REPUBLIC POLYTECHNIC

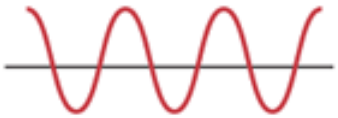
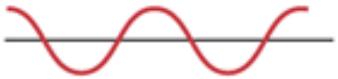
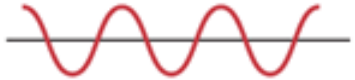
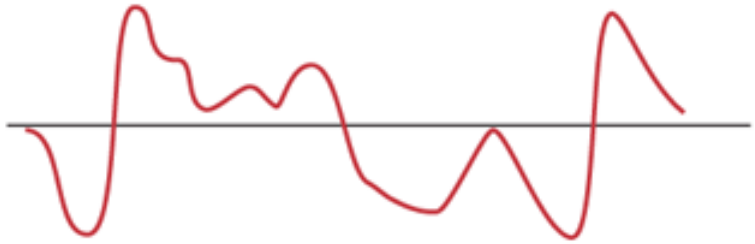
P04

Everything Else Matters Too

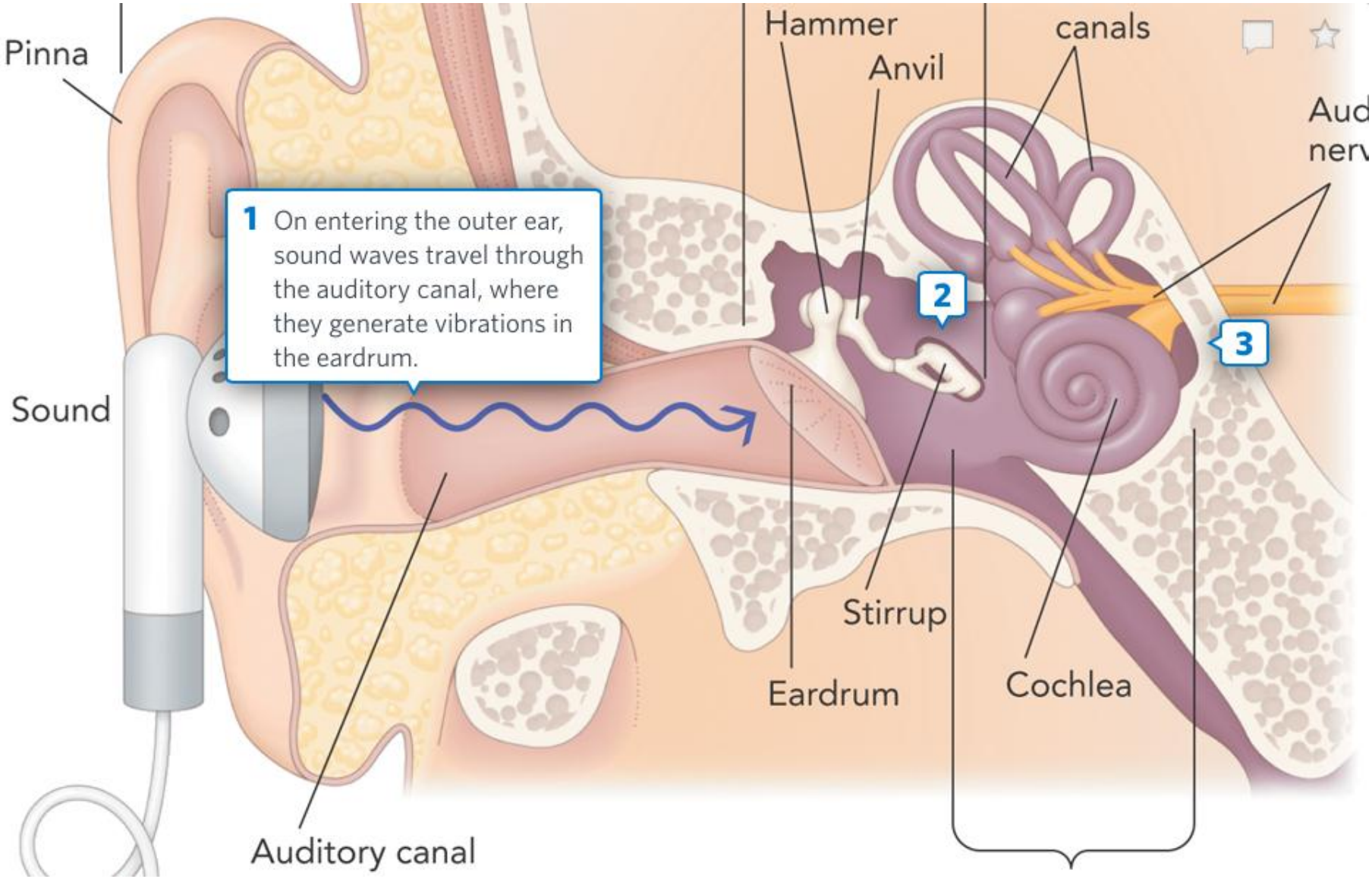
E365 – Aviation Human Factors

