HSC Biology
Communication

Focus 6:

- *Animals that produce vibrations also have organs to detect vibrations.*

Outline and Compare the detection of vibrations by insects, fish and mammals.

- Insects:
  - Have a pair of membranes on legs / abdomen.
    - Tympanic membranes.
  - Mechanoreceptors detect vibrations in a similar way to eardrums.
    - Send message to brain.
  - Hairs on exterior of body which vibrate in accordance with sound waves of specific frequencies.
    - Depend on stiffness & length of hair.
    - Often tuned to frequency of same or other species.
      - Detect potential mates or predators.

- Fish:
  - Have internal ears located close to the brain.
    - No eardrum or cochlea.
  - Vibration of water conducted through skeleton of head, to inner ear.
  - Cilia in semicircular canals detect vibrations, send message to brain.
  - Detect low frequency sound using lateral line system.
    - Long, fluid filled channel running just below skin.
    - Pores at frequent intervals connecting canals to exterior.
    - Vibrations in water detected by neuromasts.
      - Have hairs which project into fluid canals, similar to the cochlea.
  - Air filled swim bladders.
    - Located in abdomen.
    - Vibrate in response to sound waves.
    - Bones transmit vibrations from swim bladder to inner ear.

	Insects	Fish	Mammals
Structure used for detection	Tympanic membranes	Internal ear, lateral line system, swim bladder	Cochlea
Receptor cells	Mechanoreceptor cells	Hair cells in inner ear, neormasts in lateral line	Hair cells in organ of corti

Describe the anatomy and function of the human ear, including:

- **Pinna.**
- **Tympanic membrane.**
- **Ear ossicles.**
- **Oval window.**
- **Round window.**
- **Cochlea.**
- **Organ of Corti.**
- **Auditory nerve.**

	Description of Anatomy	Function
Pinna (auricle)	- Forms part of the external/outer ear; - Made of cartilage with little blood supply. - Large & fleshy.	- Localise sound waves. - Glands produce cerumen to remove dust etc...
Tympanic membrane	- Taught membrane.	- Sound waves cause it to vibrate. - Continually growing, allowing it to repair itself.
Ear ossicles	- Three small bones of inner ear. - Malleus: toward head. - Incus: attached to malleus. - Stapes: rests on oval window.	- Amplify vibrations entering the ear.
Oval window	- Membrane between middle & inner ear. - Covers opening in bony case of cochlea.	- Separates middle ear from inner ear. - Holds fluid in the cochlea. - Carries waves through perilymph.
Round window	- Membrane located in round window niche.	- Allows release of hydraulic pressure caused by vibration of stapes.

Cochlea	- Snail shaped structure. - 3 canals filled with fluid.	- Vibration patterns set vibration waves that carry to organ of Corti.
Organ of Corti	- In middle canal of cochlea. - Tectorial membrane. - Basilar membrane. - Pillars of Corti.	- Hair cells convert mechanical energy into electrochemical energy.
Auditory nerve	- Leads from cochlea to sense organ of balance to perception centre of brain.	- Transmits neural energy from cochlea to brain.

Outline the role of the Eustachian tube.

- Eustachian tube:
  - Tube connecting the middle ear to the throat.
  - Opens to allow air from the mouth to equalise pressure on either side of the tympanic membrane.
  - Equalising pressure allows for vibrations to be carried through to the inner ear.

Describe the relationship between the distribution of hair cells in the organ of Corti and the detection of sounds of different frequencies.

- The organ of Corti stretches the length of the cochlea.
  - Main components are basilar membrane, hair cells (about 15,500) & tectorial membrane.
  - Fluid filled to carry sound more effectively.
  - Vibrations move through fluid.
  - Hair cells enclosed between basilar membrane & tectorial membrane.
  - Transverse fibres vibrate in certain places, depending of frequency.
    - Fibres/hairs tuned to different frequencies of sound.
    - Long fibres tuned to low frequency (furthest from narrow end of cochlea).
    - Short fibres tuned to high frequency (nearest to the oval window).
  - Cochlea nerve fibres coiled around base of hair cells.
  - Cilia (hair cells) emersed in K^+ rich endolymph.
  - Cilia activated at points of rigorous vibration of basilar membrane.
  - Outer hair cells much more numerous though 90% of cochlea nerve fibres service inner hair cells.

