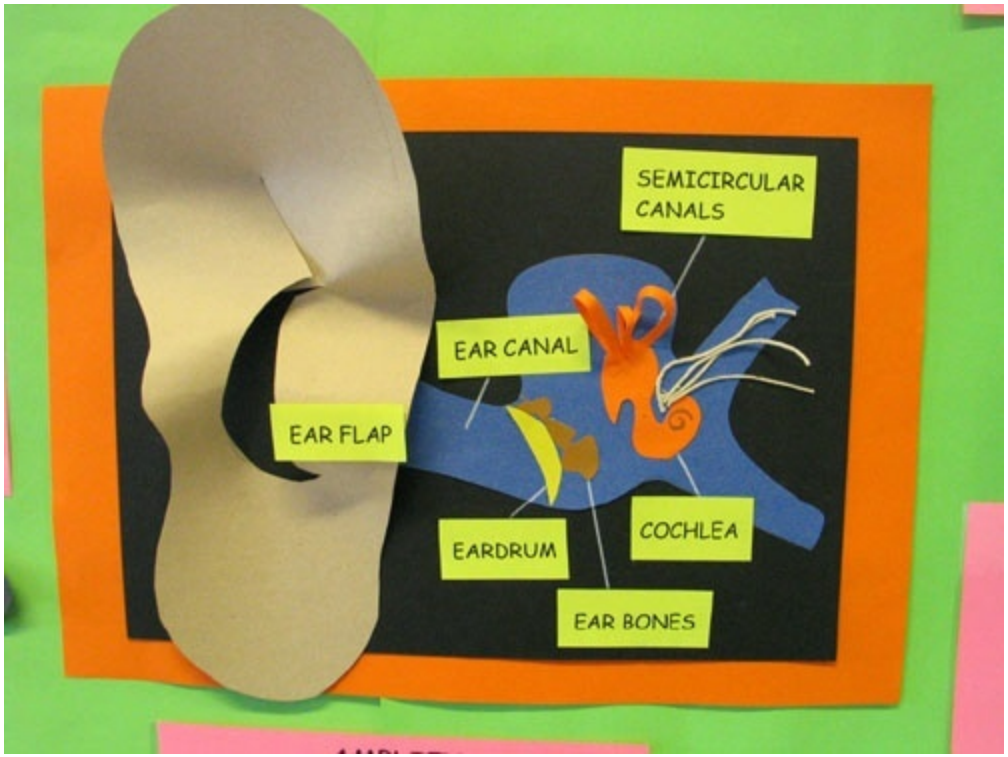
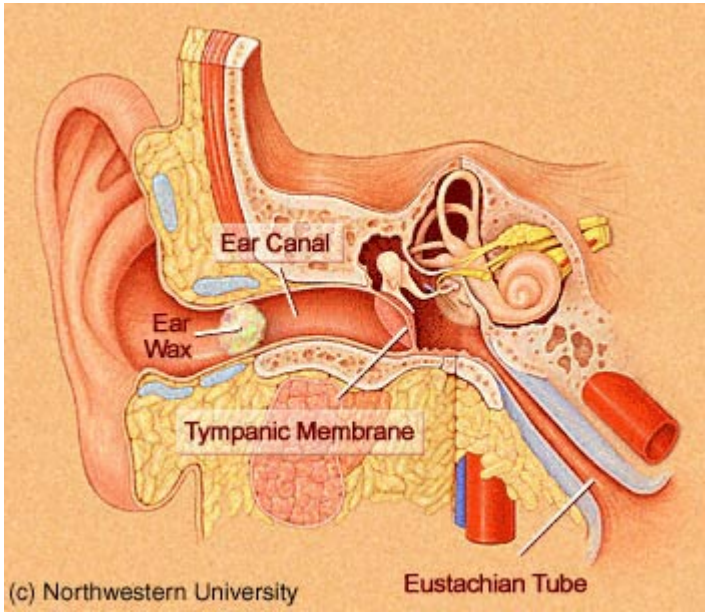
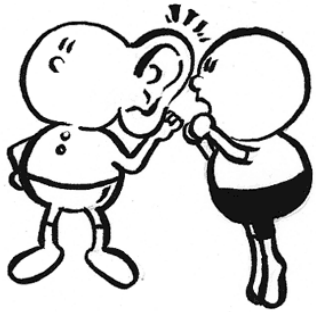
Did you hear?





It's all about the ear!

Functions



- The ear has 2 separate functions:

  Hearing and balance/equilibrium (dynamic and static equilibrium)

Do you know where the smallest bones in the body are?

The ear ossicles. They are fully developed at birth.

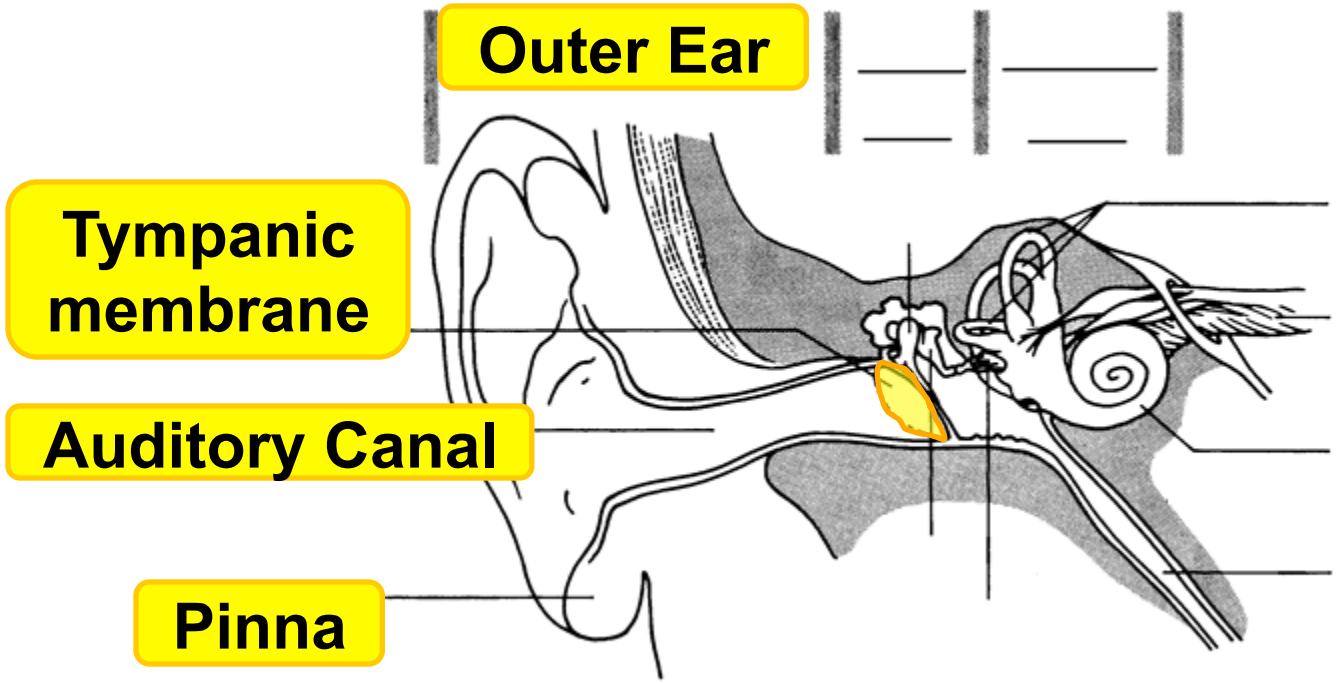
Outer Ear

Amplifies sound

Pinna – external ear flap. funnels sound into ear

Auditory canal – amplifies sound. (makes it louder)

