

# PSYC 223

# BIOLOGICAL PSYCHOLOGY

Session 7 – THE BRAIN AND THE SENSORY  
SYSTEM

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# Session Overview

- In this session, you will be introduced to the sensory system. At the beginning of this course, we discussed transmission of information from sense organs to the brain by the neurons in the nervous system. We will discuss the specific organs and how they are regulated by the brain to recreate and represent the external world around us. We will focus on vision and audition and at the end of each, we will briefly describe some disorders.

# Session Outline

The key topics to be covered in the session are as follows:

- Sensation and Perception
- The Eye and vision in the Brain
- Cortex and Vision
- Visual disorders
- The Ear and audition in the Brain
- Cortex and audition
- Auditory disorders



# Reading List

- Read Chapter Six of Biological Psychology 9<sup>th</sup> Edition by J. W. Kalat; pages 152 – 181.
- Read Chapter Seven of Biological Psychology 9<sup>th</sup> Edition by J. W. Kalat; pages 196 - 202



Topic One

# THE BRAIN AND THE SENSORY SYSTEM



# Defining Sensation and Perception

- Sensation
  - The detection of physical energy emitted or reflected by physical objects.
  - It occurs when energy in the external environment or the body stimulates receptors in the sense organs.
- Perception
  - The process by which the brain organizes and interprets sensory information.

