THE EAR

The ear is the sense organ that functions in
(1) hearing and
(2) equilibrium.

- The E is divided into three regions: (1) the outer (external) ear, (2) the middle ear, and (3) the inner ear. The only portion of the ear that is not surrounded by the temporal bone is the skin-covered flap of elastic cartilage, the auricle (pinna), which is positioned on the lateral surface of the head. The wedge-shaped internal portion of the temporal bone, the petrous portion, houses the auditory canal, the middle ear, and the inner ear.

The Ear

- The ear is divided into three regions:
  - (1) the outer (external) ear,
  - (2) the middle ear, and
  - (3) the inner ear.
- The only portion of the ear that is not surrounded by the temporal bone is the skin-covered flap of elastic cartilage, the **auricle** (pinna), which is positioned on the lateral surface of the head.
- The wedge-shaped internal portion of the temporal bone, the **petrous portion**, houses the **auditory canal, the middle ear, and the inner ear.**

STRUCTURE OF THE EAR

Lab Activity 1
Anatomy of the Ear

- Use a model of the ear and/or the following illustrations for the identification of general structures of the ear.

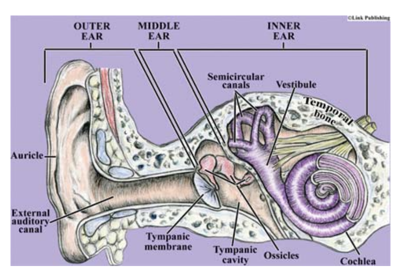


Figure 19.1
The ear is divided into three regions: (1) the outer (external) ear, (2) the middle ear, and (3) the inner ear.

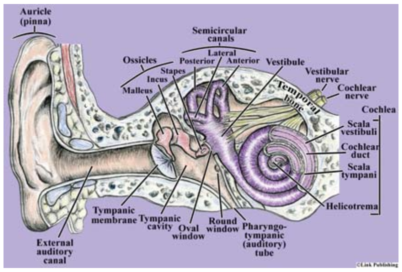


Figure 19.2
The general structure of the ear.

OUTER EAR

The outer ear consists of the
(1) auricle (pinna) and the
(2) external auditory canal.

Outer ear

- **Auricle (pinna)**
  - The auricle is the skin-covered flap of elastic cartilage located on the lateral surface of the head. The auricle traps and directs sound waves into the external auditory canal.
- **External auditory canal**
  - The external auditory canal is the canal that carries sound waves from the auricle to the tympanic membrane.
- **Tympanic membrane (eardrum)**
  - The tympanic membrane is a fibrous membrane that forms the boundary between the outer and the middle ear. The tympanic membrane transfers sound waves to the first ossicle, the malleus of the middle ear.

MIDDLE EAR

The middle ear consists of the tympanic cavity, an air-filled cavity that houses three bones, the ossicles.

Middle Ear

- The middle ear consists of the tympanic cavity, an air-filled cavity that houses three bones, the ossicles.
  - The **pharyngotympanic tube** (**Eustachian**, or **auditory, tube**) connects the middle ear to the nasopharynx for the equalization of air pressure between the tympanic cavity and the external environment.

Middle Ear

- **Ossicles**
  The ossicles are the bones that cross the middle ear.
  The names of the ossicles from the tympanic membrane to the oval window are
  - (1) the malleus,
  - (2) the incus, and
  - (3) the stapes.
- The **malleus** conducts sound vibrations from the tympanic membrane to the incus. The **incus** conducts to the **stapes**, which conducts to the oval window of the vestibule.
- The **oval window** is a membranous window of the vestibule that allows the passage of vibrations into the fluids of the cochlea.
- In the process of conduction across the middle ear sound vibrations are amplified by the ossicles about thirty times.

Lab Activity 2
The Ossicles

- Observe natural bone human ossicles and/or the following photograph.
  - Because of their small size and delicate structure, natural bone ossicles are usually in a protected display case.

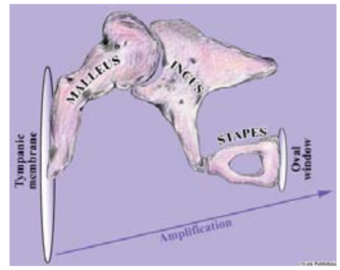


Figure 19.3
The ossicles conduct sound vibrations across the middle ear. In the process of conduction vibrations are amplified by the ossicles about thirty times.

Figure 19.4
Natural bone human ossicles. The stapes is about the width of a grain of rice. The ossicles transmit and amplify sound vibrations from the tympanic membrane to the oval window of the cochlea.