SCHOOL OF ENGINEERING

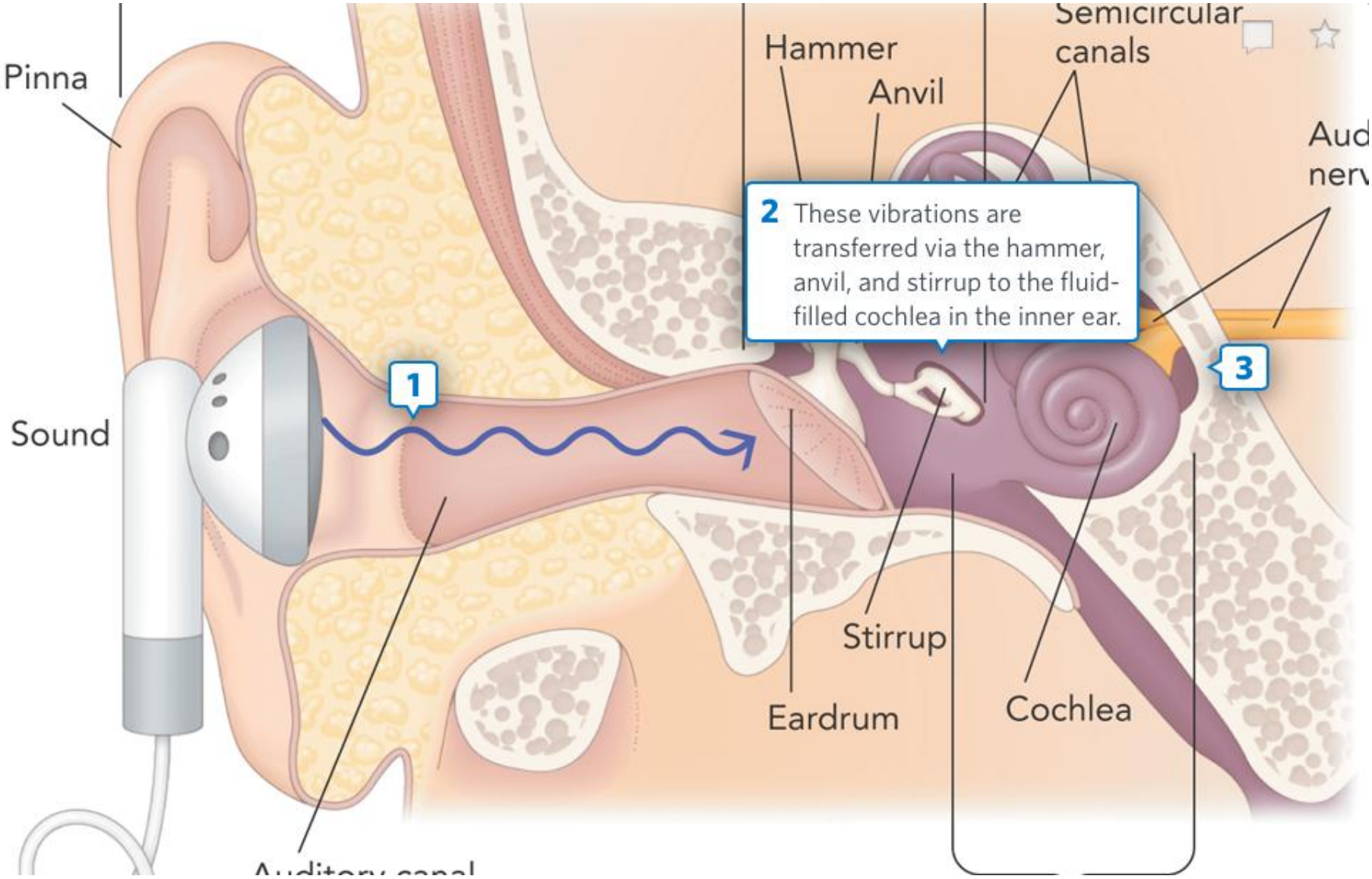
Perception of sounds

Physical Dimension	Perceptual Dimension	Form of Sound Waves
Amplitude (intensity)	Loudness	 Loud  Soft
Frequency	Pitch	 Low  High
Complex sounds	Timbre	 (Form of sound wave from a clarinet)