Tympanic membrane (ear drum) - vibrates



How the ear works: (1:33) https://www.youtube.com/watch?v=MXt_gX2Srgo

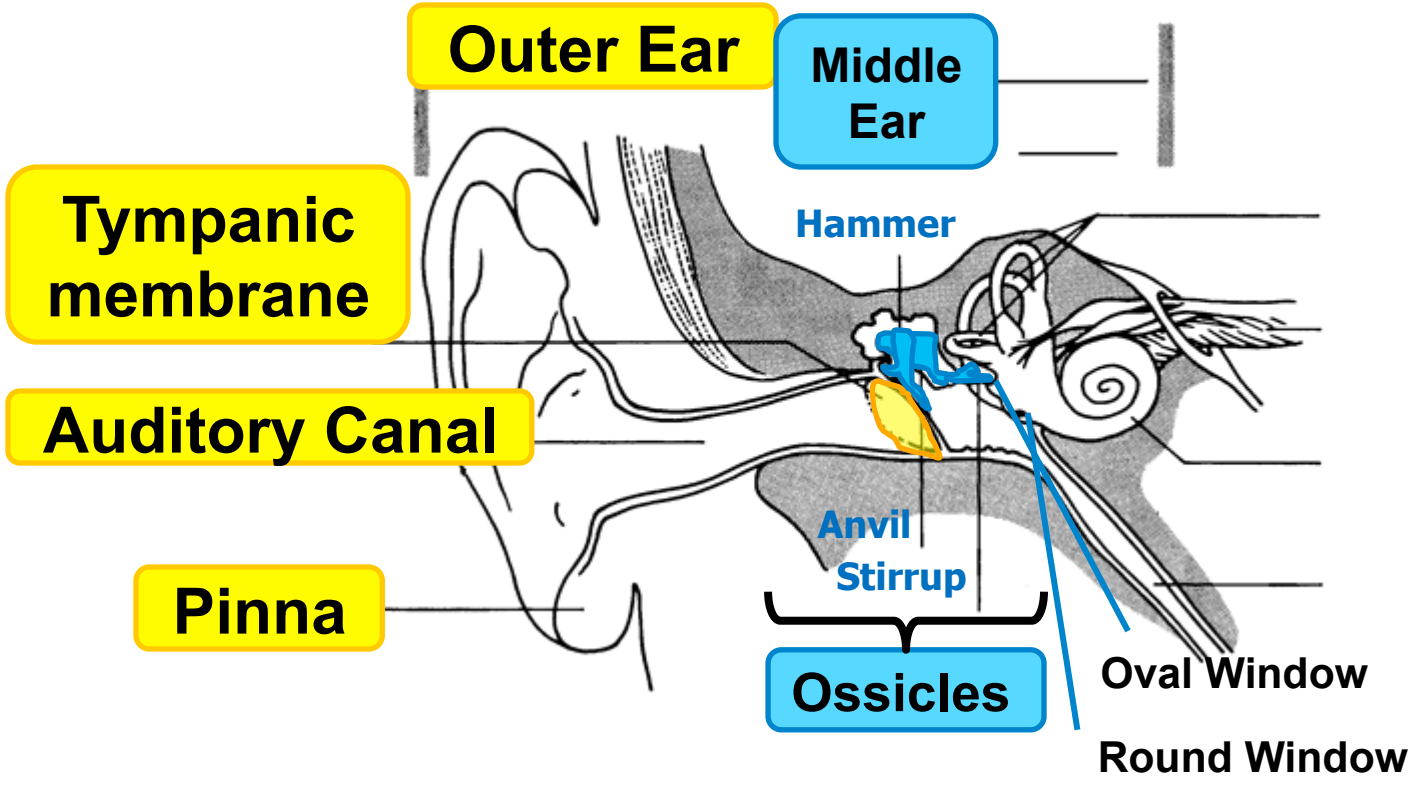
Middle Ear

air-filled

Amplifies sound

Ossicles (bones) – vibrate and amplify sound

Oval Window – sends vibrations to inner ear. Smaller than ear drum to amplify sound. As the stapes pushes in on the oval window, the **round window** membrane moves out, and this allows movement of the fluid within the cochlea, leading to movement of the cochlear inner hair cells and thus hearing.



Middle Ear

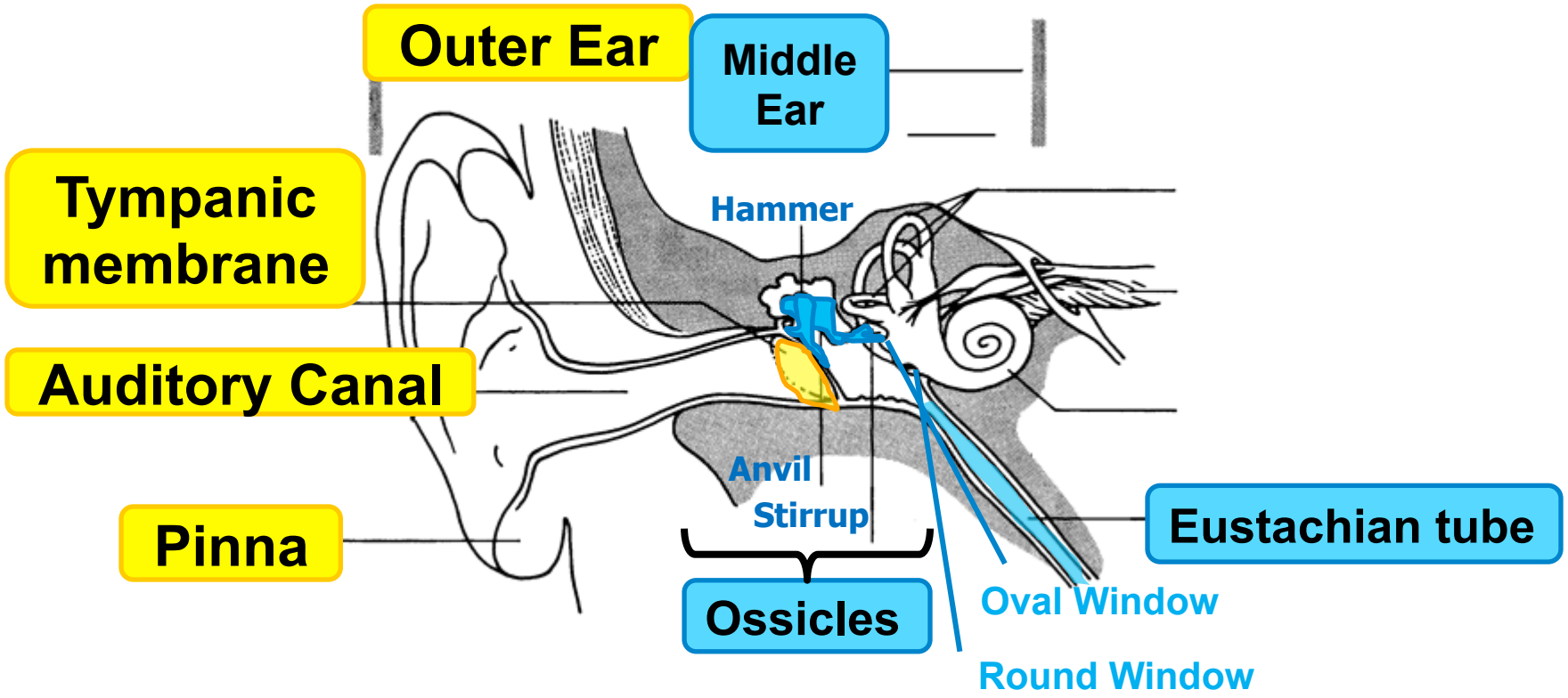
Air-filled

Amplifies sound

Ossicles (bones) – vibrate and amplify sound

Oval Window – sends vibrations to inner ear.

Eustachian tube – Connects the middle ear to the mouth and nose. Allows for equalization of pressure between the internal and external ear.
Build-up of liquid in the Eustachian tube can cause deafness and poor balance.



Inner Ear

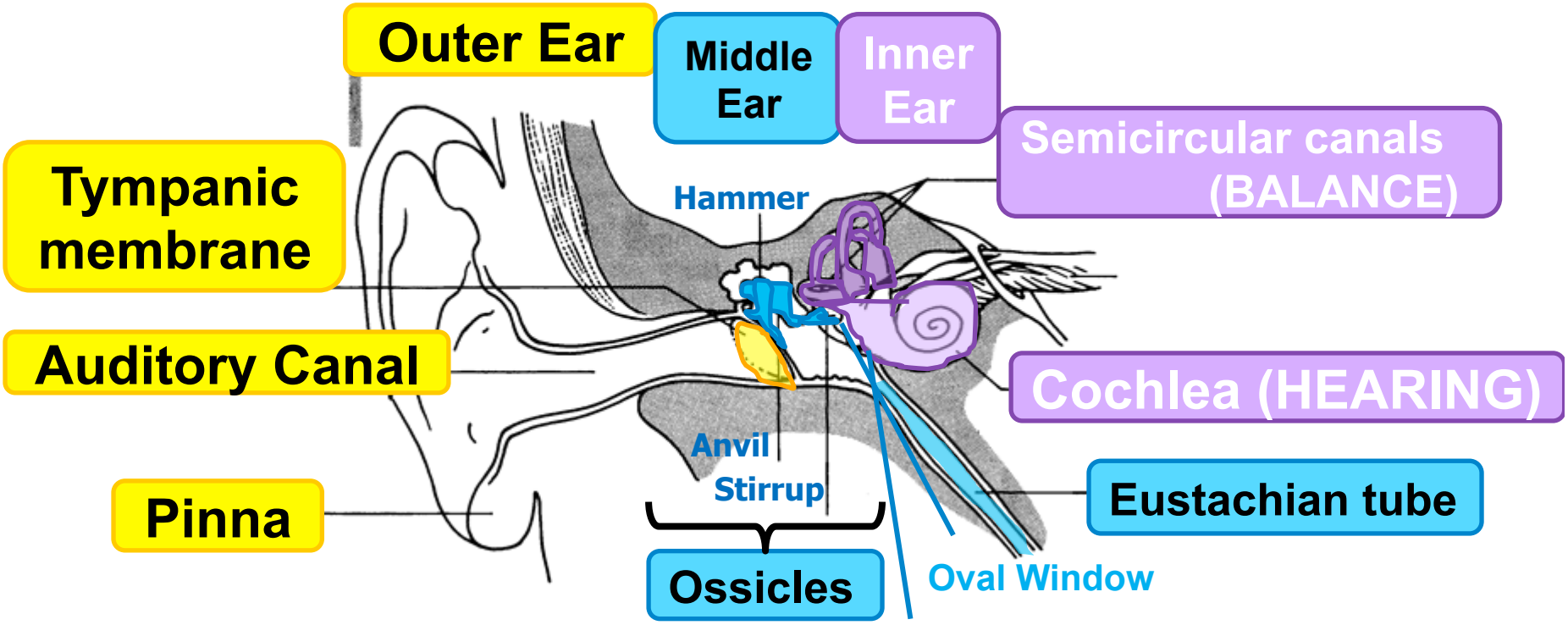
Fluid-filled

Converts vibrations into electrical impulses

Cochlea (HEARING) Hair cells on the basilar membrane identify sound waves and convert them into action potentials

Semicircular canals (BALANCE) Movement of fluid in the canals provides information about body movement