INNER EAR

The inner ear consists of
(1) the cochlea,
(2) the vestibule, and
(3) the semicircular canals.

Inner Ear

- The inner ear consists of
  - (1) the cochlea,
  - (2) the vestibule, and
  - (3) the semicircular canals.
- As with the auditory canal and the middle ear, the inner ear is also surrounded by the petrous portion of the temporal bone.
- The inner ear consists of a series of complex cavities that interconnect forming a maze-like structure, a **labyrinth**. Bone surrounds the structures of the inner ear and forms a cavity, called the **osseous labyrinth**. The osseous labyrinth contains a fluid called **perilymph**.
- The structures of the inner ear, a series of canals and receptors, are called the **membranous labyrinth**. The membranous labyrinth extends through the bony labyrinth, and thus is surrounded by **perilymph**. Internally, the membranous labyrinth contains a fluid called **endolymph**.

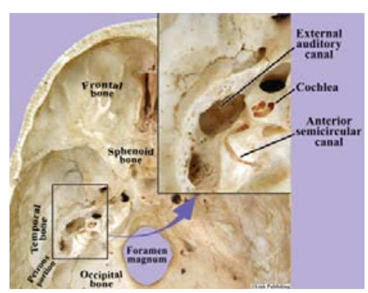


Figure 19.5
A portion of the left ear is exposed by dissection of the human skull with a bone saw. The bony chambers of the inner ear, which include the cochlea and the semicircular canals, are shown. These chambers are called the bony labyrinth and house the membranous labyrinth, a series of canals and receptors that function as the sensory receptors of the inner ear.

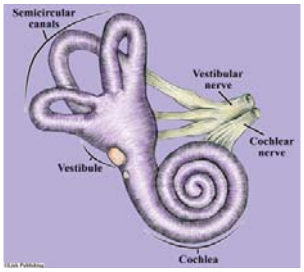


Figure 19.6
General structure of the inner ear. The inner ear consists of three major regions, the semicircular canals, the vestibule, and the cochlea.

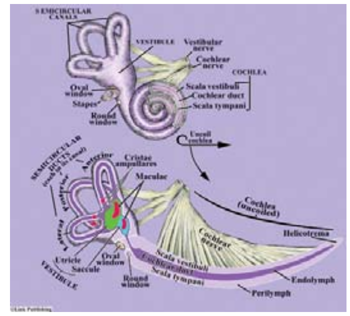


Figure 19.7
General structure of the inner ear. The illustrations show the structure of the cochlea both coiled and uncoiled.

Cochlea

The cochlea is the coiled, “snail-shaped” portion of the inner ear. It consists of about 2 ½ turns of a cavity (osseous labyrinth) that encloses a membranous canal of three fluid-filled chambers, the

- (1) scala vestibuli,
- (2) cochlear duct (scala media), and
- (3) scala tympani.

- **Scala Vestibuli**
  - The scala vestibuli begins at the base of the cochlea at the oval window, the membranous window that junctions with the stapes. The scala vestibuli continues to the tip of the cochlea (cochlear apex). At the cochlear apex the scala vestibuli merges with the scala tympani at a region called the helicotrema.

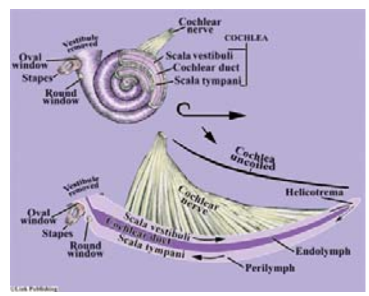


Figure 19.8
The cochlea is the coiled, “snail-shaped” portion of the inner ear. It consists of about 2 ½ turns of a cavity (osseous labyrinth) that encloses a membranous canal of three fluid-filled chambers, the **(1) scala vestibuli**, **(2) cochlear duct (scala media),** and **(3) scala tympani**.

Cochlea

- **Scala tympani**
  - The scala tympani continues back toward the base of the cochlea where it ends at the round window. The round window is located in the wall of the middle ear. Both the scala vestibuli and the scala tympani contain a fluid called **perilymph**.
- **Cochlear duct (or scala media)**
  - Located between the scala vestibuli and the scala tympani is the cochlear duct (or scala media). The cochlear duct contains the receptor, the **organ of Corti**, where sound vibrations are converted into electrical stimuli. The cochlear duct is continuous with the membranous cavities and canals of the vestibule and the semicircular canals. The cochlear duct and its associated cavities and canals contain the fluid called **endolymph**.