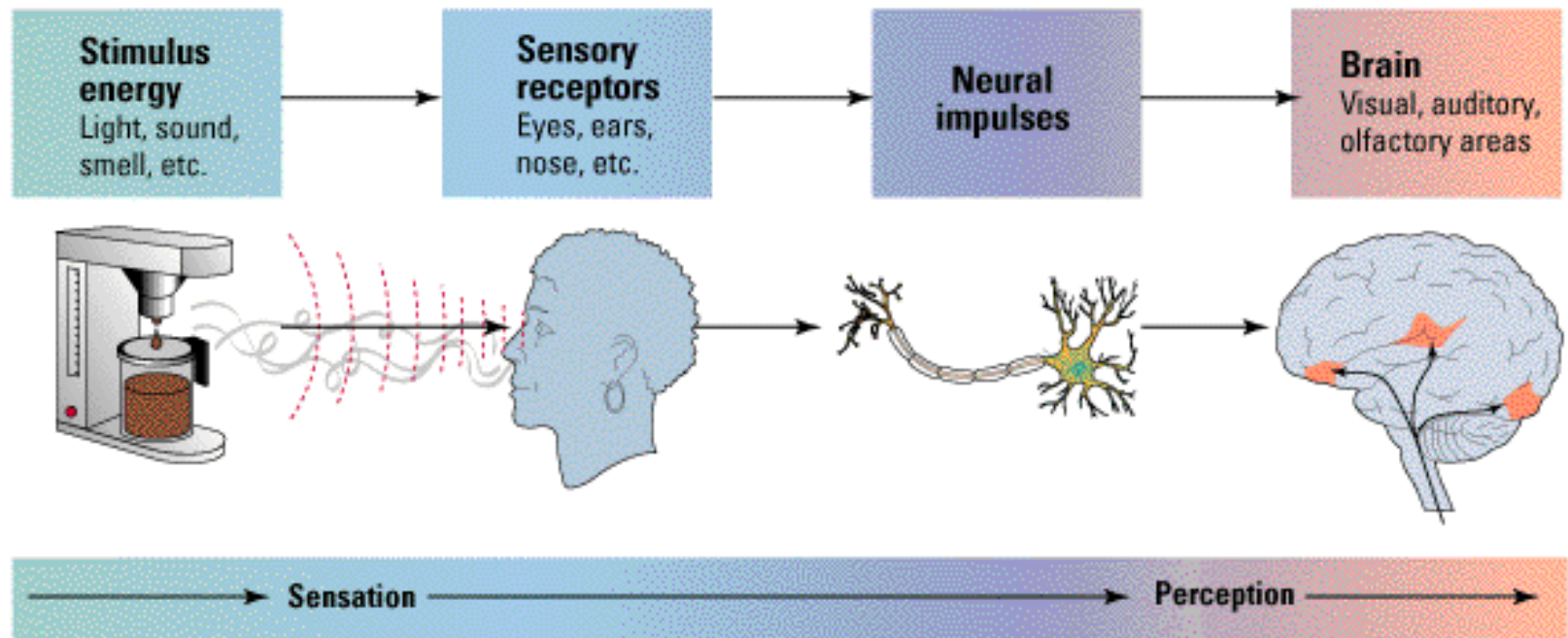


# Law of Specific Nerve Energies

- In 1912, Lord Edgar Douglas Adrian showed that all neurons carry the same energy, *electrical energy*, in the form of *action potentials*.
- This means, all signals getting to the brain are the same in nature or quality. What is experienced however, depends on the part of the brain to which nerves deliver their action potentials (e.g., light from nerves arriving at the visual cortex and sound from nerves arriving at the auditory).
- Different sensory modalities exist because signals received by the sense organs stimulate different nerve pathways leading to different areas of the brain. This is the theory propounded by Johannes Muller called the *Law of Specific Energies*.



# Sensation & Perception Processes



Source: Kassin, S. (1998). *Psychology*, 2<sup>nd</sup> Ed. NJ: Prentice Hall.



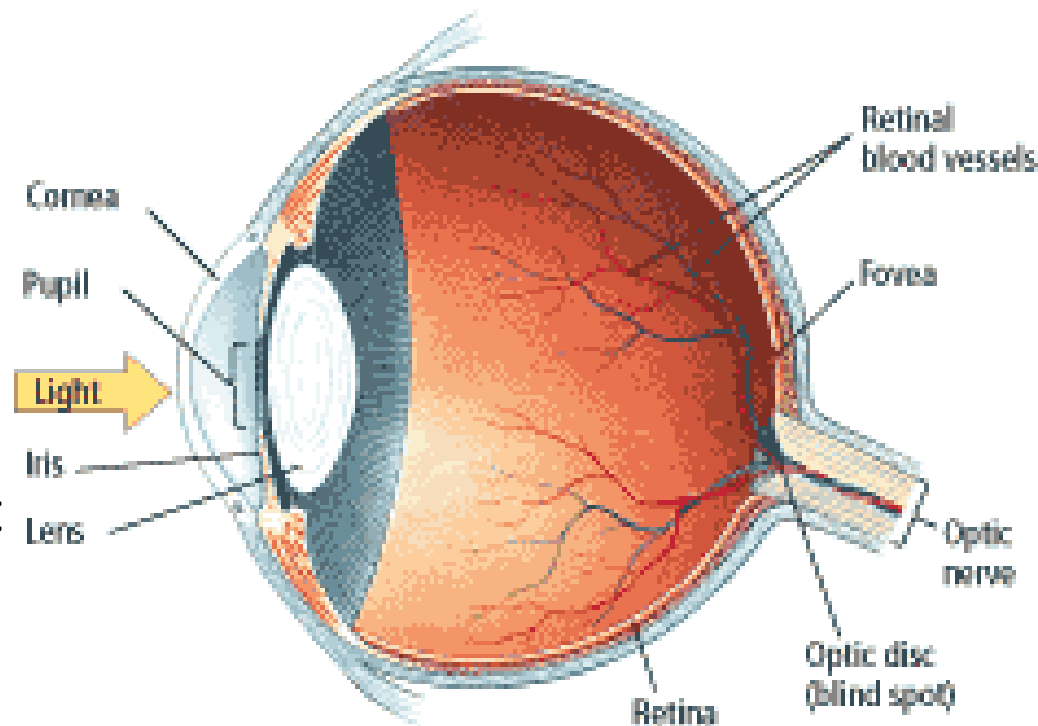
Topic Two

# THE EYE AND VISION IN THE BRAIN



# Structure of the Eye

- Cornea
  - Protects eye and bends light toward lens.
- Lens
  - Focuses on objects by changing shape.
- Iris
  - Controls amount of light that gets into eye.
- Pupil
  - Widens or dilates to let in more light.



# Cells in the Eye

- Retina
  - Neural tissue lining the back of the eyeball's interior, which contains the receptors for vision.
- Rods
  - Visual receptors that respond to dim light.
- Cones
  - Visual receptors involved in colour vision. Most humans have 3 types of cones.