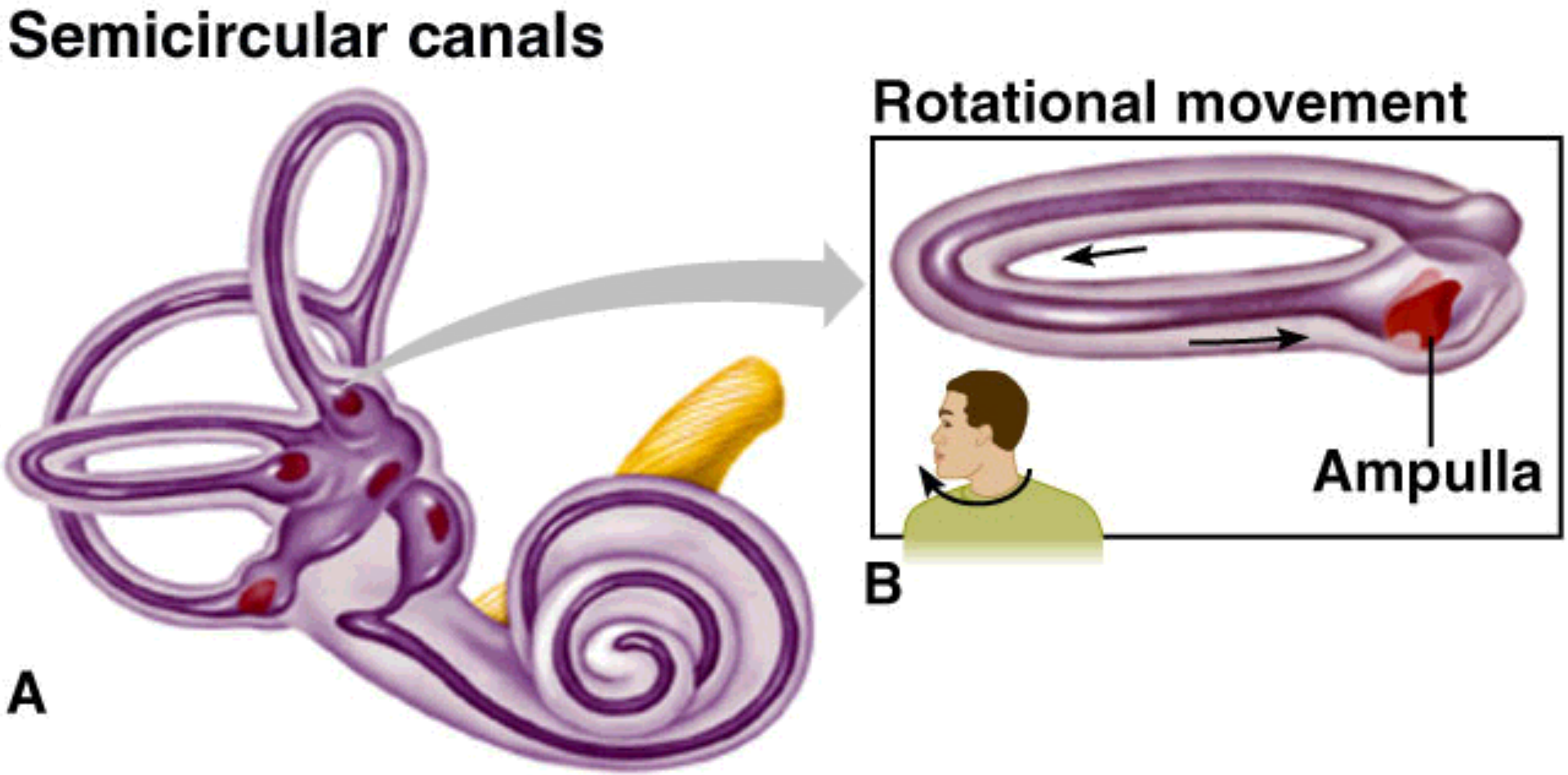
dynamic equilibrium



Bozeman: Sensory System 10:31
The ear starts at 5:30
http://www.youtube.com/watch?v=TAzTFgPSP1iU

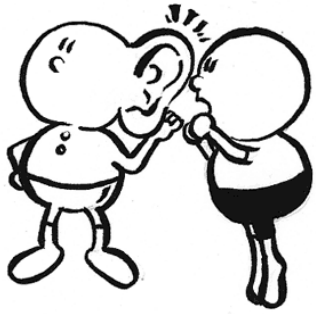
Hearing Animation https://www.youtube.com/watch?v=0NJ_EAQjR3c

Equilibrium and Balance

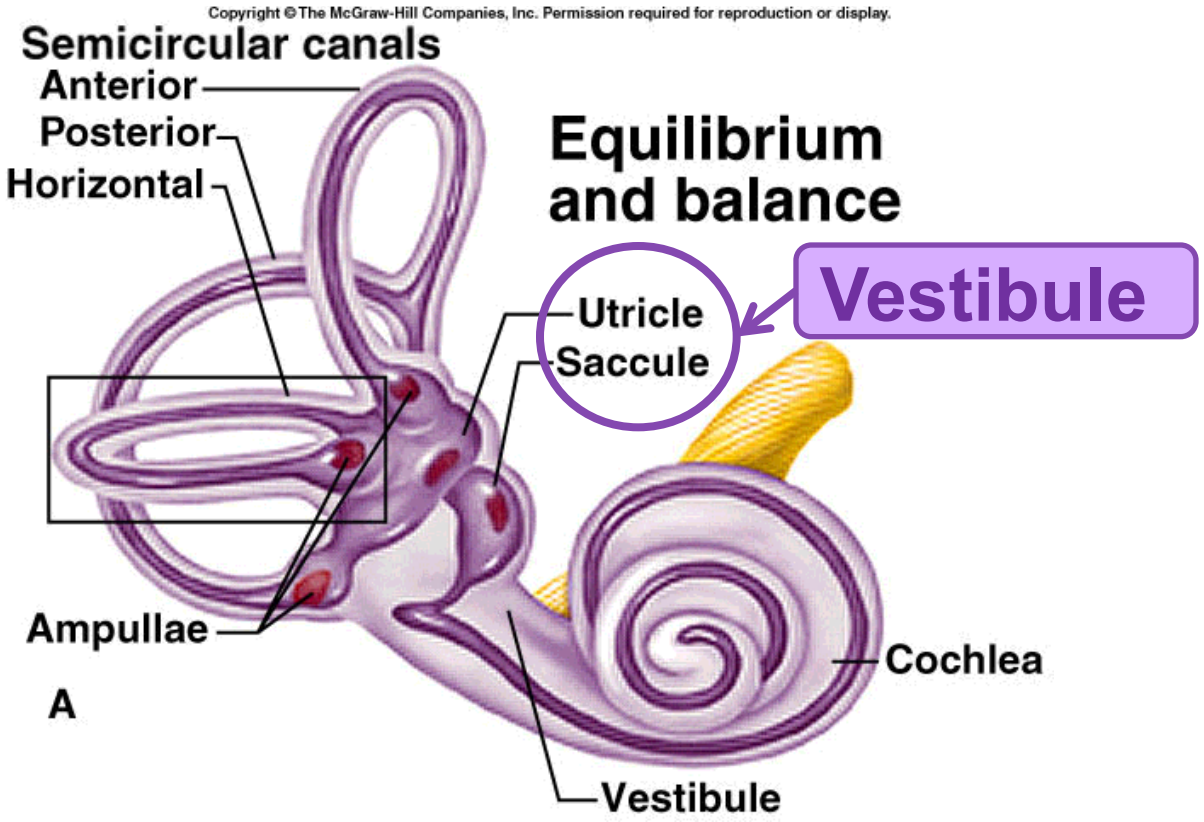


What causes motion sickness?

Inner ear - the vestibule



- Found at the **base** of the semicircular canals
- Connected to the middle ear by the oval window
- Provides information about **head position - static or gravitational equilibrium**



Inner Ear

Fluid-filled

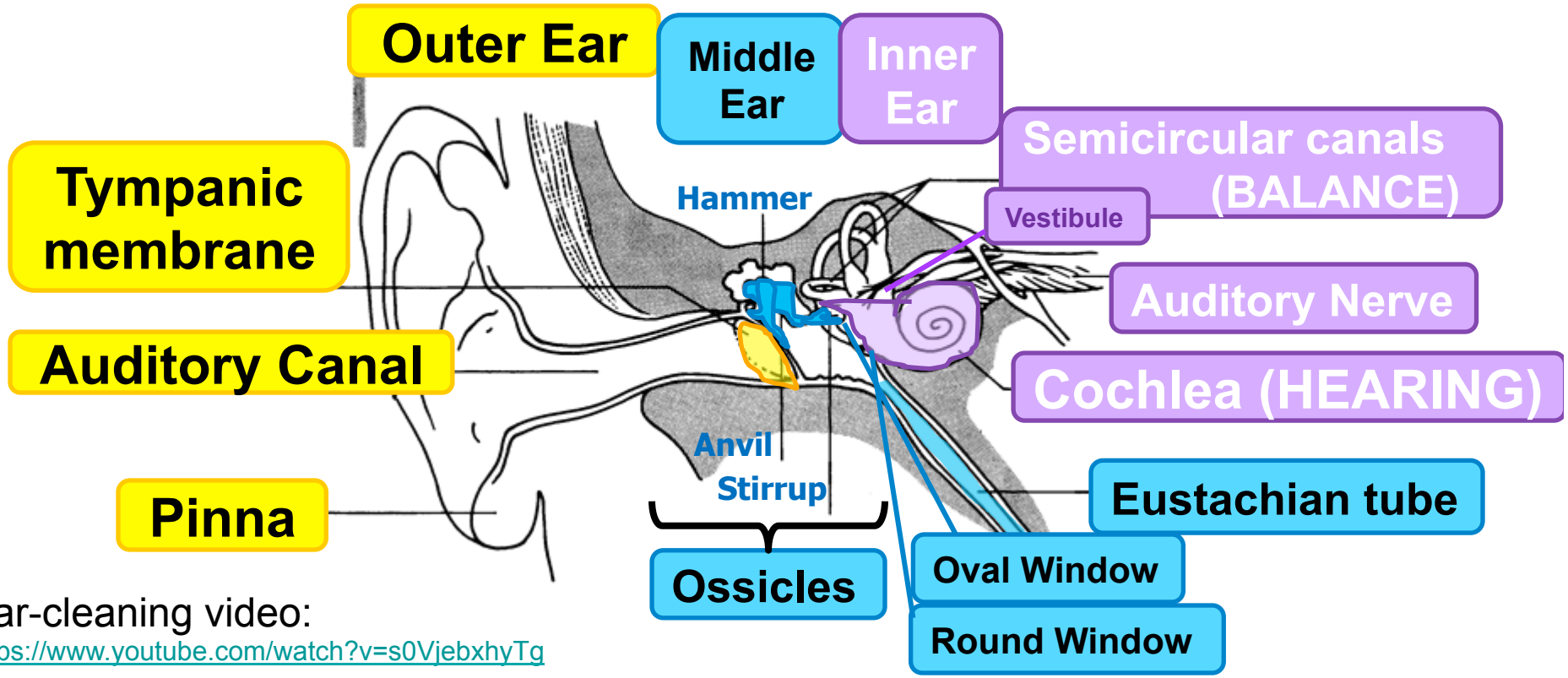
Converts vibrations into electrical impulses