Vestibule

- The vestibule is the portion of the inner ear located between the cochlea and the semicircular canals.
- The vestibule contains two regions,
  - (1) the **saccule** and
  - (2) the **utricle**, each containing receptors called maculae (spot-like areas), the **macula sacculi** and the **macula utriculi**, respectively.
  - The maculae respond to **gravity and linear motion** and function in **equilibrium and maintenance of body position**.

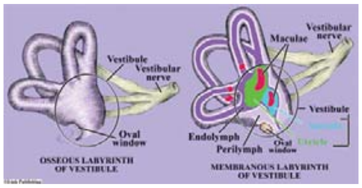


Figure 19.9
The vestibule is the portion of the inner ear located between the cochlea and the semicircular canals.

Semicircular Canals

- Each of the three semicircular canals,
  - (1) the anterior,
  - (2) the posterior, and
  - (3) the lateral, projects from the vestibule in the direction descriptive of its name.
  - Each semicircular canal contains a fluid-filled membranous duct, the **semicircular duct**, that has an enlarged area called an **ampulla**.
  - Each ampulla contains a receptor, the **crista ampullaris**, that responds to **rotational motion and maintains equilibrium**.

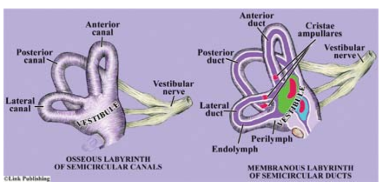


Figure 19.10
The three semicircular canals, (1) the anterior, (2) the posterior, and (3) the lateral, project from the vestibule in the direction descriptive of its name. The semicircular canals function in reception of rotational movements.

Semicircular Canals

- The semicircular canals are position to respond to movement in the three planes of space, the
  - (1) sagittal plane,
  - (2) frontal plane, and the
  - (3) horizontal plane.
- Two of the semicircular canals, the anterior and posterior, project vertically and respond to **rotational motion in the two vertical planes, the sagittal plane (front-back rotation) and the frontal plane (side-to-side rotation).**
- Anterior and Posterior Semicircular Canals
  - The **anterior semicircular canal** responds to **front/back rotational** motion (sagittal plane) such as in swaying the head in indicating "yes," and the **posterior semicircular canal** responds to **side/side rotational motion** (frontal plane) such as swaying the head side-to-side.
- Lateral Semicircular Canal
  - The **lateral semicircular canal** responds to **rotational motion in the horizontal plane** such as the rotating the head in indicating "no."

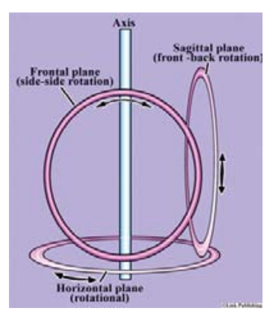


Figure 19.11
The semicircular canals follow three planes and respond to rotational movements to maintain equilibrium.

Lab Activity 3
Cochlea

- Observe a slide preparation labeled “Cochlea” and/or the following illustrations and photographs. Preparations of the “cochlea” are obtained by sectioning specimens of the inner ear.
  - Thus, in addition to the cochlea, the slide preparation may show other structures of the inner ear such as the semicircular canals (with their ducts and receptors such as the crista ampullaris) and a region of the vestibule (with its receptor, the macula).
  - Usually, the inner ear specimen is section so that the cochlea shows its central axis with the cochlea’s individual turns.

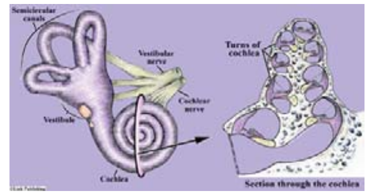


Figure 19.12
The cochlea is sectioned along its central axis to produce a view showing the cochlea’s individual turns.

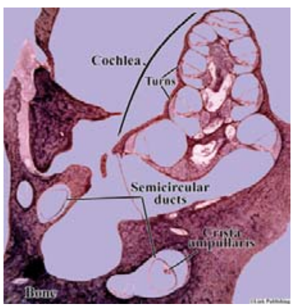


Figure 19.13
A photograph of a sectioned inner ear. In addition to the cochlea, the slide preparation may show other structures of the inner ear such as the semicircular canals and vestibule. This photograph shows the semicircular canals housing the semicircular ducts and a receptor, the crista ampullaris.

Lab Activity 3
Cochlea

- Each section of a turn of the cochlea contains sections of three chambers. The three chambers are
  - (1) the scala vestibuli,
  - (2) the cochlear duct (scala media), and
  - (3) the scala tympani.
- The bony cochlea spirals around a central region called the **modiolus**.
  - The modiolus houses the **spiral ganglion**, a region that contains the cell bodies of the cochlea’s sensory neurons. Fibers from the spiral ganglion exit to form the **cochlear nerve**.

