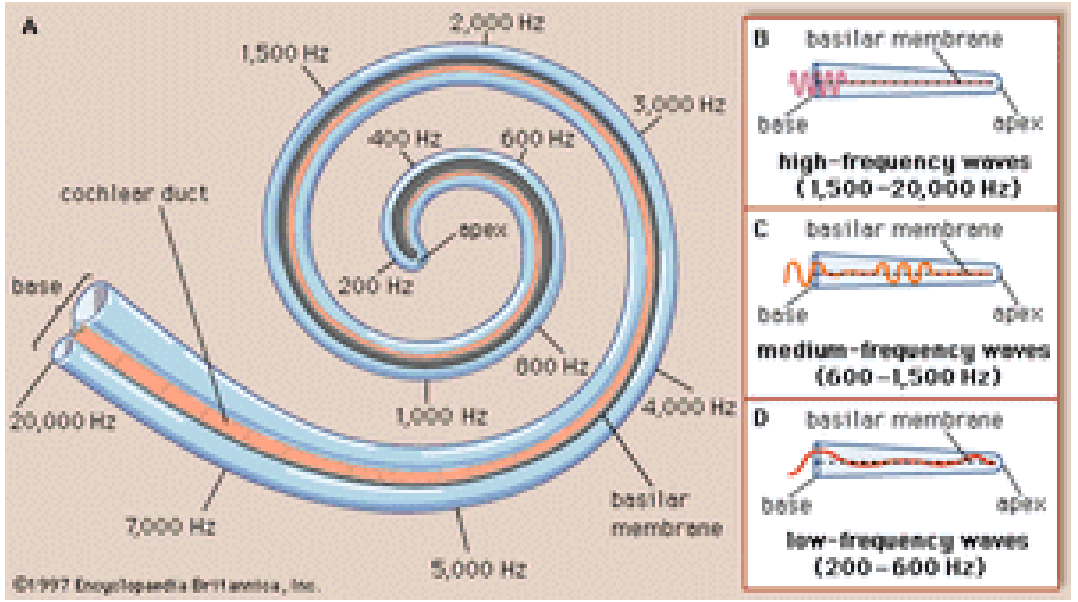
INNER EAR

1. **Inner ear** is also in the form of a cavity that is situated within the skull. This chamber is also known as the bony labyrinth.
2. **The inner ear is further divisible into three parts**:
   a) **Vestibule** which is situated in the middle part of the internal ear. It communicates with the other structures of the middle ear.
   b) **Three semicircular canals** which are structures that are situated at right angles to each other. These canals help in maintaining equilibrium and can sense the position of the head in relation to the body.
   c) **Cochlea** which is the organ responsible for perception of sound.
3. The inside of the cochlea is filled with a fluid called **lymph**.