## RODS

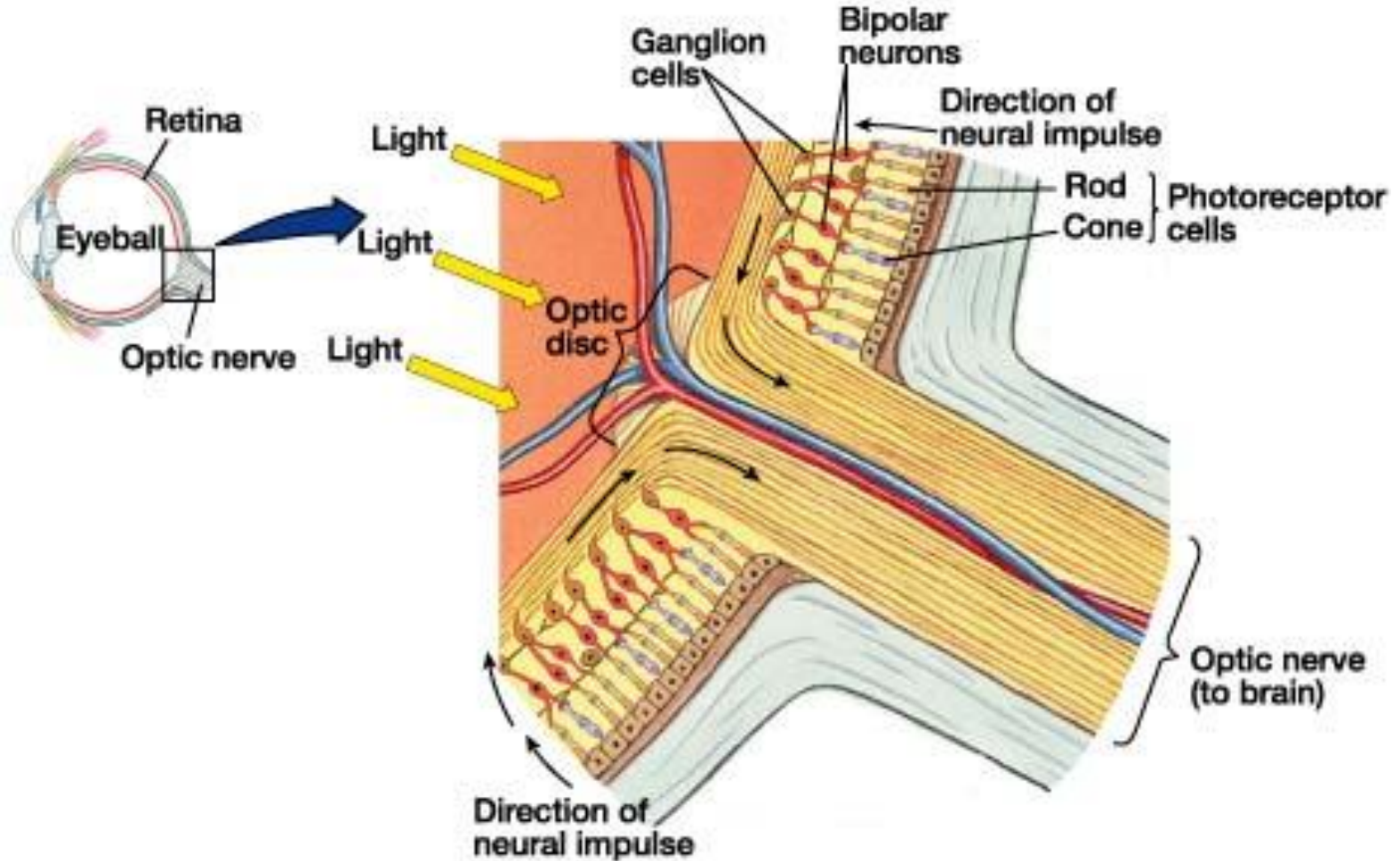
- Black and white vision
- Operate well in low level light – night vision
- Sensitive to brightness, darkness and movement
- Mainly located in outer part of retina
- Poor acuity (low sharpness and focus)
- Excellent for peripheral vision rather than direct
- 19x the number of cones

## CONES

- Daytime and colour vision
- Excellent visual acuity – sharp and clean images
- Concentrated in the fovea
- Not useful at night – can't discriminate colours
- Outnumbered by rods 19:1



# The Structures of the Retina



# The Visual System

- Much visual processing is done in the brain.
  - Some cortical cells respond to lines in specific orientations (e.g. horizontal).
  - Other cells in the cortex respond to other shapes (e.g., bulls-eyes, spirals, faces).
- Feature-detectors
  - Cells in the visual cortex that are sensitive to specific features of the environment.