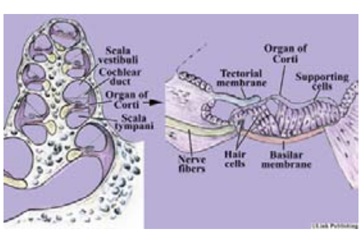


Figure 19.14
The three chambers are (1) the scala vestibuli, (2) the cochlear duct (scala media), and (3) the scala tympani. The cochlear duct contains the organ of hearing, the organ of Corti.

Lab Activity 3
Cochlea

- Observe a single turn of the cochlea. Frequently, structural damage occurs when the specimen is sectioned, so several turns may have to be examined before all of the structures are identified.

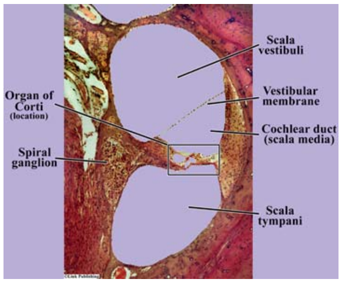


Figure 19.15
A photograph of a cross section of a turn of the cochlea as seen with low power magnification. Each section of a turn of the cochlea contains sections of three chambers. The three chambers are (1) the scala vestibuli, (2) the cochlear duct (scala media), and (3) the scala tympani.

Lab Activity 3
Structures of Cochlea

- **Scala vestibuli**
  - The scala vestibuli is the chamber that originates at the oval window. The oval window transfers sound vibrations from the stapes into the fluid of the scala vestibuli, the perilymph. A thin membrane, the vestibular membrane, forms the floor of the scala vestibuli.
- **Cochlear duct (scala media)**
  - The cochlear duct is the middle chamber located between the scala vestibuli and the scala tympani. The vestibular membrane forms its roof. The floor of the cochlear duct is formed by the basilar membrane on which sits the organ of hearing, the organ of Corti. Sound vibrations pass from the scala vestibuli into the cochlear duct.
- **Basilar membrane**
  - The basilar membrane is a fibrous membrane that forms the floor of the cochlear duct (scala media). The organ of Corti sits upon on its surface. Sound (pressure) vibrations in the cochlear duct set the basilar membrane and its associated organ of Corti into motion.

Lab Activity 3
Structures of Cochlea

- **Scala tympani**
  - The scala tympani is the chamber inferior to the basilar membrane. It terminates at the round window, which is located inferior and posterior to the oval window. Sound vibrations that pass into the scala tympani are absorbed by the round window.
- **Organ of Corti**
  - The organ of Corti, or the organ of hearing, consists of
    - (1) supporting cells and
    - (2) receptor cells (hair cells).
    - The hair cells generate electrical potentials when vibrations of the basilar membrane move their "hairs" (stereocilia) against the overhanging tectorial membrane.

Lab Activity 3
Structures of Cochlea

- Observe the details of the organ of Corti, the
  - (1) supporting cells and
  - (2) receptor cells (hair cells) with high magnification. Usually, the minute "hairs" (stereocilia) of the hair cells cannot be observed.

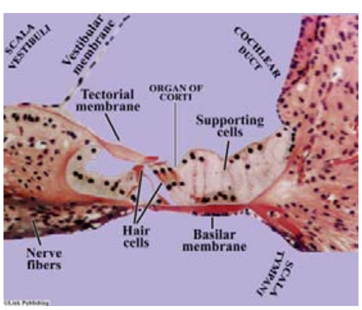


Figure 19.16
The organ of hearing, the organ of Corti, consists of (1) supporting cells and (2) receptor cells (hair cells). The hair cells generate nerve impulses when vibrations of the basilar membrane move their "hairs" (stereocilia) against the overhanging tectorial membrane.

Lab Activity 3
Structures of Cochlea

- **Tectorial membrane**
  - The tectorial membrane is a gelatinous membrane that overhangs and contacts the hair cells of the organ of Corti. During specimen preparation, the tectorial membrane may be moved away from its overhanging position.
- **Spiral ganglion**
  - The spiral ganglion is located in the modiolus and follows the turns of the bony tube. The spiral ganglion consists of the cell bodies of the sensory neurons that form the cochlear nerve. The cochlear nerve merges with the vestibular nerve to form the vestibulocochlear nerve (cranial nerve VIII).