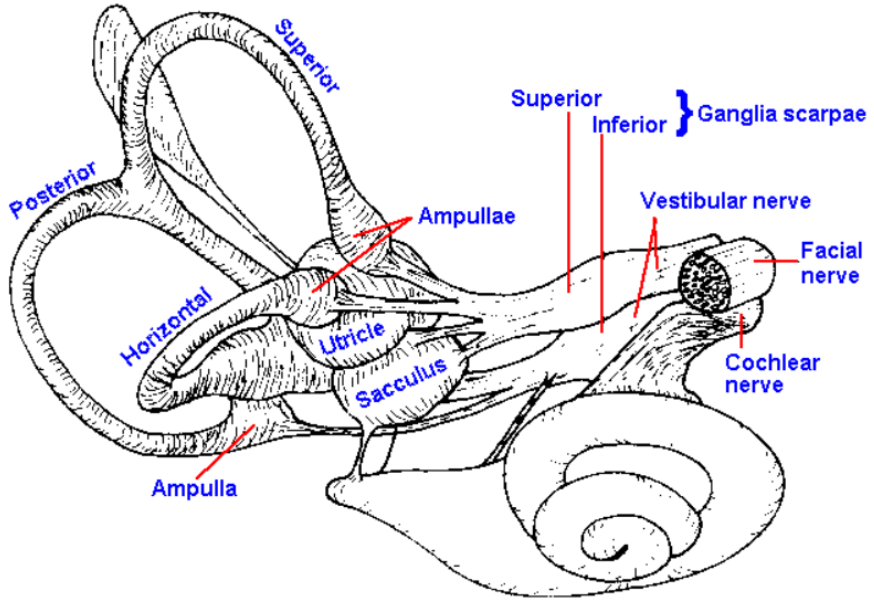
INNER EAR - COCHLEAR

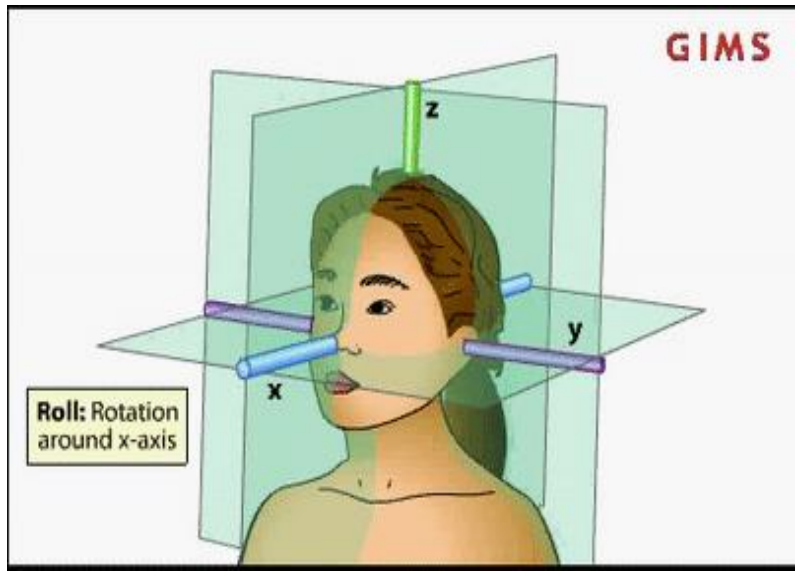
1. **Cochlea is a fluid-filled**, spiral-shaped cavity found in the inner ear that plays a vital role in the sense of hearing and participates in the process of auditory transduction.
2. **Within the cochlea the different frequencies of complex sounds are sorted out**, or analyzed, and the physical energy of these sound vibrations is converted, or transduced, into electrical impulses that are transmitted to the brainstem by the **cochlear nerve**,
3. **Cochlear nerve a**lso known as the acoustic nerve, is the sensory nerve that transfers auditory information from the cochlea to the brain.



VESTIBULAR SYSTEM

1. **Vestibular system** is made up of
2. **Three semicircular canals**
3. **Otolith organs**, which are found diagonally under the semicircular canals.
4. **It's function is to** provides sense of balance and information about body position.
5. This **allows rapid compensatory movements in response to both self-induced and externally generated forces.**