# Reception

- **Electromagnetic energy** - *light* sensed from the environment. This is the reflection of objects to the eye that stimulates the cells in the eye
- **RODS** (black and white) and **CONES** (C for colour) are photoreceptors that pick up the electromagnetic energy
- This **energy** must be **CHANGED** for the brain to be able to interpret it...



# Transduction

- The electromagnetic energy is converted, changed or **'transduced'** into **electrochemical energy**.
- This is the energy that stimulates all neurons in the nervous system.
- This means that information sensed by the rods and cones can be sent as **neural impulses** (action potentials) to the visual cortex.





# From Eye to Cortex

- The retina projects to *subcortical regions* in the brain
- The Lateral Geniculate nucleus (LGN) in the thalamus is the major target of the retinal ganglion cells
  - 1) the *lateral geniculate nucleus*, the major subcortical center relaying visual information to the primary visual cortex;
  - 2) the *superior colliculus*, which control orienting eye movements;
  - 3) the *hypothalamus*, which regulate the circadian rhythms; and
  - 4) the *pretectum*, which control the pupillary light reflex
- The Lateral Geniculate nucleus (LGN) in the thalamus is the major target of the retinal ganglion cells. It receives inputs from both eyes and relays these messages to the primary visual cortex



# Visual Transmission and Processing

- Area V1 (the part of the visual cortex where vision first arrives from the thalamus) is responsible for *conscious vision*
  - Conscious vision is the awareness of an object
  - Damage to area V1 leads to cortical blindness, i.e., inability to see even though the eye is not damaged.
- Assignment: Research for the phenomenon known as *Blind sight*.



# Visual Processing

- Ventral Pathways (Temporal)
  - From the primary visual cortex (Area V1), signals about vision are transmitted to several parts of the visual cortex for processing of other aspects of the information received.
  - Pathways that lead to the temporal lobe are called Ventral Pathways.
  - These carry signals about shape and movement of the object
  - The ventral pathway is specialised for recognising shapes and objects including faces.
  - When the temporal lobes area damage it may be related to impairment in recognising shapes and faces.



# Visual Processing

- Dorsal Pathways (Parietal)
  - Another pathway leads to the parietal lobe and they are referred to as Dorsal pathway.
  - This provides information about we locate the object in space. For example, our ability to shape our fingers around a pen or gripping a ball are based on information received about the object.
  - Helps to locate and move toward an object or move around objects.
- Since the Ventral and Dorsal pathways are separate, damage to one can leave the other intact.
- Damage to ventral would lead to inability to name or recognise an object but able to reach for it.



Topic Three

# VISUAL DISORDERS



# Visual Deficit

- Visual Agnosia
  - Inability to recognize objects despite satisfactory vision
  - Results from damage in the temporal lobe
    - Ventral Stream
  - They can remember and describe shapes from memory but cannot recognize them



# The Visual Brain in Action

- **Prosopagnosia (Face Agnosia)**
  - Inability to recognize faces, even familiar people like siblings and spouses
  - The people with this disorder can recognize objects, letters and words but cannot recognise faces.
  - They can be accurate about age (old or young), sex (male or female) but can't identify the person.
  - Occurs after damage to the fusiform gyrus located in the inferior temporal cortex
- **Optic Ataxia**
  - Deficit in the visual control of reaching and other movements
  - Damage to parietal cortex Can recognize objects normally
- **Motion blindness**
  - Inability to perceive movement of objects, speed or direction of the movement
  - Possibly related to damage in Medial Temporal lobe