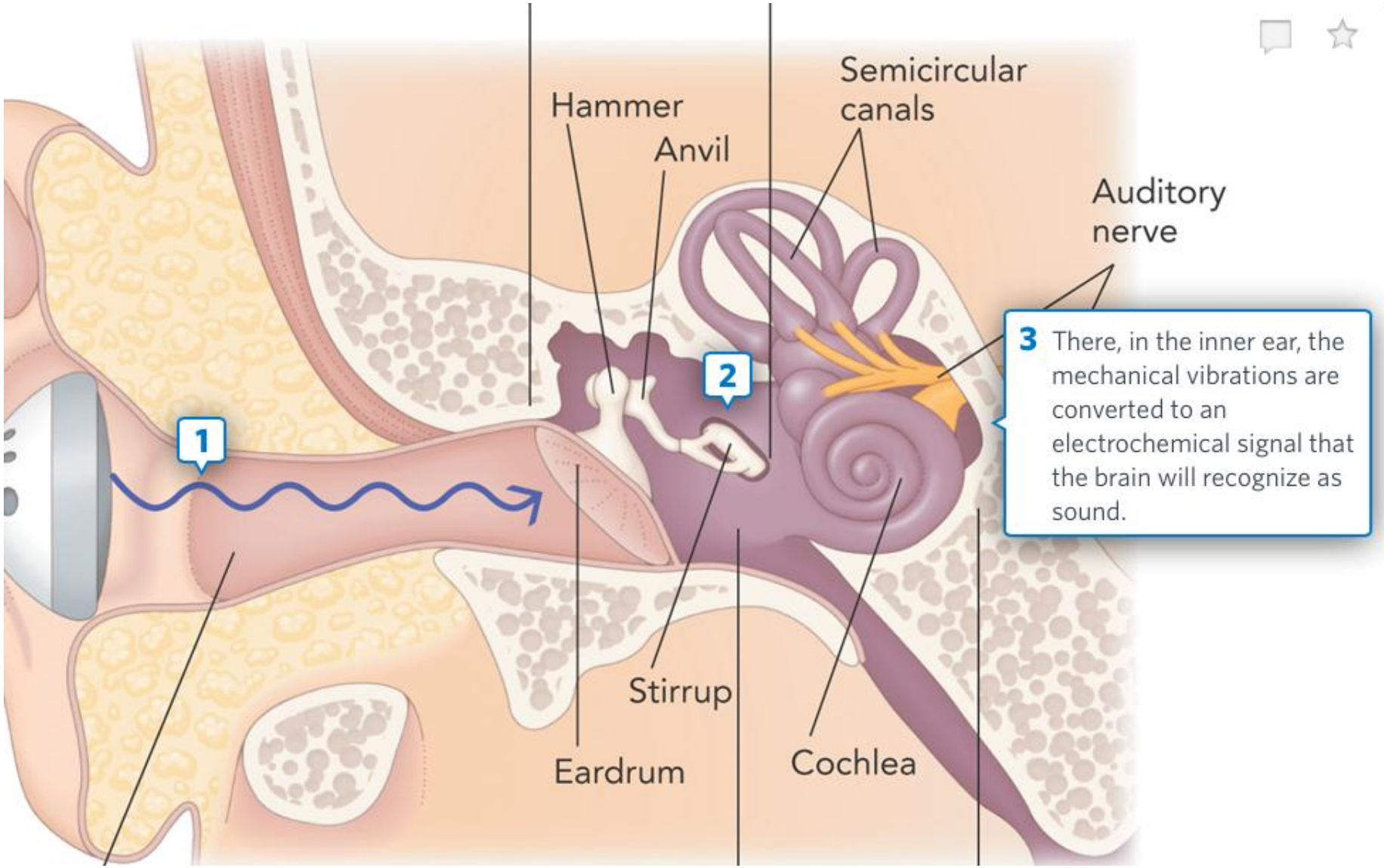
Sensing sounds – Outer ear



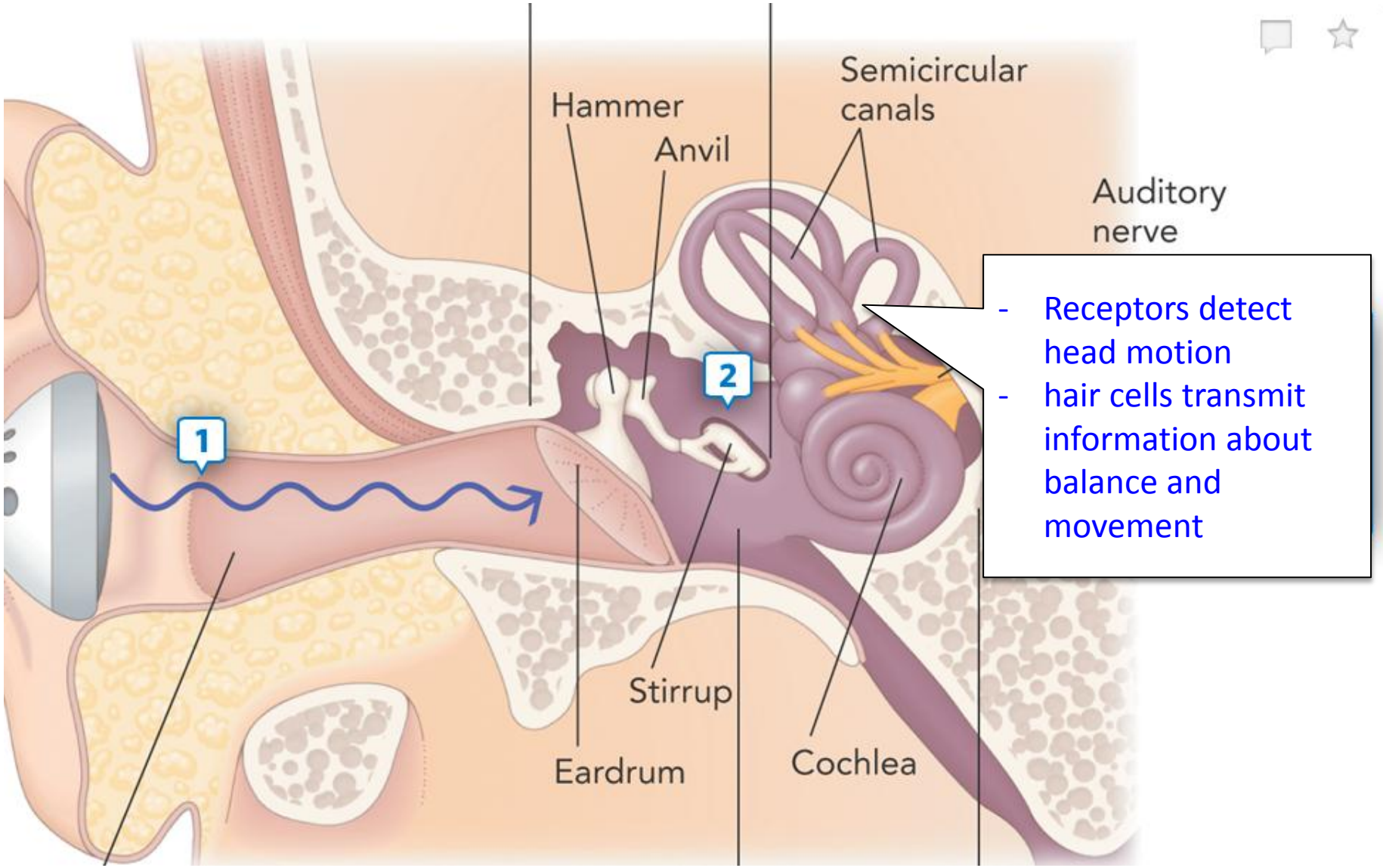
Sensing sounds – Middle ear



Sensing sounds – Inner ear



Semicircular canals



- Receptors detect head motion
- hair cells transmit information about balance and movement

Performance of the human ear

- Sound intensity limits
  - 0 – 140 dB
- Sound frequency limits
  - 20 – 20,000 Hz
- Conductive hearing loss
  - Disorders in the mechanical structures of the outer (eardrum) and middle ear (hammer, anvil, stirrup).
- Sensorineural hearing loss
  - Damage to neural structures in the cochlea, auditory nerve or central auditory system.