Cochlea (HEARING) Hair cells on the basilar membrane identify sound waves and convert them into action potentials

Semicircular canals (BALANCE) – dynamic equilibiurm

Vestibule (balance) - static equilibrium

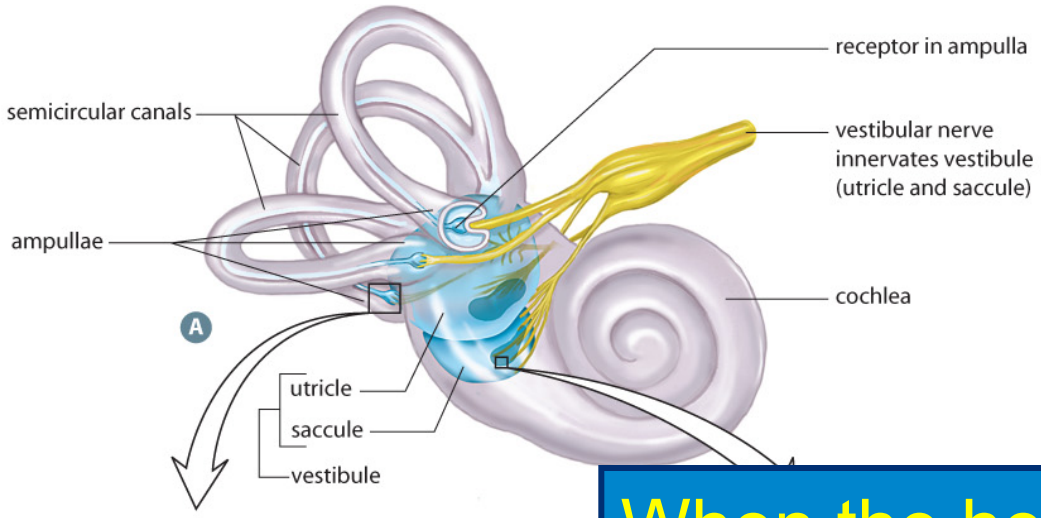
Auditory Nerve - carries nerve impulse to temporal lobe



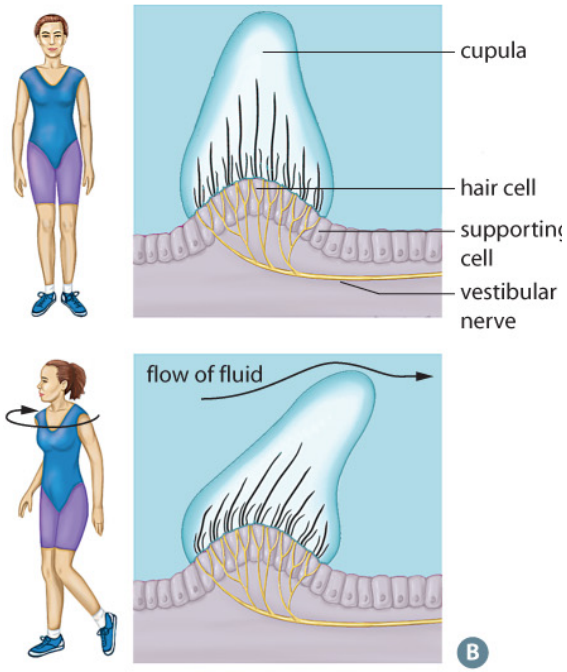
Ear-cleaning video:
https://www.youtube.com/watch?v=s0VjebxhyTg

Semicircular canals

Dynamic or Rotational Equilibrium



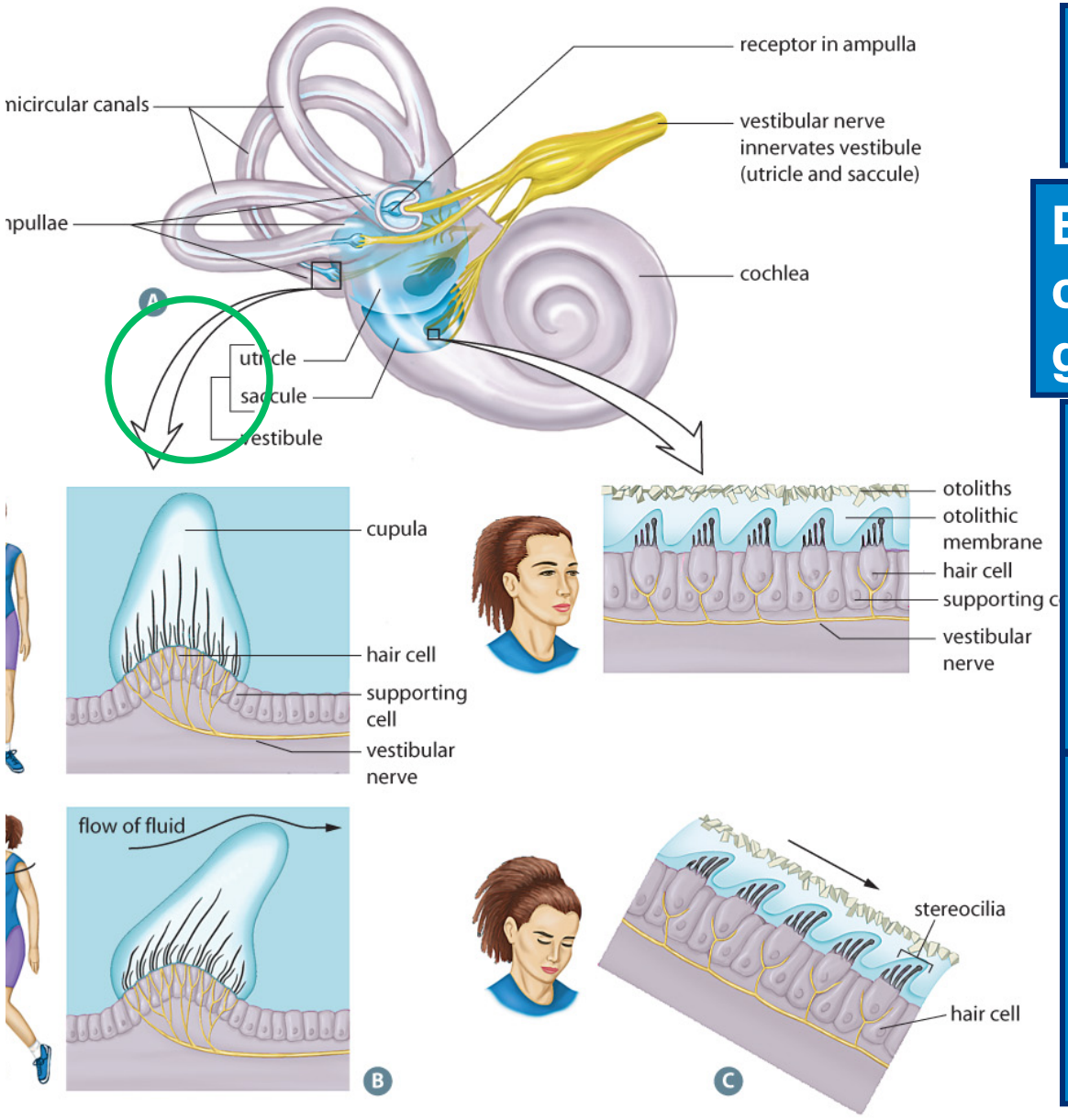
The semicircular canals contain mechanoreceptors that detect head and body rotation.



When the head rotates, the fluid inside the semicircular canals moves **and bends the stereocilia in the cupula** causing the **hair cells** to send an **action potential** through the vestibular nerve to the brain**. (cerebellum)**