MECHANISM OF HEARING

Sound

- Sound is a form of energy that consists of **vibrations** that are transmitted through elastic, solid, liquid, or gas mediums with a frequency range of **20 - 20,000 hertz**, the frequency range that is capable of detection by the human ear.
- A sound wave is produced as a **vibrating structure**, such as the vocal cords, pushes against (compresses) air molecules then rebounds to produce an area of less compression.
- Thus, air molecules leave a vibrating surface as sound waves, each sound wave consisting of an area of **high compression (high pressure) followed by an area of low compression (low pressure).**

Sound

- **Wavelength**
  – The distance from a wave peak to the next wave peak is the **wavelength**. In a given period of time, an increased number of waves can be presented by decreasing their wavelength, or in the same given period of time, a decreased number of waves can be presented by increasing their wavelength.

Sound

- **Frequency**
  – Frequency is the number of vibrations (or waves) in a given unit of time.
  – **Hertz** is a unit of frequency measurement, where one hertz is equivalent to one cycle (wave) per second. The greater the number of cycles (waves) per second the **shorter the wavelength** and the higher the frequency (higher hertz). Thus, the frequency of 20 hertz exhibits twenty cycles (waves) per second and is the lowest frequency that a human can hear. The frequency of 20,000 hertz exhibits twenty thousand cycles (waves) per second, and is the highest frequency that a human can hear.
  – **Pitch** is the quality of the sound that is dependent on the frequency. The higher the pitch the higher the frequency, the lower the pitch the lower the frequency.

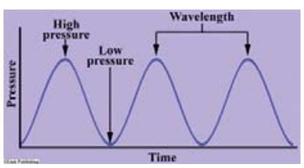


Figure 19.17
Air molecules leave a vibrating surface as sound waves, each sound wave consisting of an area of high compression (high pressure) followed by an area of low compression (low pressure).

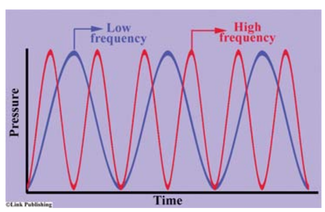


Figure 19.18
Frequency is the number of vibrations (high compressions - low compressions, or waves) in a given unit of time.

Sound

- **Amplitude**
  - Amplitude is the **intensity of sound**, or the quantity of the energy of the wave. In hearing amplitude is interpreted as **loudness**.
  - The greater the amplitude of the sound waves, the louder the sound. The **decibel** is a unit (logarithmic) used to express the intensity of sound.

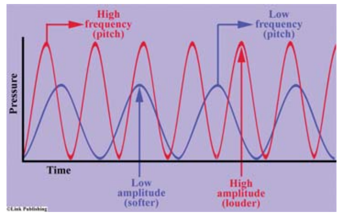


Figure 19.19
Amplitude is the intensity of sound, or the quantity of the energy of the wave. In hearing amplitude is interpreted as loudness.

PATHWAYS OF SOUND CONDUCTION

Sound Conduction to the Cochlea

- Sound waves passing along the auditory canal strike the **tympanic membrane** and set it into motion.
- The vibrations of the tympanic membrane are transferred to the first ossicle, the **malleus**. The ossicular chain transfers and amplifies the sound vibrations by way of the last ossicle, the **stapes**, to the **oval window**.
- The **oval window** transfers the sound vibrations as pressure waves to the fluid, the **perilymph**, of the cochlear chamber called the **scala vestibuli**. The pressure waves pass along the perilymph of the scala vestibuli and continue into the perilymph of the **scala tympani**. At the terminus of the scala tympani the pressure waves strike the **round window**, which absorbs their energy.

Sound Conduction to the Cochlea

- As the pressure waves (energy of the sound waves) pass along the perilymph, they set into motion regions of the **basilar membrane**.
- The regions of the basilar membrane that are set into motion are determined by the basilar membrane's structure.
  - The area of the basilar membrane that is **closest to the oval window (base of cochlea) is structured to respond and move when stimulated by pressure waves of high frequency**.
  - Moving toward the **apex of the cochlea (away from the oval window) the basilar membrane is set into motion by increasingly lower frequencies**.

Sound Conduction to the Cochlea

- **Frequency and Amplitude**
  - Thus, frequency is determined by the **location** of the basilar membrane that is set into motion. The **amplitude (intensity) of the pressure waves determines how much the basilar membrane is moved**. Loud sounds produce large (high amplitude) waves that result in greater movement of the basilar membrane than softer sounds produce.