    - Presbycusis

Auditory Displays

- Advantages of Auditory Displays:
  - Better than visual displays at capturing attention of operators in unexpected situations
    - Attention is grabbed when a siren sounds whereas a warning light may go unnoticed
- Examples of Auditory Displays:
  - Public Address System
  - Warning/Alarm signals
    - Horn (car)
    - Siren (ambulance)
    - Whistle(train)

Usage of auditory displays

- Warnings
- Low Lighting Environment
- Origin of signal is itself a sound
- Message is simple and short
- Information is not needed to be retained for future use
- Immediate action is needed
- Continuously changing information is presented
- Visual system is overburdened
- Speech channels are fully employed
- Illumination limits use of vision
- Receiver/Operator moves from one place to another

Principles of auditory display

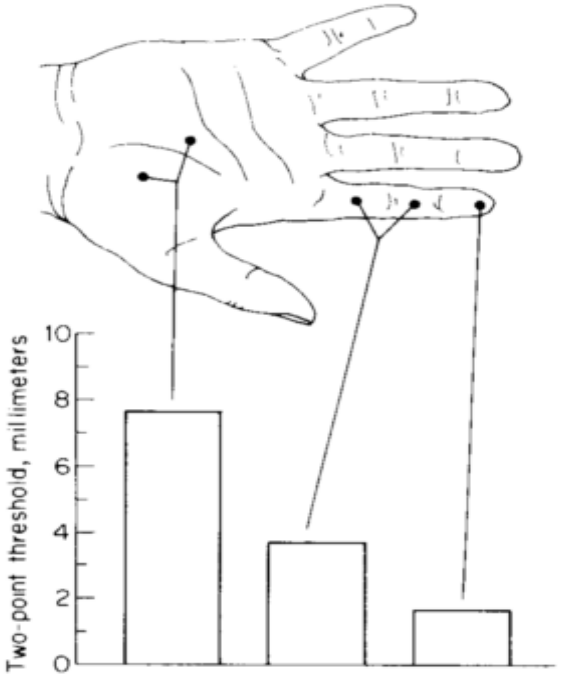
- Compatibility
  - Type of sound must be compatible with information transmitted
- Approximation
  - Attention-demanding signal, then designation signal
- Dissociability
  - Auditory signals should be easily discernable from any ongoing audio input
- Parsimony
  - Input signals to the operator should not provide more information than is necessary
- Invariance
  - The same signal should designate the same information at all times