Topic Four

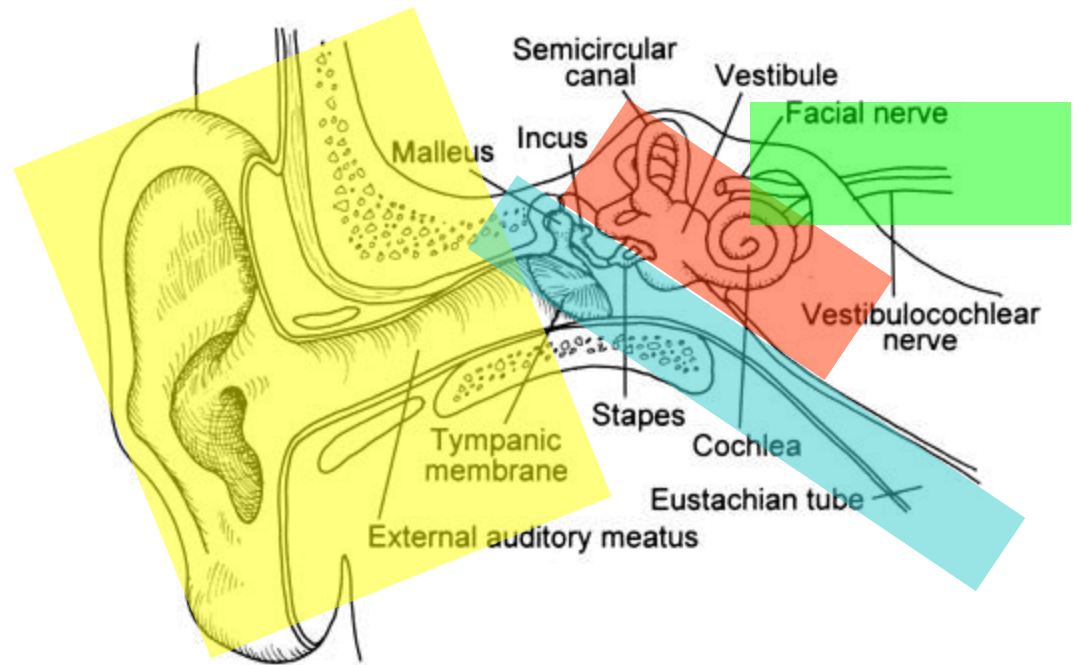
# THE EAR AND AUDITION IN THE BRAIN





# Ear structures

- Peripheral
  - Outer ear
  - Middle ear
  - Inner ear
  - Auditory nerve
- Central
  - Brainstem
  - Midbrain
  - Cerebral