Sound Conduction to the Cochlea

- **Depolarization and Conduction**
  - When the basilar membrane moves, it moves the associated **hair cells** of the organ of Corti. The hair cells are moved against the tectorial membrane resulting in the bending of their "hairs" (extensions of the plasma membrane called stereocilia). The hair cells are **depolarized** by the movement of their stereocilia. Depolarization of the hair cells leads first to the **depolarization of bipolar cells in the spiral ganglion**, then to the **depolarization of the cochlear fibers**.
  - The cochlear fibers produce the action potentials transmitted by the cochlear nerve.
  - Increased movement of the basilar membrane (due to increased amplitude of the pressure waves) increases the number of hair cells that are depolarized. Increased stimulation by increasing the number of stimulated hair cells results in neural information that is interpreted as the loudness of the sound.

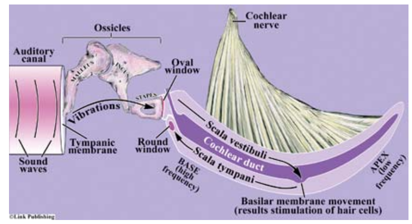


Figure 19.20
Pathway for the conduction of sound energy from the auditory meatus to transduction at the organ of Corti.

Neural Conduction to the Brain

Neural Conduction to the Brain

- The cochlear nerve leaves the cochlea and joins the vestibular nerve as the **vestibulocochlear nerve** (cranial nerve VIII). As the vestibulocochlear nerve enters the brainstem cochlear fibers branch into the cochlear nucleus the medulla.
- Most fibers crossover to the opposite side of the brain and enter the **midbrain**. Some fibers target the midbrain and their sensory information in used in auditory reflexes.
- Fibers leave the midbrain and enter the **thalamus**, the sensory relay center of the brain. The thalamus functions to distribute the sensory information to specific areas of the **auditory cortex of the temporal lobe for interpretation**.

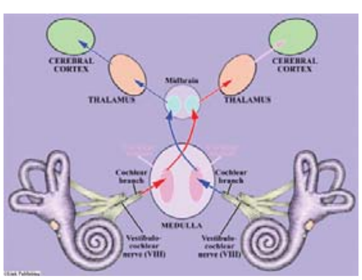


Figure 19.21
Simplified pathways showing the route of cochlear fibers.

HEARING TESTS

Hearing Tests

Deafness is the term used to describe any loss of hearing. It is classified as either

- (1) conduction deafness or
- (2) sensorineural deafness.

- **Conduction deafness**
  - Conduction deafness results from any loss of hearing due to the inability of sound to be conducted to the sensory apparatus (organ of Corti) of the inner ear. Causes include occlusion of the external auditory canal, damage to the tympanic membrane, inflammation of the middle ear, and immobility of the ossicles (otosclerosis).
- **Sensorineural deafness**
  - Sensorineural deafness results from any loss of hearing due to damage to the sensory apparatus (organ of Corti) or damage to neural transmission (vestibulocochlear nerve, VIII).

Weber's and Rinne's Tests

- Weber's and Rinne's tests are used to differentiate between conduction and sensorineural deafness.

Weber's Test

- Weber's test is used to screen for conduction or sensorineural deafness. A vibrating tuning fork in placed centrally on the forehead or the head. Sound should be heard equally well in both ears (no lateralization) if there is no conduction or sensorineural deafness.

- **Conductive hearing loss**
  - If there is a conductive hearing loss, lateralization (better hearing) occurs in the ear with conductive hearing loss (unilateral conductive hearing loss). The affected ear is receiving sound mostly by bone conduction and extraneous room noise is blocked. Thus, the affected ear hears this sound louder.
- **Sensorineural hearing loss**
  - If there is a sensorineural hearing loss, lateralization occurs to the better ear.

Lab Activity 4
Weber's Test

- **Procedure**
  - Place a vibrating tuning fork (512 Hz) onto the center of the forehead (or head).
  - Ask the subject if the sound is heard better in (1) the left ear, (2) right ear, or (3) equally well in both ears.
  - Record the subject's answer in the worksheet.

Weber's and Rinne's Tests

- **Rinne's Test**
  - Hearing by conduction of sound by air is about two times better than hearing by bone conduction.
  - If a vibrating tuning fork is placed on the mastoid process, the subject hears the sound mostly by bone conduction. If the still vibrating tuning fork is immediately moved to the position in front of the external auditory canal, the subject should hear the sound louder.
  - If there is **conductive hearing loss**, bone conduction is heard louder than air conduction.
  - If there is **sensorineural hearing loss**, both air conduction and bone conduction are reduced with air conduction being better than bone conduction.