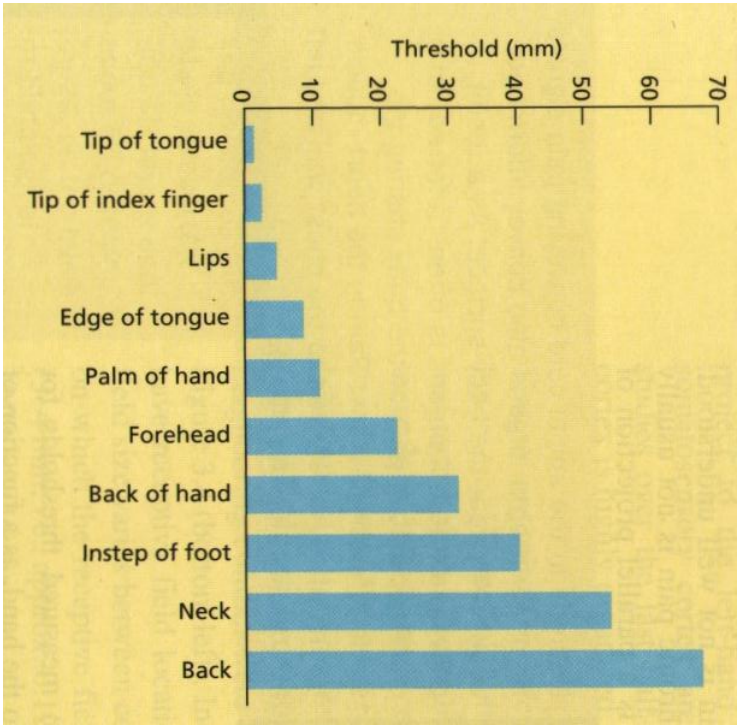
Cutaneous senses

- Touch
  - Mechanical energy of the pressure against the skin
  - Sensitivity is not uniform across all areas of the skin
- Temperature
  - Warm and cold thermoreceptors
- Pain
  - Intense stimulation of any one of our senses

Two-point threshold of touch

- Measure of touch sensitivity
  - smallest distance between two pressure points at which the points are perceived as separate.
- Tactile displays that require fine discriminations are best designed for fingertip reception.