Outline the role of the sound shadow cast by the head in the location of sound.

- Sound shadow (or sonic):
  - Phenomenon caused by the obstruction or absorption of a sound wave by an object in its path.
  - Greatest effect achieved when sound source & absorbing object aligned.

- Humans are binaural.
  - Head creates a sonic shadow for the ear further away from source of sound.
  - High frequency sounds absorbed easier than low frequency sounds.
    - Plays an important role in locating the source of a sound.

- Visually impaired people use sound shadows & echolocation to navigate & interpret cues.

Gather, Process & Analyse information from secondary sources on the structure of a mammalian ear to relate structures to functions.

- Overall function of ear is to capture sound, amplify it & convert into electrochemical signals which are sent to the brain to be perceived.

- Pinna designed to capture sounds & transmit them to inner ear.
  - Taught tympanic membrane carries vibrations into middle ear.
  - Ear ossicles amplify vibrations created by tympanic membrane.
  - Oval window transmits vibrations from ossicles to fluid in the cochlea.
  - Round window compensates for pressure in cochlea.
  - Cilia in organ of Corti (cochlea) detect vibrations & produce a nerve impulse which is sent to the brain via the auditory nerve.

Process Information from secondary sources to Outline the range of frequencies detected by humans as sound and Compare this range with two other mammals, Discussing possible reasons for the differences identified.

	Human	Cat	Dog	Bat
Frequency range (Hertz)	20-20,000	60-65,000	15-50,000	100,000-110,000
Reasons	- Communication. - Hear surrounding environment. - Sound produced fits well within this range.	- Requires sensitive hearing for hunting. - Hear predators.	- Requires sensitive hearing for hunting. - Hear predators.	- High frequency sounds allow for echolocation.

Process information from secondary sources to Evaluate a hearing aid and a cochlear implant in terms of:

- **The position and type of energy transfer occurring.**
- **Conditions under which the technology will assist hearing.**
- **Limitations of each technology.**

	Hearing Aid	Cochlear Implant
Description	- Artificial hearing device. - Battery operated. - Microphone, amplifier, earphone in 1 unit. - Amplifies vibrations allowing them to initiate action potential. - Uses normal auditory pathway. - Less detailed sound detection than Cochlear Implant. - Developed in 1920s.	- Artificial hearing device. - Battery operated. - Implanted receiver, electrode array, speech processor & headset. - Electrically stimulates nerves in cochlea. - Bypasses normal auditory pathway. - More detailed sound than hearing aid. - Developed by Australian Graeme Clark in 1980s.
Positioning	- Sits in curve of pinna.	- Receiver & electrode array implanted in inner ear. - Headset & speech processor external.
Conditions when hearing may be assisted	- Ruptured tympanic membrane, damaged ossicles. - Only used with adequate residual hearing.	- Damaged hair cells in cochlea. - Profoundly deaf people who are not suitable candidates for hearing aids.

Energy transfer	- Microphone detects sound waves. - Amplified. - Channelled into auditory canal. - Follows normal path of sound wave,	- Microphone detects sound waves. - Speech processor converts to electrical signal. - Code sent to headset, transmitted to implant. - Signals converted to electrochemical messages, sent to brain. - Sound perceived.
Limitations of technology	- No surgery. - Basically invisible. - No side effects. - No programming. - Background noise problem. - Limited distance (3m). - Residual hearing maintained. - Does not substitute damage to inner ear nerve fibres. - Successful at any age. - Hearing difficulties may remain.	- Surgery required. - Visible. - Side effects of operation. - Expensive, on-going costs. - Programming required. - Background noise a problem. - Limited distance. - Deaf when processor not worn. - Quality not based on residual hearing capabilities. - Best when installed before age of 5.