Lab Activity 4
Rinne's Test

- **Procedure**
  - Place a vibrating tuning fork (512 Hz) onto the mastoid process of the right ear.
  - Ask the subject to tell you immediately when the sound can no longer be heard. Then, quickly position the tuning fork in front of the external auditory canal.
  - Ask the subject if the sound can still be heard.
  - Repeat the test for the left ear.
  - Record the subject's answer in the worksheet.

EQUILIBRIUM

Equilibrium is a function of sensory structures of the inner ear that register the orientation of the head. The regions of the inner ear that function in equilibrium are the **vestibule** and the **semicircular canals**.

Vestibule

- The vestibule is the portion of the inner ear located between the cochlea and the semicircular canals.
- The vestibule contains two regions,
  - (1) the saccule and
  - (2) the utricle,
- The saccule and utricle house receptors called maculae (spot-like areas), the macula sacculi and the macula utriculi, respectively.
- The receptors of the maculae respond to **gravity and linear motion and function in equilibrium and maintenance of body position by detecting the orientation of the head.**

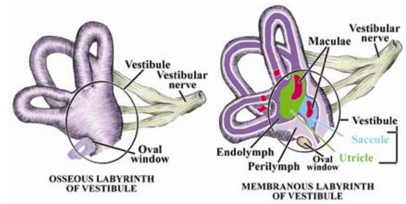
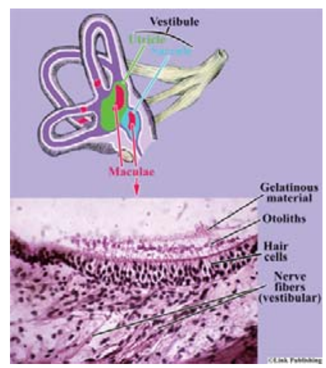


Figure 19.22
The vestibule is the portion of the inner ear located between the cochlea and the semicircular canals. The vestibule contains two regions, (1) the saccule and (2) the utricle, each containing receptors called maculae.

Maculae

- The maculae of the vestibule (the saccule and utricle) consist of areas of hair cells covered with a gelatinous material containing small crystals of calcium carbonate, the **otoliths**.
- Gravity and linear movements influence the position of the gelatinous material and otoliths in respect to the hair cells. Movement of the otoliths and the gelatinous material over the “hairs” (stereocilia) of the hair cells, results in changes in the polarity of the hair cells.
- Thus, depending upon the polarity (hyperpolarization or depolarization) of the hair cells, they can increase or decrease production of action potentials (nerve impulses) of the vestibular nerve fibers.

Figure 19.23
The maculae of the vestibule (the saccule and utricle) consist of areas of hair cells covered with a gelatinous material. Embedded in the gelatinous material are small crystals of calcium carbonate, the otoliths. A high power photograph of a macula is shown with its associated otoliths and gelatinous material.



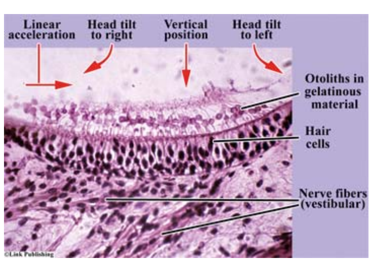


Figure 19.24
The otoliths and the associated gelatinous material move against the “hairs” (stereocilia) of the hair cells in response to gravity and straight line linear movements. Movement of the stereocilia results in electrical changes in the hair cells providing the stimulus for excitation or inhibition of the vestibular fibers.

Semicircular canals

- Each of the three semicircular canals,
  - (1) the anterior,
  - (2) the posterior, and
  - (3) the lateral, projects from the vestibule in the direction descriptive of its name.
  - Each semicircular canal contains a fluid-filled membranous duct, the semicircular duct, that has an enlarged area called an **ampulla**.
  - Each ampulla contains a receptor, the **crista ampullaris**, that responds to **rotational motion and maintains equilibrium**.

Semicircular Canals

- Two of the semicircular canals, the anterior and posterior, project vertically and respond to rotational motion in the two vertical planes, front-back (sagittal plane) and side-to-side (frontal plane).
  - The anterior semicircular canal responds to front/back (sagittal plane) rotational motion such as in swaying the head in indicating "yes," and the posterior semicircular canal responds to side/side (frontal plane) rotational motion such as swaying the head side-to-side.
- The lateral semicircular canal responds to rotational motion in the horizontal plane such as the rotating the head in indicating "no."