Vestibule

Static or gravitational equilibrium

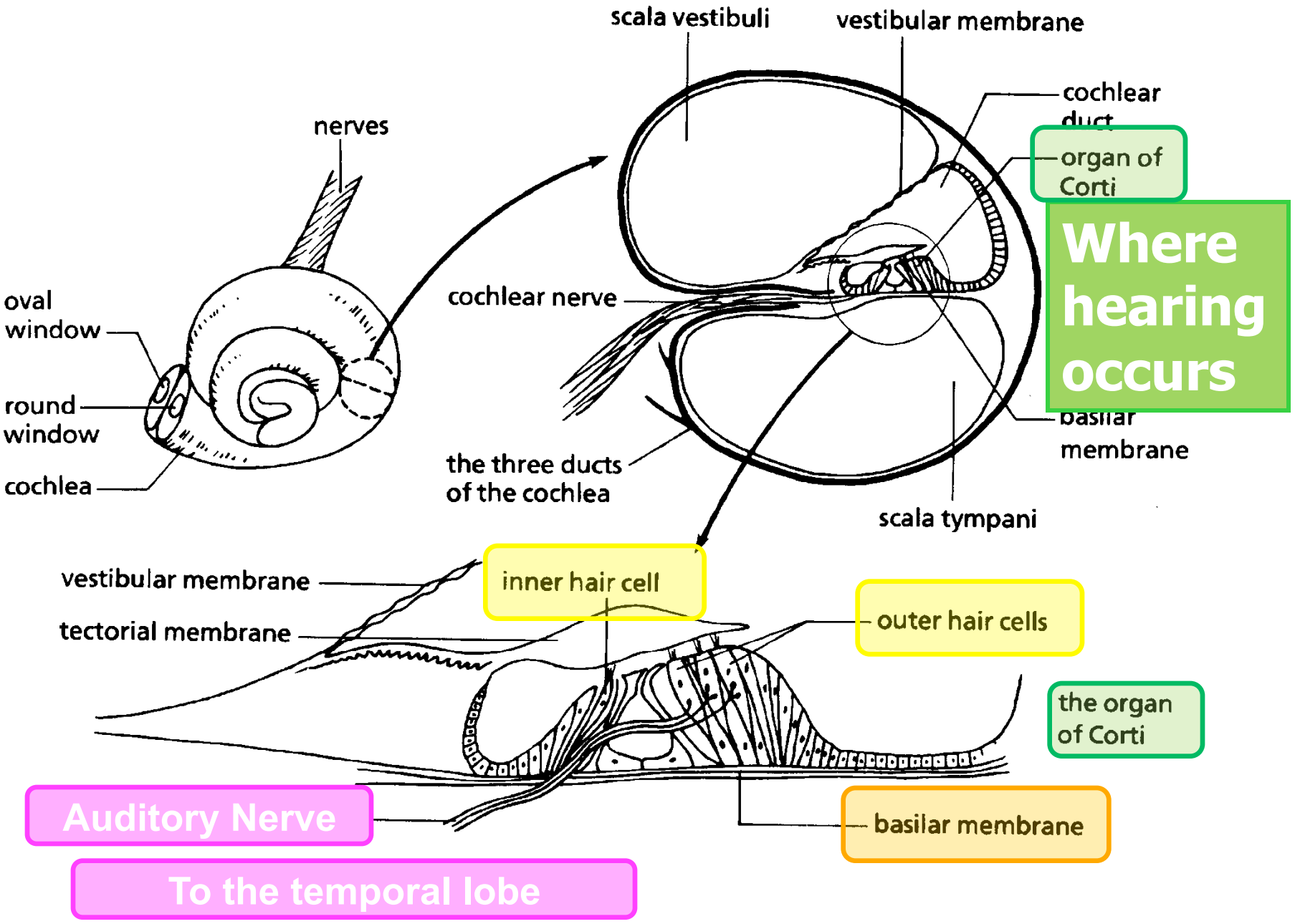


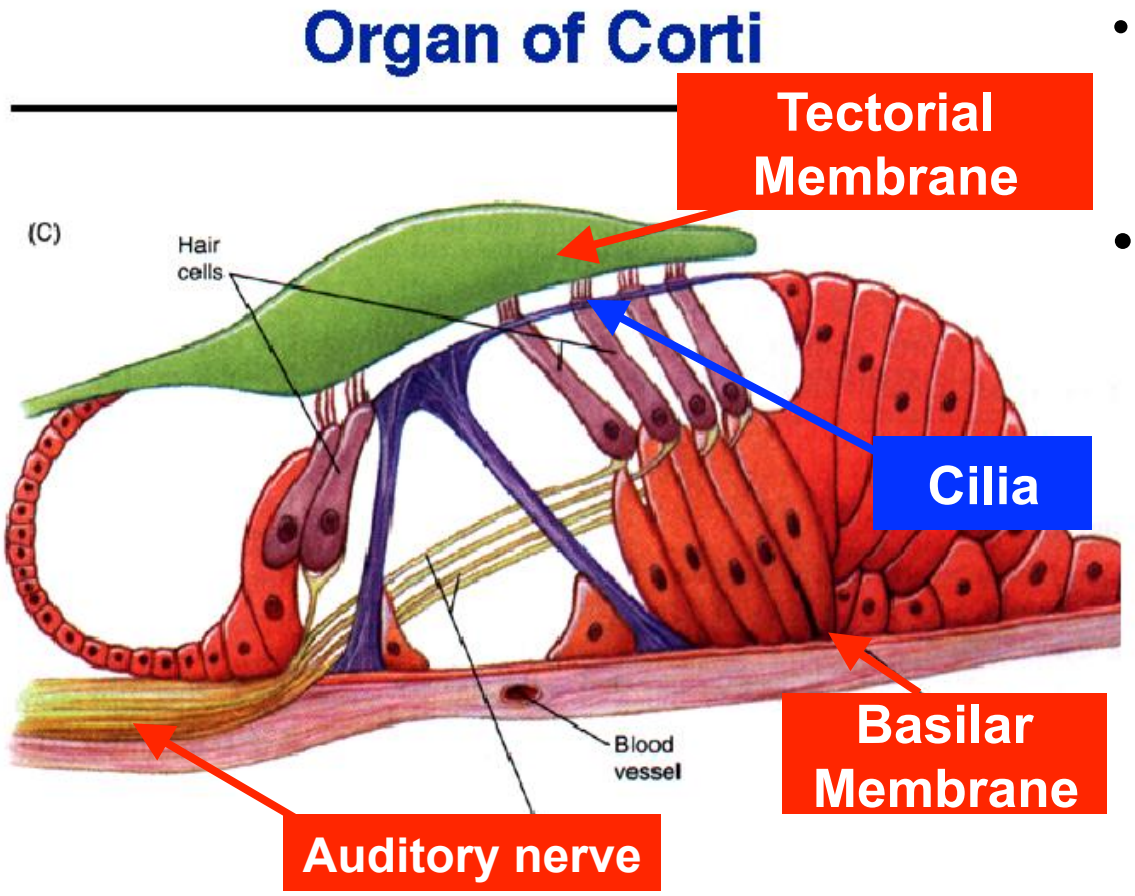
The utricle and saccule make up the vestibule.

Both of these structures contain calcium carbonate granules, called otoliths.

When the head dips forward or back, gravity pulls on the otoliths.

This bends the hair cells, causing them to send a neural impulse to the brain.

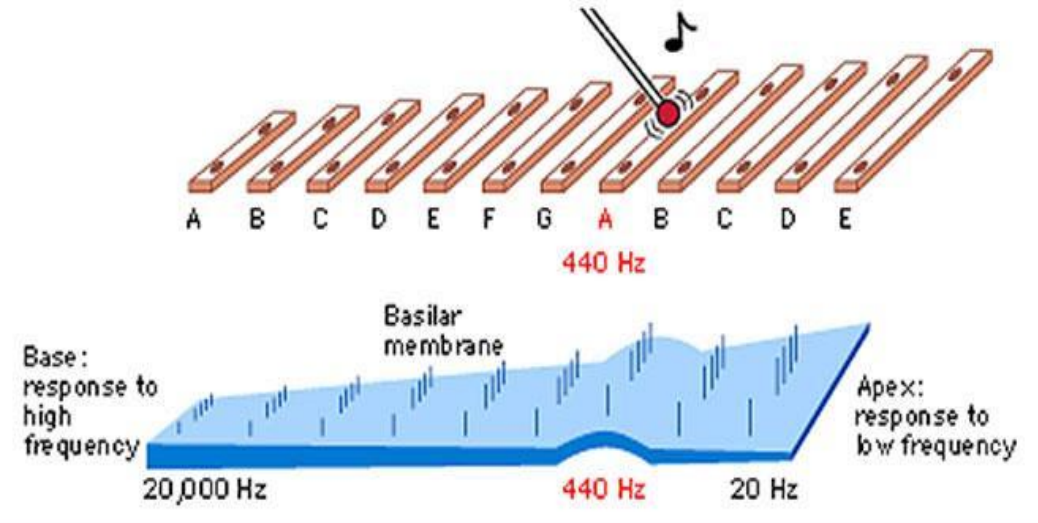

scala vestibuli
vestibular membrane
cochlear duct
organ of Corti
Where hearing occurs
nerves
oval window
round window
cochlea
cochlear nerve
the three ducts of the cochlea
basilar membrane
scala tympani
vestibular membrane
tectorial membrane
inner hair cell
outer hair cells
the organ of Corti
basilar membrane
Auditory Nerve
To the temporal lobe



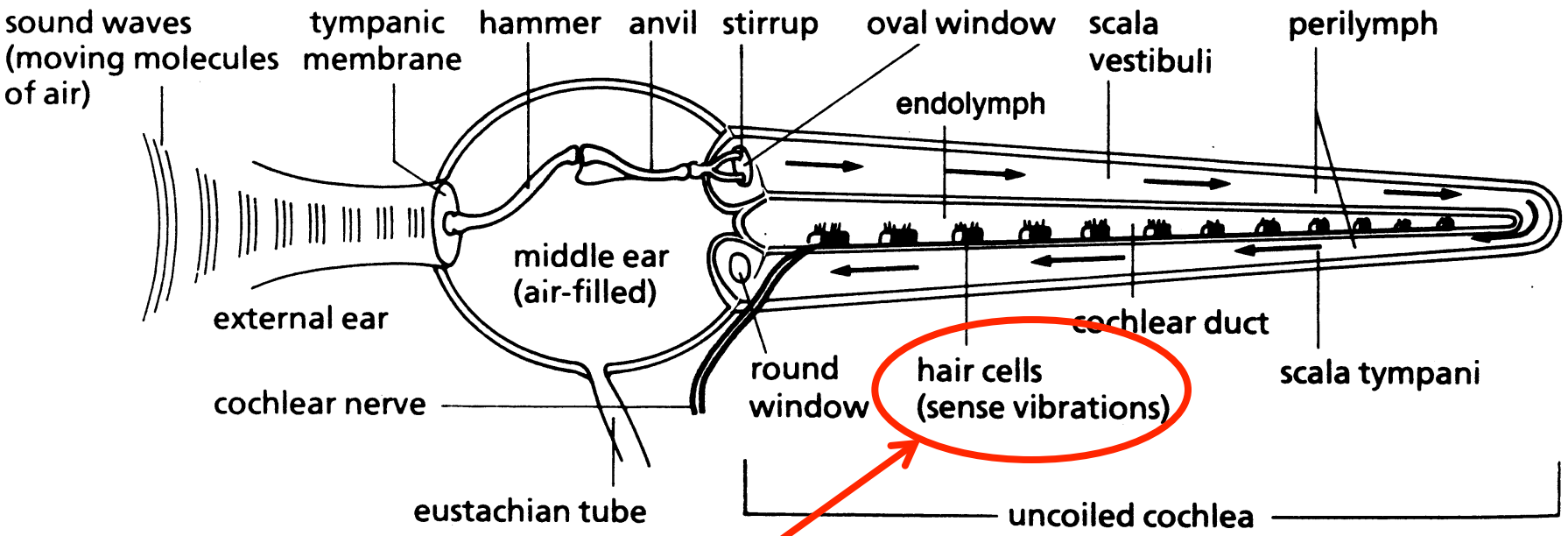
- **Basilar membrane** starts out stiff and narrow and becomes flexible and broad
- **When the basilar membrane moves, it causes bending of the hair cells and action potentials are sent to the temporal lobe of the brain**