# Hearing

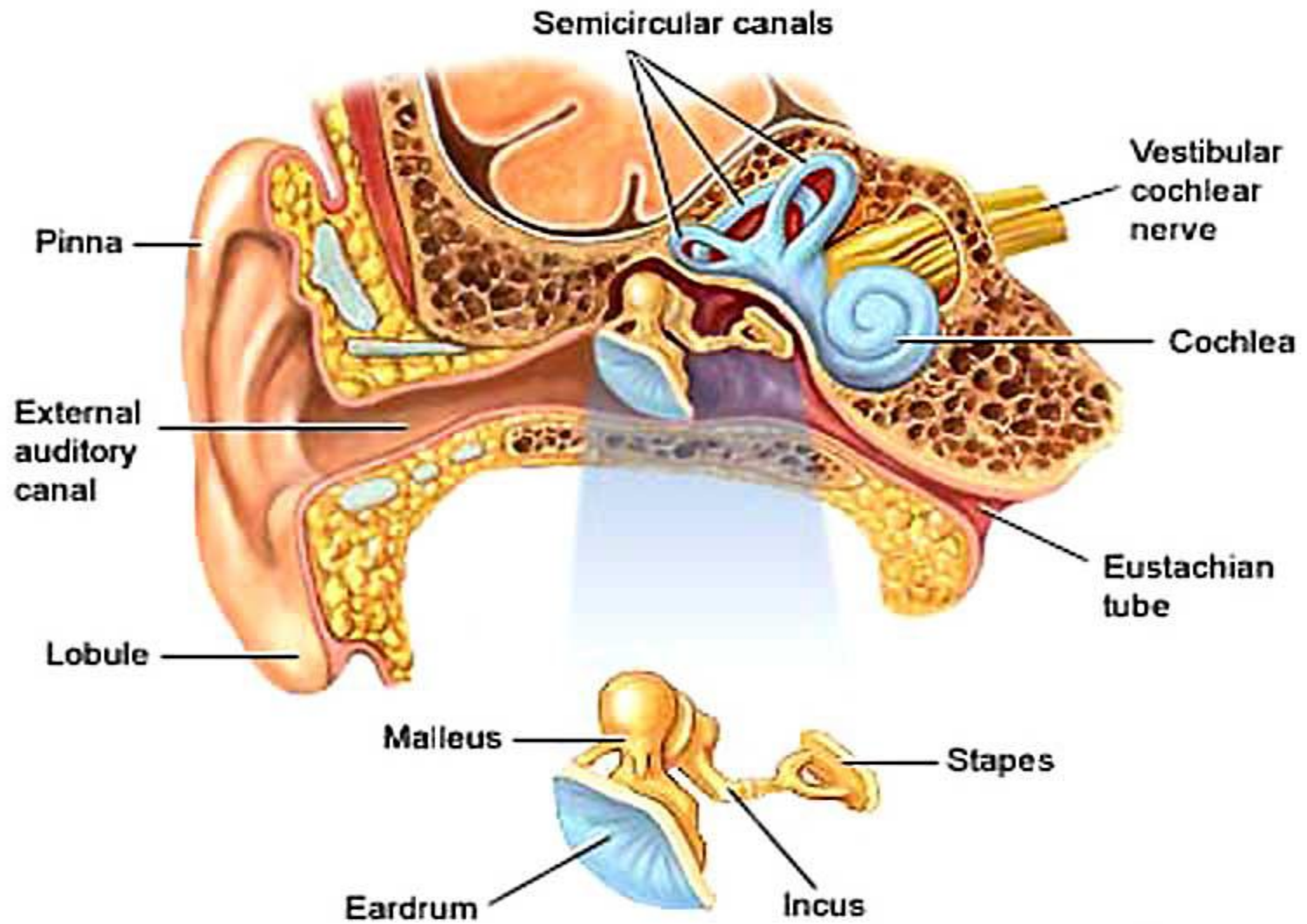
- Inner ear
  - The innermost portion of the ear, containing the cochlea, the vestibular sacs, and the semicircular canals
  - Cochlea
    - The snail-shaped, fluid-filled chamber in the inner ear that contains the hair cells (the sound receptors)
  - Hair cells
    - Sensory receptors for hearing, found in the cochlea



# Hearing

- Reflection of sound in pinna (earlobe) provides spectral cues about elevation of a sound source
- Middle ear is a cavity containing an ossicular lever which matches the acoustical impedance of the inner ear so sound energy is effectively transmitted (60%)
- Inner ear contains the cochlea where sound is converted into a neural signal

# Anatomy and function



# Middle Ear - Ossicles

- Air-filled tympanic cavity which includes 3 of the smallest bones in the body:
  - Malleus (hammer)
  - Incus (anvil)
  - Stapes (stirrup)
- Ossicular chain:
  - Transmits acoustic energy from tympanic membrane to inner ear
  - Delivers sound vibrations to inner ear fluid
  - Muscles can dampen response: Prevents the inner ear from being overwhelmed by excessively strong vibrations



# Sound Transmission

- Sound wave caused by vibrating objects moves through the air and enters external auditory canal reaching membrane or eardrum.
- Vibrations propagate through the middle ear through mechanical action of three bones the hammer, anvil and stirrup (or malleus, incus and stapes).
- Because of the length of the ear canal, it is capable of amplifying sounds with frequencies of approximately 3000 Hz.
- The cochlea and the semicircular canals are filled with a water-like fluid.

# Sound Transmission

- Cochlea in the inner ear contains a *basilar membrane*.
- Traveling wave of sound moves across the basilar membrane moving the hair cells (neurons).
- The inner surface of the cochlea is lined with over 16000 hair cells.
- Each hair cell has a natural sensitivity to a particular frequency of vibration.
- The brain decodes the sound frequencies based on which hair cells is activated.
  - This is known as *place principle*.