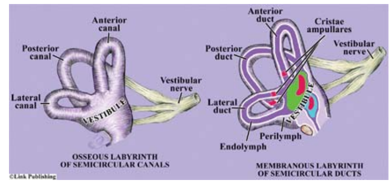


Figure 19.25
The three semicircular canals, (1) the anterior, (2) the posterior, and (3) the lateral, project from the vestibule in the direction descriptive of its name. The semicircular canals function in reception of rotational movements.

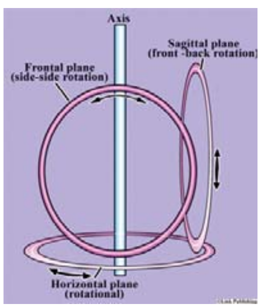


Figure 19.26
The semicircular canals follow three planes and interpret rotational movement for maintaining equilibrium.

Lab Activity 6 Crista ampullaris

- Observe a slide preparation labeled "Crista ampullaris." Each of the fluid-filled semicircular canals has an enlarged area called an ampulla. Each ampulla contains a receptor, the crista ampullaris.
- The crista ampullaris consists of
  - (1) hair cells (receptors) that are covered by a gelatinous material called the
  - (2) cupula.

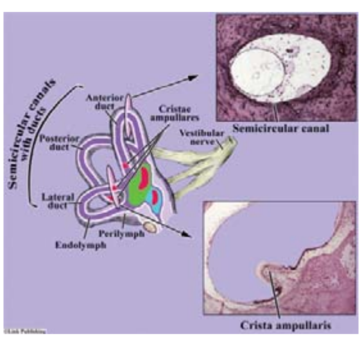


Figure 19.27
Each semicircular canal contains a fluid-filled membranous duct, the semicircular duct, that has an enlarged area called an ampulla. Each ampulla contains a receptor, the crista ampullaris, that responds to rotational motion.

Lab Activity 6 Crista ampullaris

- A rotational movement of the head causes the fluid (endolymph) in a semicircular duct to move against the cupula of the crista ampullaris.
- The movement of the cupula stimulates the hair cells. The hair cells produce electrical stimuli that result in either depolarization or hyperpolarization of the vestibular nerve fibers.
- Depolarization of the vestibular fibers results in nerve impulses that leave the crista ampullaris by way of the vestibular nerve.
- The vestibular nerve joins with the cochlear nerve to form the vestibulocochlear nerve (VIII), which enters the brainstem.

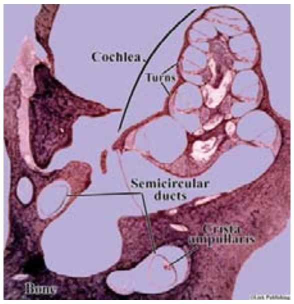


Figure 19.28
A photograph of a sectioned inner ear. This photograph shows the semicircular canals housing the semicircular ducts and a receptor, the crista ampullaris.

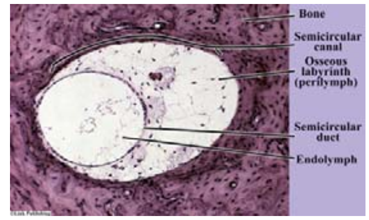


Figure 19.29
This photograph shows a cross section of a semicircular canal. Each canal contains a semicircular duct that houses fluid called endolymph. Rotation of the head results in movement of the endolymph against a receptor called the crista ampullaris. The osseous labyrinth surrounds the semicircular ducts and contains perilymph.

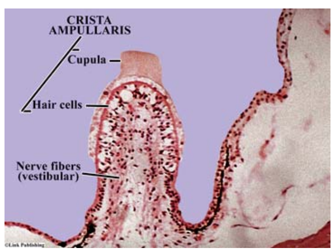


Figure 19.30
This photograph shows the crista ampullaris. The crista ampullaris is located in an enlarged area of the semicircular canal, the ampulla. Movement of endolymph against the cupula stimulates the hair cells. The hair cells produce electrical stimuli that result in either depolarization or hyperpolarization of the vestibular nerve fibers.

PATHWAY TO THE BRAIN

- The vestibular nerve fibers join to form the vestibular nerve. The vestibular nerve merges with the cochlear nerve to form the vestibulocochlear nerve (VIII).
- Each vestibulocochlear nerve enters the brain stem where vestibular fibers from each nerve enter two vestibular nuclei.
- Each of the two sets of vestibular nuclei functions to maintain equilibrium and to control eye movements in the stabilization of the visual image on the retina during head movement.
- To obtain this function vestibular information is relayed to several central nervous system areas. Among these areas, information is relayed to the cerebellum for motor coordination, to the cerebral cortex for conscious awareness, and to other brain stem nuclei (to control eye and motor movements), and to motor tracts of the spinal cord.