Amazing video on the workings of the ear:

http://www.sumanasinc.com/webcontent/animations/content/soundtransduction.html

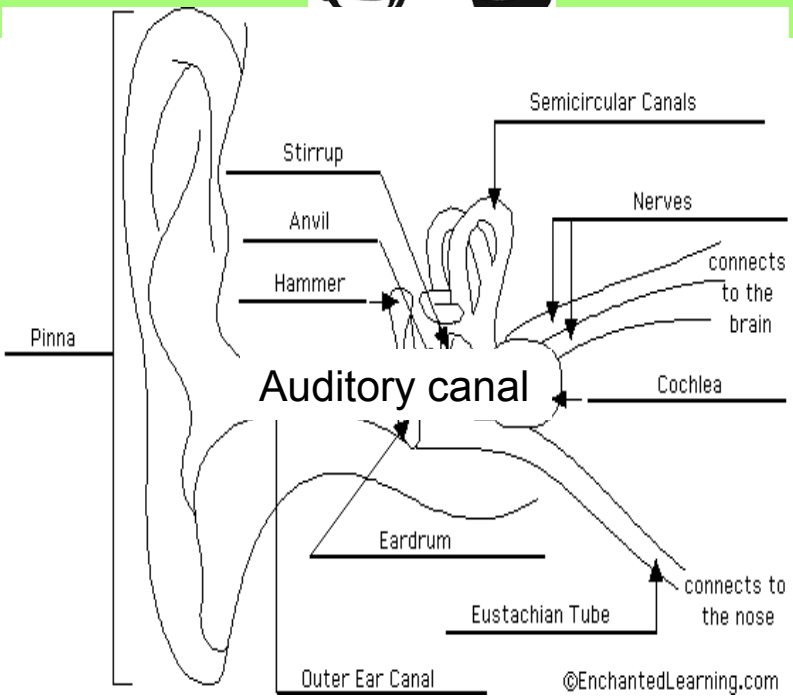


Outer | Middle | Inner



Sensory receptors = convert sound vibrations into action potentials

List the path that sound takes through the ear to the temporal lobe

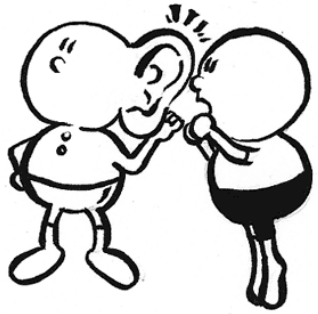


1. Pinna
2. Auditory canal
3. Tympanic Membrane
4. Ossicles
   - Hammer
   - Anvil
   - Stirrup
5. Cochlea
   - Organ of Corti
   - Basilar membrane
   - Hair cells
6. Auditory nerve
7. Temporal lobe

PATOCAT

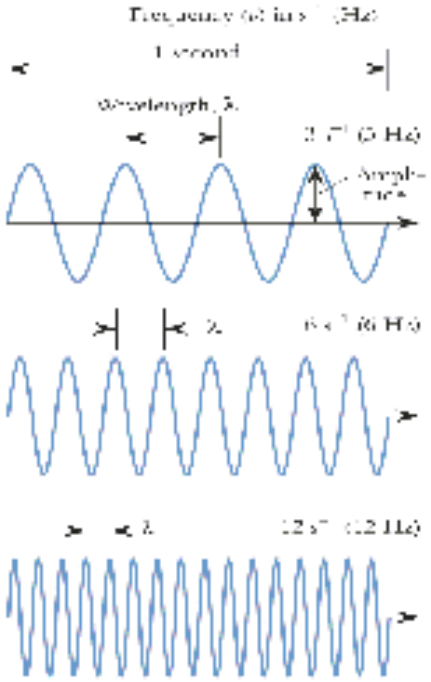
Auditory Transduction video:
https://www.youtube.com/watch?v=PeTriGTENoc&safety_mode=true&persist_safety_mode=1&safe=active

Pitch and Loudness

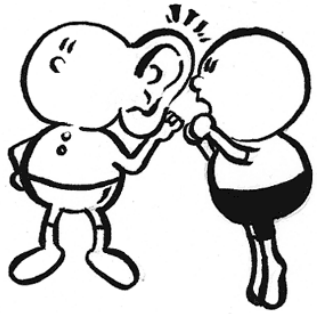


- **Cochlea** is responsible for identifying **pitch** and **loudness**
- The **stiff, narrow basilar membrane** and rigid hair cells detect **high frequency** (pitch) sounds
  - These sounds die faster
- The **wider and more flexible** part of the **basilar membrane** further down detects **low frequency** (pitch) sounds
  - These sounds resonate in the ear

Humans can hear between 20 and 20 000 Hz



Just how loud is loud?



- Loudness is measured in **decibels (db)**

Click here for an article about iPods and hearing

Sound	Intensity (db)
Ticking of a Watch	20
Whisper	30
Normal Speech	50-60
Car Traffic	70
Alarm Clock	80
Lawn Mower	95
Chain Saw	110
Jackhammer	120
Jet Engine	130