PHYSIOLOGY OF HEARING

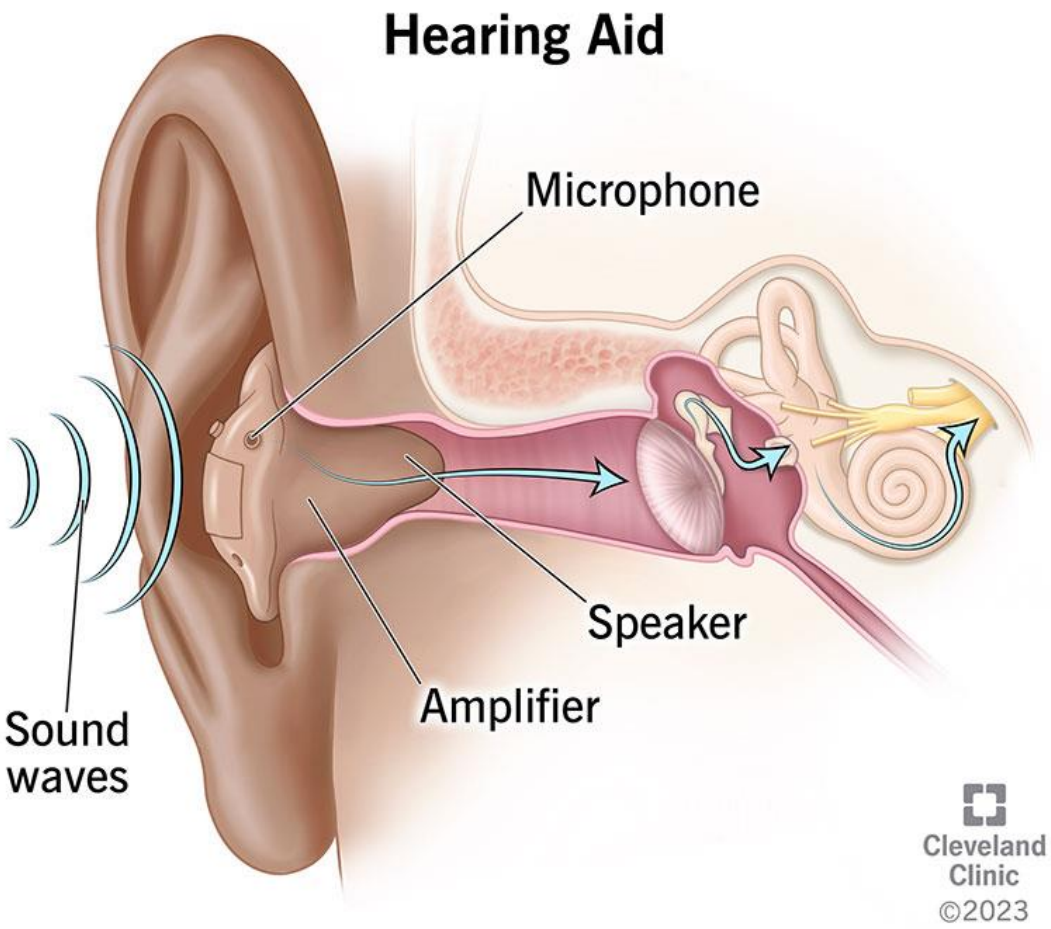
The sequence of events that take place hearing of sound can be summarized as follows:

1. **Sound waves that are trapped by the pinna** are directed into the external auditory canal.
2. The waves strike the **ear drum which produces oscillation** on the membrane.
3. The oscillations are transmitted on to the **bones of the middle ear**, namely the malleus, the incus and the stapes.
4. The waves are transmitted by the stapes to the **vestibule** that transmits the sound waves into the cochlea.
5. **Disturbances occurs in the fluid** contained within the cochlea called lymph.
6. The disturbances are picked up by the hair cells called the organ of Corti, which causes the **generation of membrane potential**.
7. **Membrane potential is converted into action potential** which is carried to the auditory centres of the brain.
8. information is processed and **perception of sound occurs** in the auditory centres.

HEARING AIDS

1. **Hearing aids** are small electronic devices that amplify sounds and deliver them to your ear.

2. **Hearing aids** help people with hearing loss, improve hearing and speech comprehension so they can participate more fully in daily life.