# The central auditory system

- The neuron signals travel starting from the auditory nerve to the lower (ventral) cochlear nucleus.
- Then signal travels through lateral lemniscus, inferior colliculus, thalamus, to auditory cortex.





# Anatomy and function

- Signals from each ear converge on the superior olivary complex - important for sound localization
- Inferior colliculus is sensitive to location, absolute intensity, rates of intensity change, frequency - important for pattern categorization

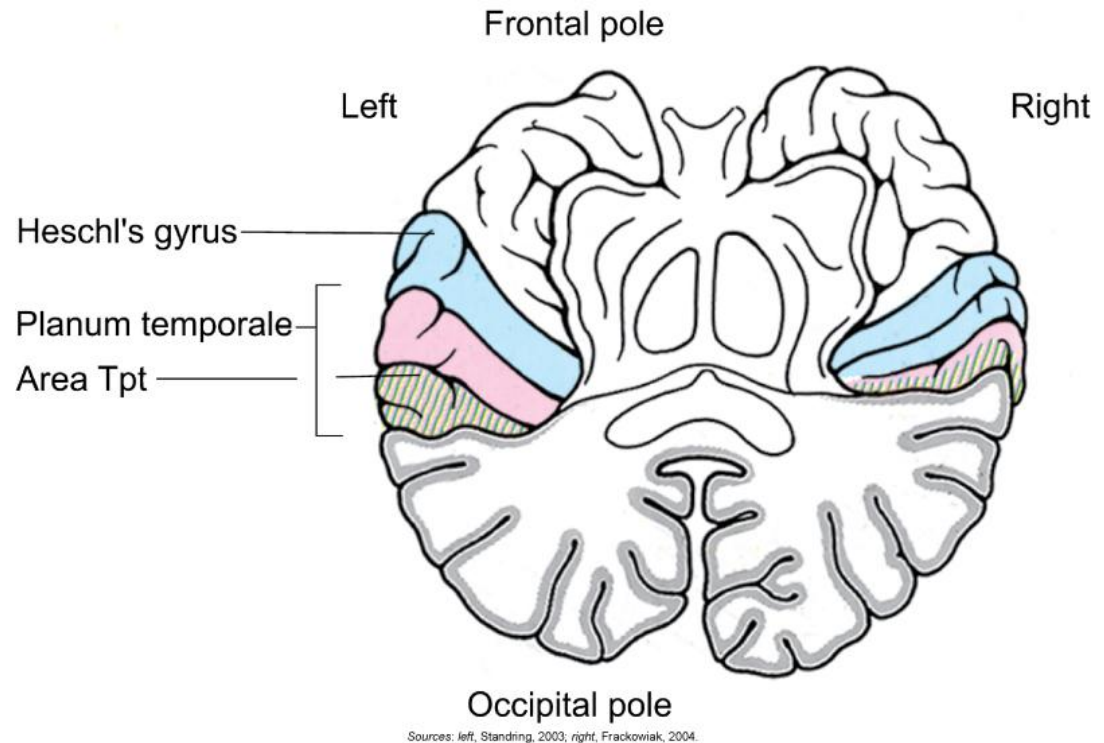


# Anatomy and function

- Auditory cortex specializes in sound processing.
- These processes provide a wide range of perceptual abilities like selecting a single person's voice in a crowded space or recognizing melody even when it is played off-key.

# Auditory cortex

- In humans primary auditory cortex is located within Heschl's gyrus.
- Another important region in auditory cortex is planum temporale located posterior to Heschl's gyrus.
- Posterior to planum temporale is what Carl Wernicke associated with speech comprehension (Wernicke area).



# Hearing dysfunction

- Conductive hearing loss
  - Occurs when sound is not conducted efficiently through the outer ear canal to the eardrum and the tiny bones (ossicles) of the middle ear.
  - Usually involves a reduction in sound level or the ability to hear faint sounds.
  - Can often be corrected medically or surgically.
- Sensorineural hearing loss
  - Occurs when there is damage to the inner ear (cochlea), or to the nerve pathways from the inner ear to the brain. cannot be medically or surgically corrected. This is the most common type of permanent hearing loss.

Reduces the ability to hear faint sounds. Even when speech is loud enough to hear, it may still be unclear or sound muffled.



# References

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