Music above 90 db is said to cause hearing loss

Damage to the hair cells of the inner ear causes hearing loss

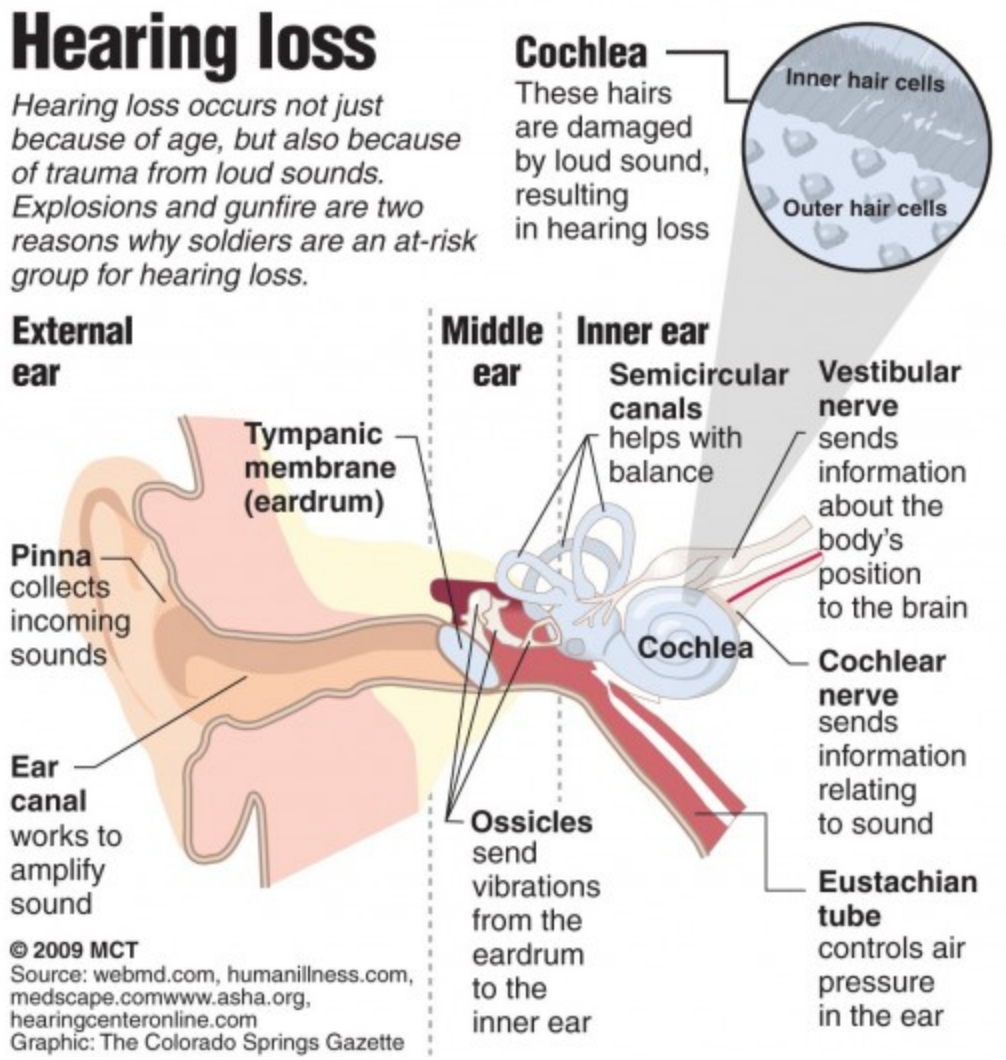
Reasons for Hearing Loss

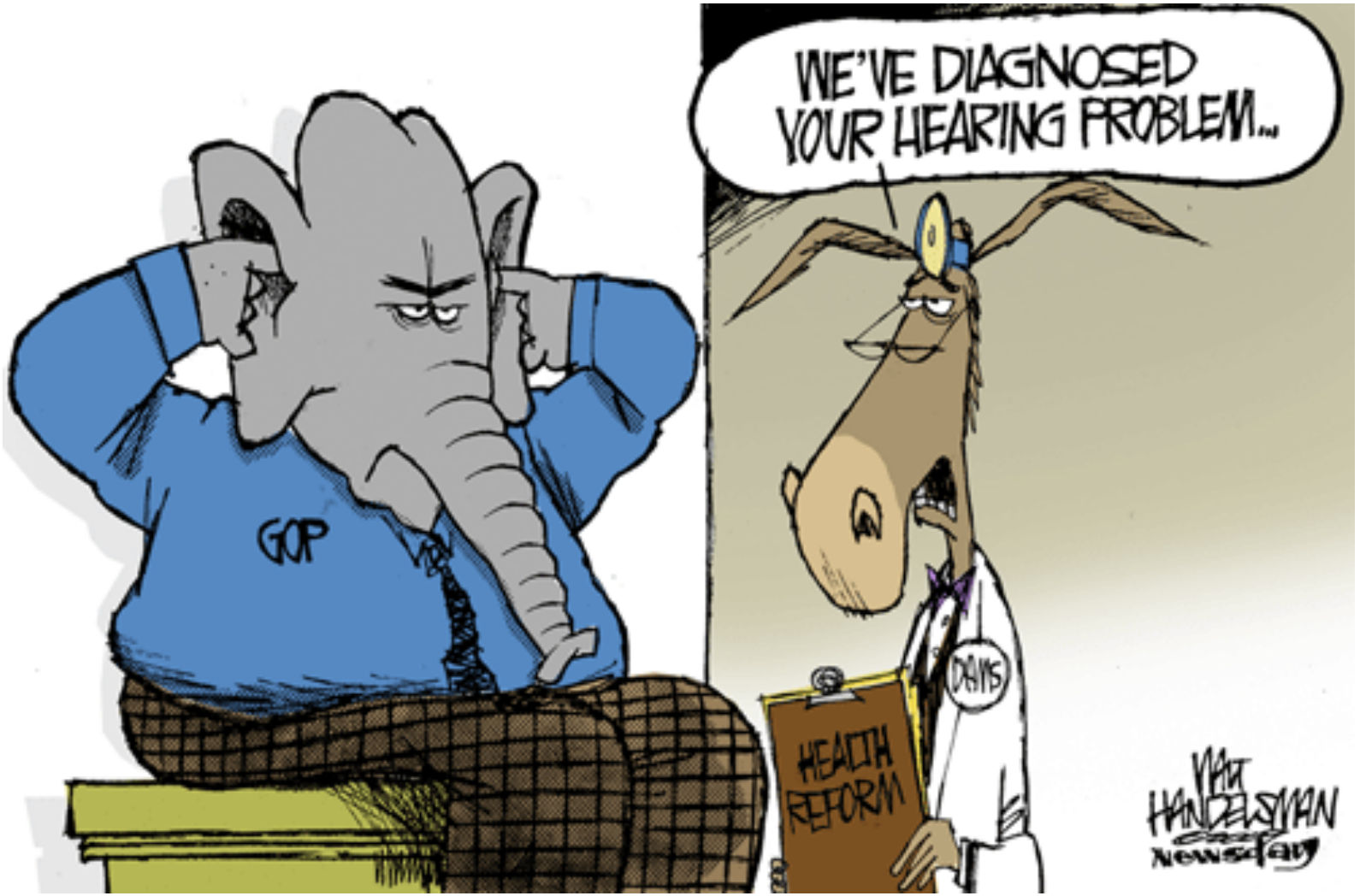
Conductive causes: blockage of the ear canal.

Sensorineural causes: damage to the hair cells or nerves.

Prolonged exposure to **loud noises** causes the hair cells on the cochlea to become less sensitive.

Ototoxic drugs - Certain drugs can affect hearing by damaging the nerves involved in hearing. Antibiotics, aspirin, ibuprofen.




WE'VE DIAGNOSED YOUR HEARING PROBLEM...
GOP
DEMS
HEALTH REFORM
MATT HANDELSMAN
Newsday

Treatments for Hearing Loss

If a foreign body is found in the ear canal, the doctor will try to **take it out.**

People with conductive hearing loss can have the middle ear reconstructed by an ear, nose, and throat specialist. (**surgery**)

Hearing aids are effective and well tolerated for people with conductive hearing loss.

People who are profoundly deaf may benefit from a **cochlear implant.**

**"My wife said I don't listen to her.
At least I think that's what she said."**

Tinnitus – ringing in the ear

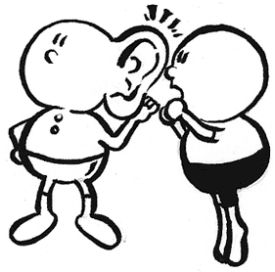
Tinnitus is commonly described as a ringing in the ears, but it also can sound like roaring, clicking, hissing, or buzzing.

Tinnitus (pronounced tin-NY-tus or TIN-u-tus) **is not a disease**. It is a symptom that something is wrong in the auditory system, which includes the ear, the auditory nerve that connects the inner ear to the brain, and the parts of the brain that process sound.

But it can also be the result of a number of health conditions, such as:

- **Noise-induced hearing loss** – working in a loud environment, or attending a concert
- **Ear and sinus infections**
- **Diseases of the heart or blood vessels**
- Brain tumors
- Hormonal changes in women
- Thyroid abnormalities

Tinnitus – treatments



Tinnitus does not have a cure yet, but treatments that help many people cope better with the condition are available.

Hearing aids often are helpful for people who have hearing loss along with tinnitus.

Counseling helps you learn how to live with your tinnitus.

Wearable sound generators are small electronic devices that fit in the ear and use a soft, pleasant sound to help mask the tinnitus.

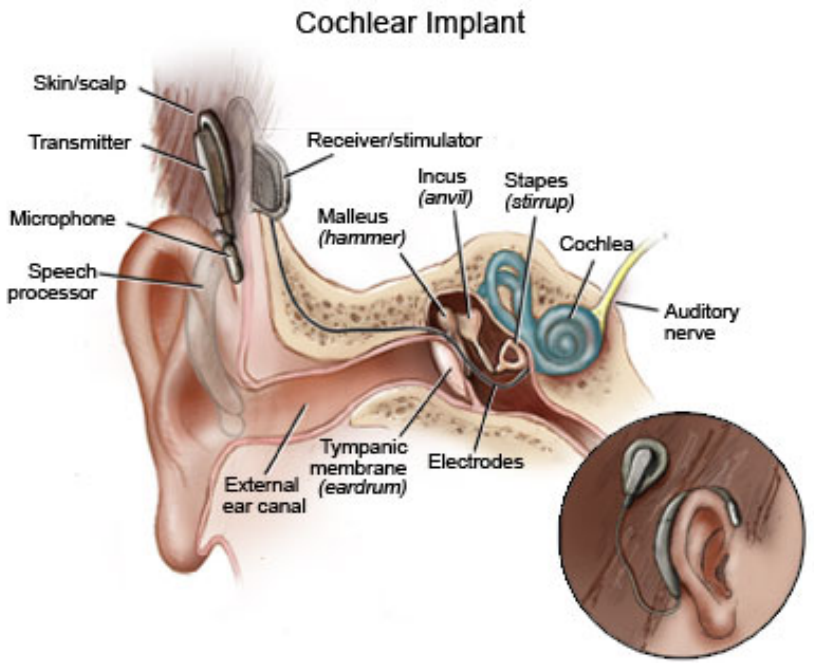
Prevention of tinnitus

Noise-induced hearing loss, the result of damage to the sensory hair cells of the inner ear, is one of the most common causes of tinnitus. Anything you can do to limit your exposure to loud noise—by moving away from the sound, turning down the volume, or wearing earplugs or earmuffs— will help prevent tinnitus or keep it from getting worse.

Being hard of hearing made Ursula every pharmacy customer's worst nightmare.

Cochlear Implant

A small complex electronic device that is surgically placed (implanted) within the inner ear to help persons with certain types of deafness to hear.



A cochlear implant has four basic parts:

1) a microphone, which picks up sound from the environment;
2) a speech processor, which selects and arranges sounds picked up by the microphone;
3) a transmitter and receiver/stimulator, which receive signals from the speech processor and convert them into electric impulses; and
4) electrodes, which collect the impulses from the stimulator and send them to the brain.

The image cannot be displayed. Your computer may not have enough memory to open the image, or the image may have been corrupted. Restart your computer, and then open the file again. If the red x still appears, you may have to delete the image and then insert it again.

Baby hears for first time

https://www.youtube.com/watch?v=HTzTt1VnHRM

Cochlear Implant

What parts of the ear do the 4 parts of the cochlear implant correspond to?

A cochlear implant has four basic parts:

1) a microphone, which picks up sound from the environment;

Pinna, auditory canal, tympanic membrane

2) a speech processor, which selects and arranges sounds picked up by the microphone;