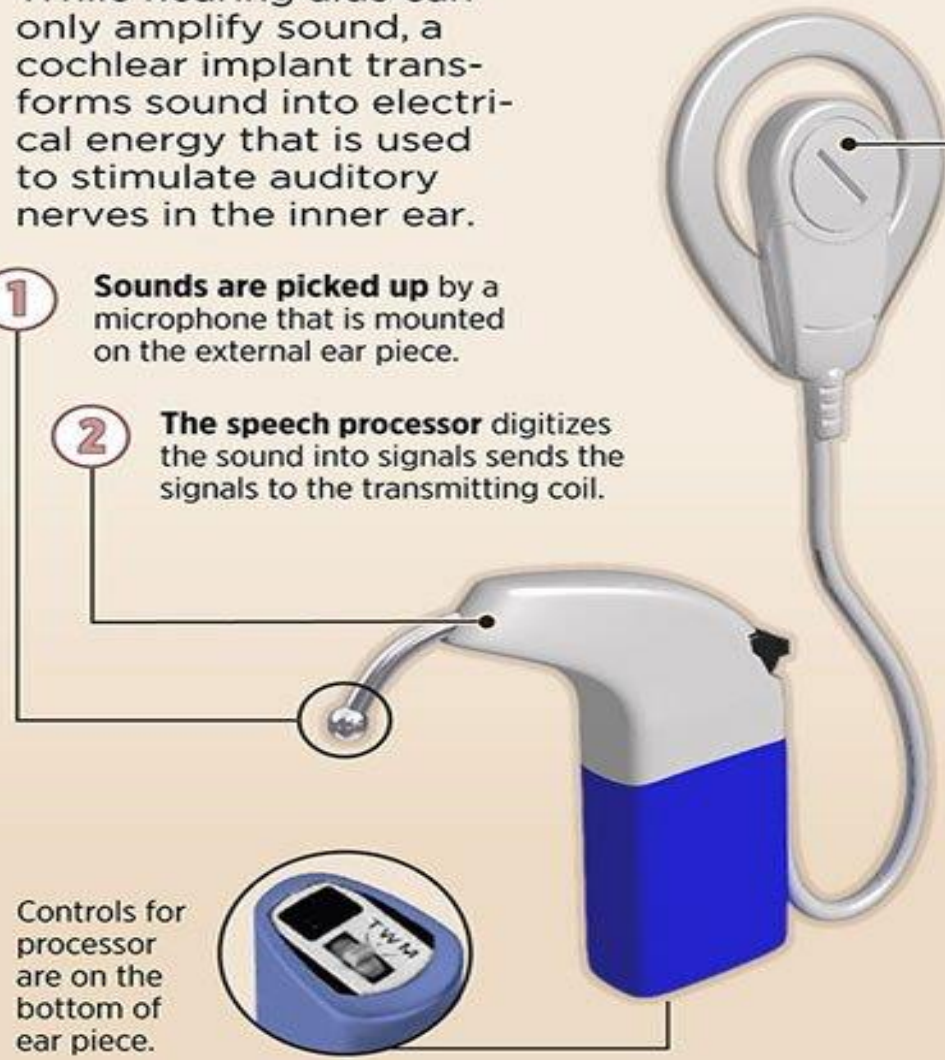
WHO USES HEARING AIDS

1. Hearing aids work best for people with **sensorineural hearing loss**.
2. **Sensorineural hearing loss** is a result of damage to your inner ear or auditory nerve (the nerve that connects your ear to your brain).
3. Causes of sensorineural hearing loss include:
   a) Aging.
   b) Disease.
   c) Infection.
   d) Loud noises.
   e) Certain medications.