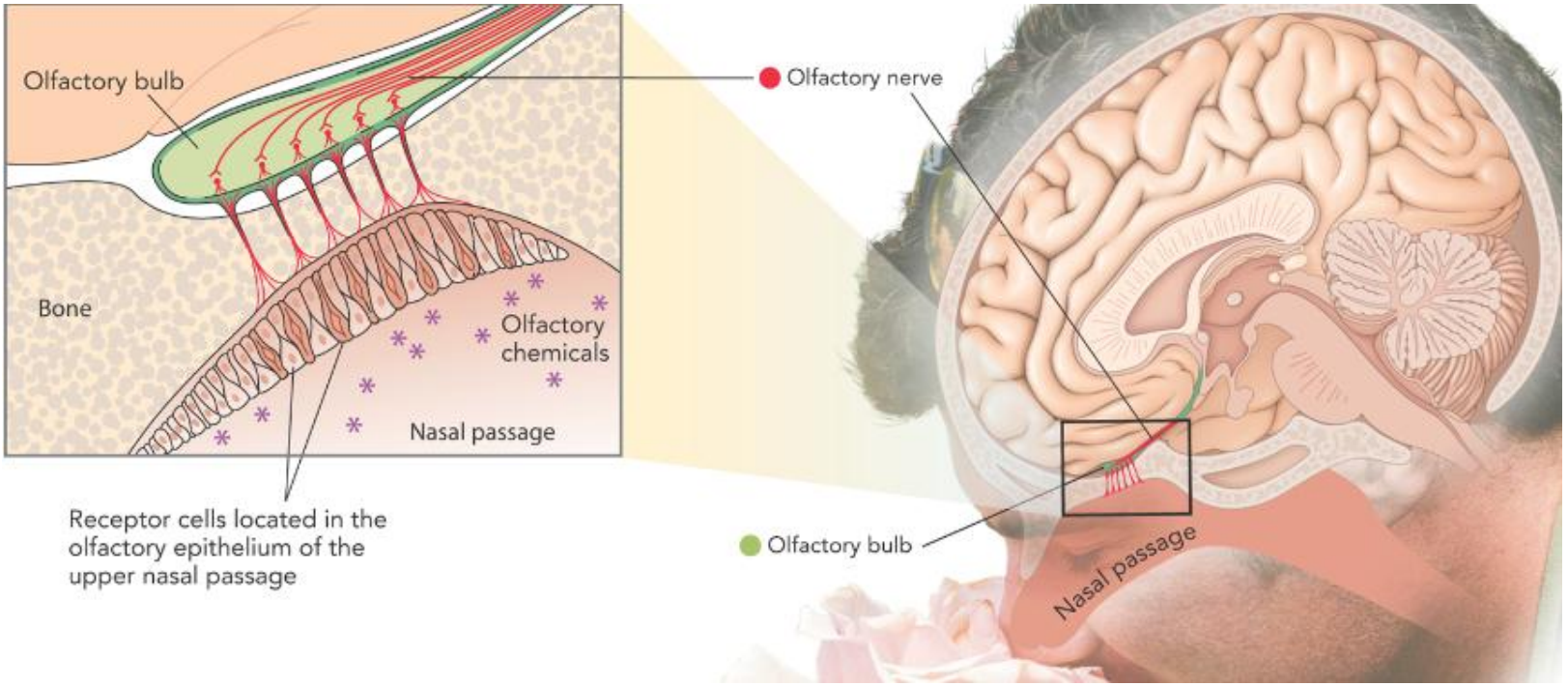


Usage of tactile displays

- When sound is not allowed
  - During live performances in a concert hall, mobile phones put to vibration mode
- In noisy environments where sounds will not be heard
- For the visual and hearing impaired
  - Braille print for the blind
- When visual and auditory senses are overburdened
  - Tactile Situational Awareness System

Smelling

- Airborne molecules of an odour reach tiny receptor cells in the roof of the nasal cavity.
  - The receptor cells form a mucus-covered membrane called the olfactory epithelium.
- The olfactory nerve carries information about the odour to the brain for further processing.



Olfactory Displays

- No widespread applications
  - Cannot be depended on as a reliable source of information as people differ greatly with respect to sensitivity to odors
  - Serve primarily as warning devices
- Examples of Olfactory Displays:
  - Gas companies add odorant to natural gas so we can detect gas leaks at home. LPG itself is odourless.
  - Fire prevention systems release carbon dioxide, with a wintergreen odour added as a warning
  - US metal mines use “stench” systems to alert workers during emergency evacuations
    - Reach vast areas which might not be economically reached by visual or auditory warnings.

Learning Objectives

- Functions and limitations of our ear, nose and skin.
- Design considerations and usage of auditory, tactile and olfactory displays