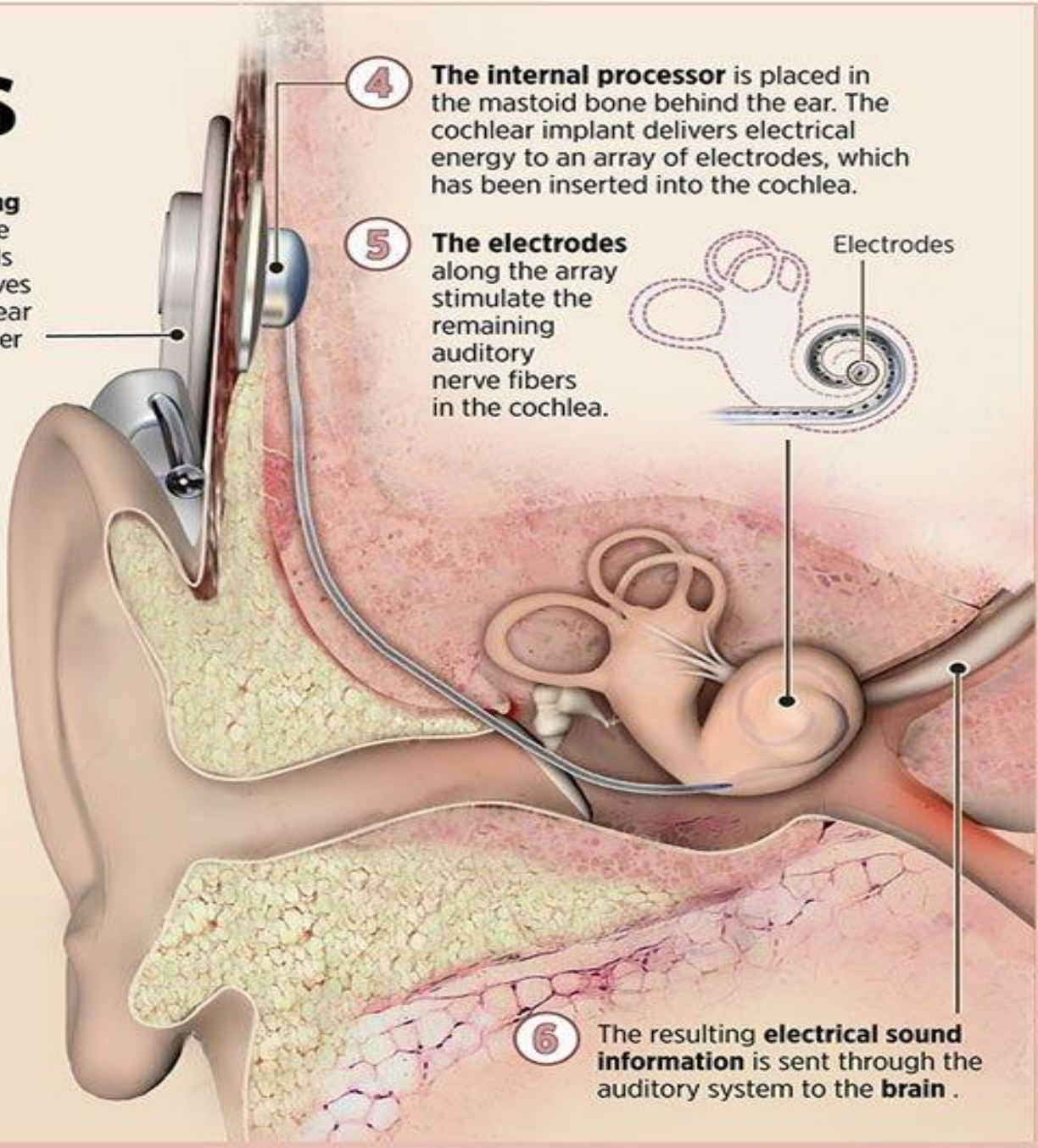
Cochlear implants

While hearing aids can only amplify sound, a cochlear implant transforms sound into electrical energy that is used to stimulate auditory nerves in the inner ear.

1. **Sounds are picked up** by a microphone that is mounted on the external ear piece.
2. **The speech processor** digitizes the sound into signals sends the signals to the transmitting coil.
3. **A transmitting coil** sends the coded signals as radio waves to the cochlear implant under the skin.
4. **The internal processor** is placed in the mastoid bone behind the ear. The cochlear implant delivers electrical energy to an array of electrodes, which has been inserted into the cochlea.
5. **The electrodes** along the array stimulate the remaining auditory nerve fibers in the cochlea.
6. The resulting **electrical sound information** is sent through the auditory system to the **brain** .



Controls for processor are on the bottom of ear piece.



SOURCE: University of Miami Leonard M. Miller School of Medicine

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