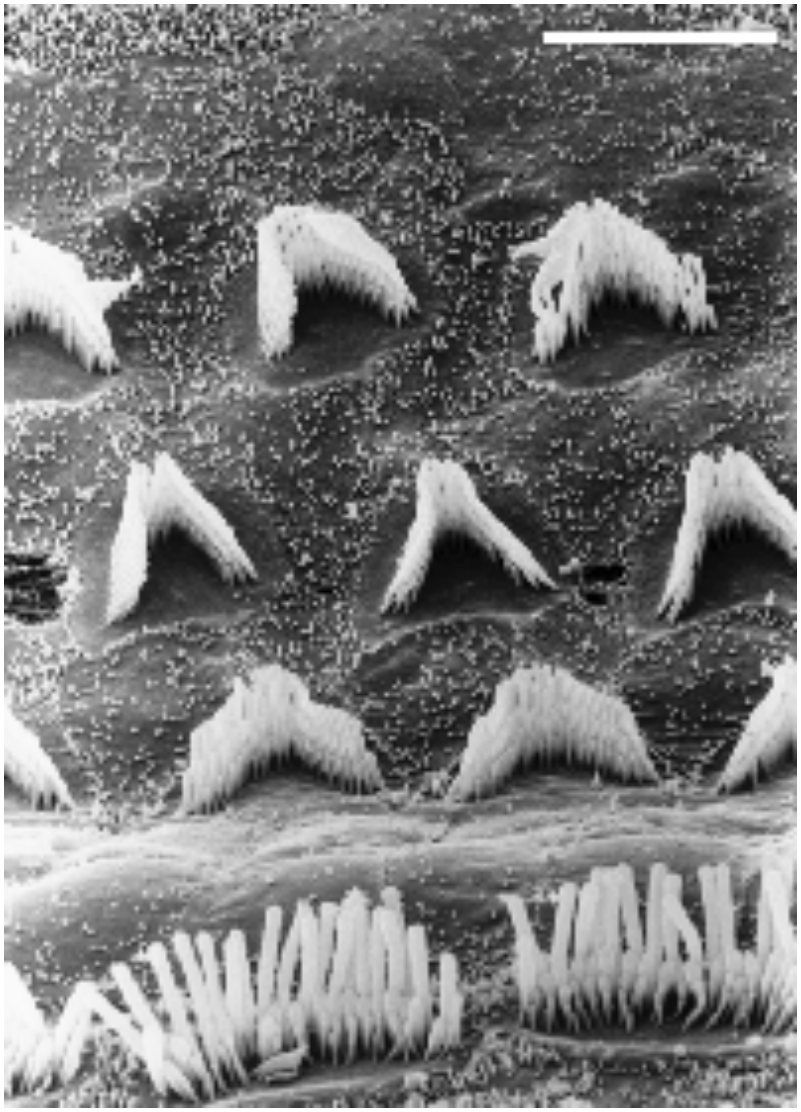
Cochlea or Organ of Corti

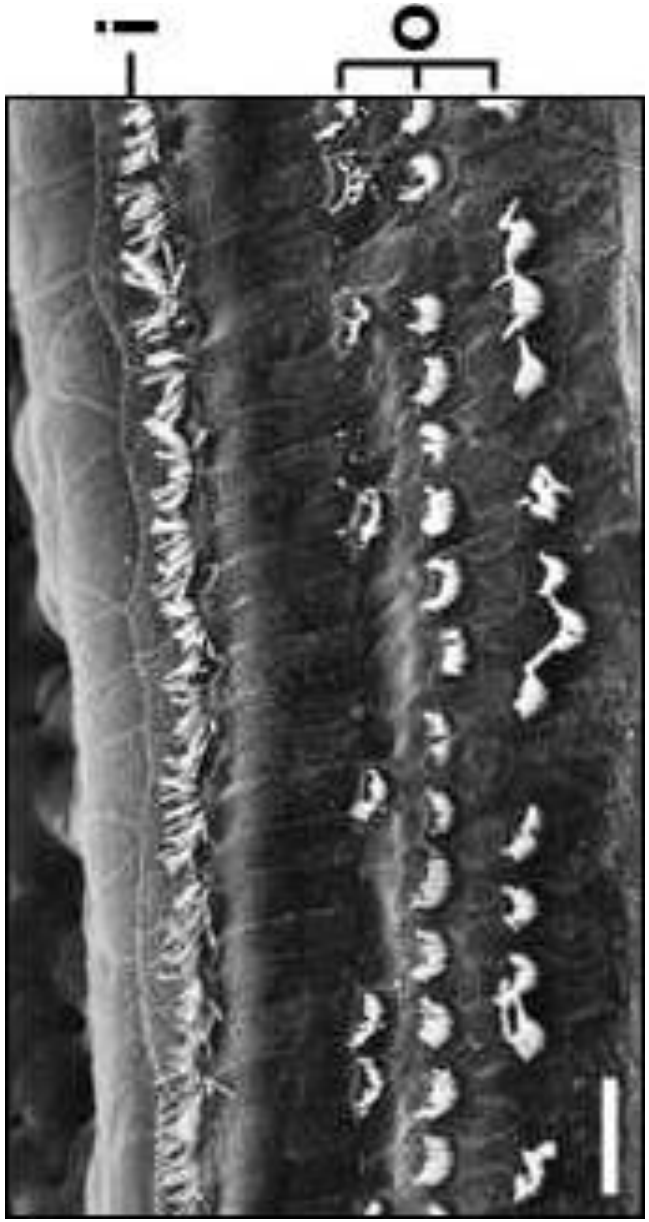
3) a transmitter and receiver/stimulator, which receive signals from the speech processor and convert them into electric impulses; and

hair cells

4) electrodes, which collect the impulses from the stimulator and send them to the brain.

Auditory nerve

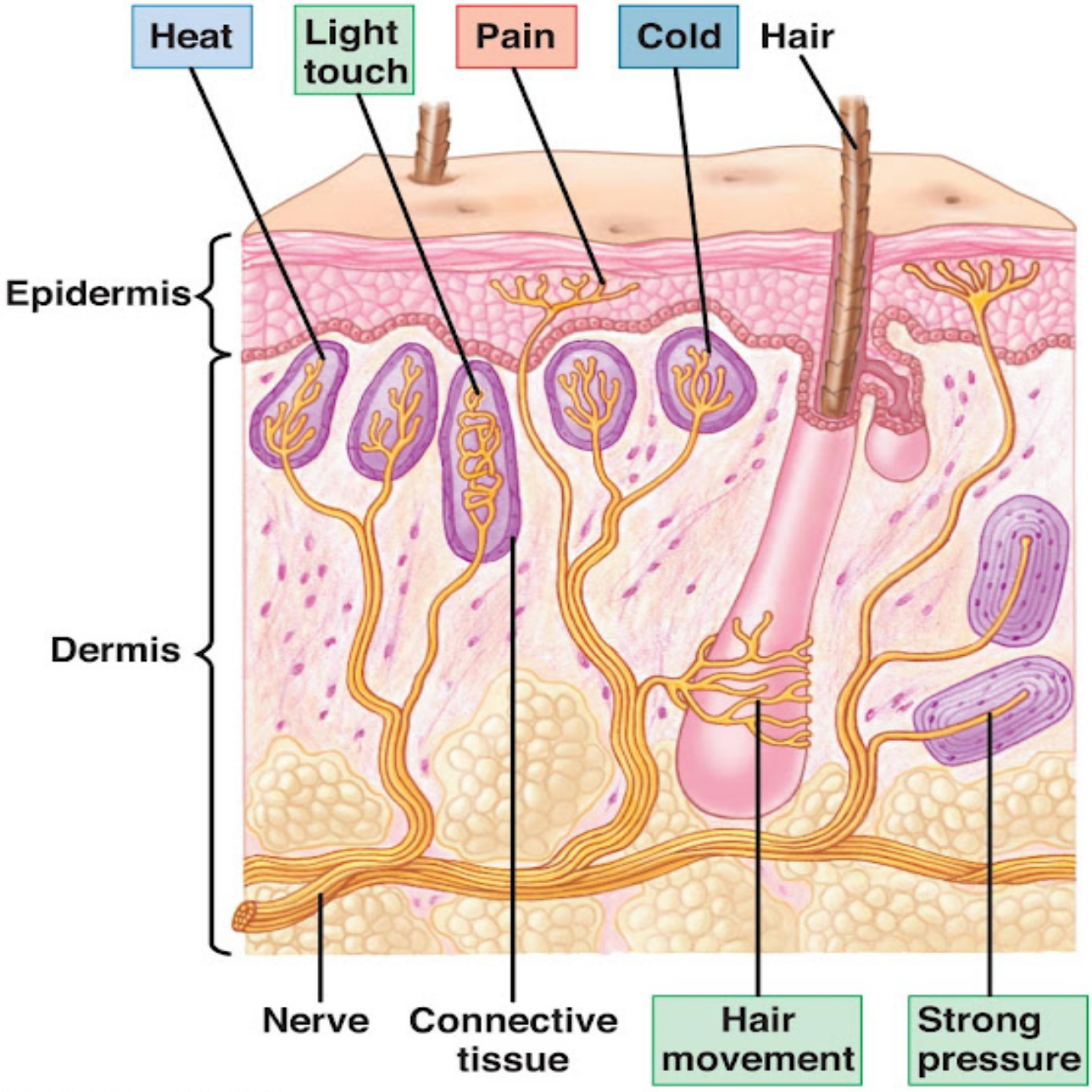




OTHER BODY SENSORY RECEPTORS

Skin receptors

- We have many different types of receptors in the skin
  - **Pressure** – detect the movement of skin or changes in the body surface
    - **Mechanoreception (ear, pressure)**
  - **Temperature** – detects changes in external temperature
    - **Thermoreception (temperature)**



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Do you know you're wearing clothes?

- **Sensory adaptation** occurs once the **receptor becomes accustomed to the stimulus**
- Neurons stop firing even if the stimulus is still present
  - Ex. Jumping in a cold lake and bad smells

How do we know where our hands are in space?

Limb Position:

- **Proprioceptors** are **stretch receptors** in muscles, tendons and joints throughout the body.
- **They send information about body position to the brain.**
- Can depend on whether or not you see!

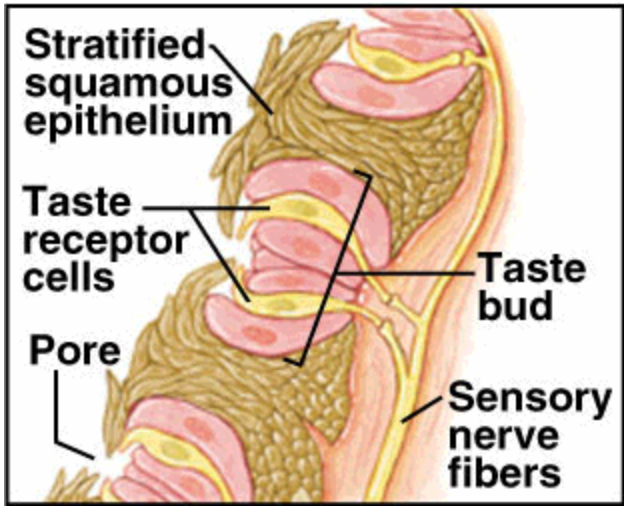
The Magic of Proprioception

Proprioception means your body's awareness of its position in three-dimensional space. All your joints have specialized nerve endings – **proprioceptors** – that send this important information to your brain. **Regular exercise makes these receptors very smart.** Both strength training and aerobic exercise can increase the connections between proprioceptors and the brain.

The more connections, the less chance of injury. You may be able to walk away from unforeseen accidents that could cause real damage to another person who's not doing the exercises you do.

Tasty!

- Taste receptors (found inside taste buds) pick up the chemicals in dissolved food
- **Chemoreceptors** then send AP's down the neuron



Humans can detect 5 different types of tastes: bitter, sour, salty, sweet, Umami(MSG)

How do you eat your aspirin?

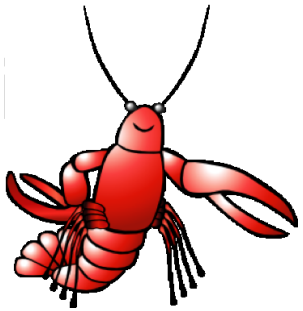
Tasty!

- We thought taste buds were found on the upper surface of tongue
- But taste buds are not uniformly distributed across the surface of the tongue
    - Taste sensations are registered below the surface of the tongue
    - Small amount on surface of pharynx and larynx
- Each taste bud can actually detect various tastes because they contain many chemoreceptors

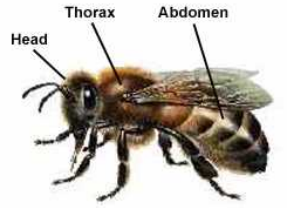
Do other animals have taste receptors?

- Octopi have taste receptors on their tentacles

- Crayfish have taste receptors on the antennae



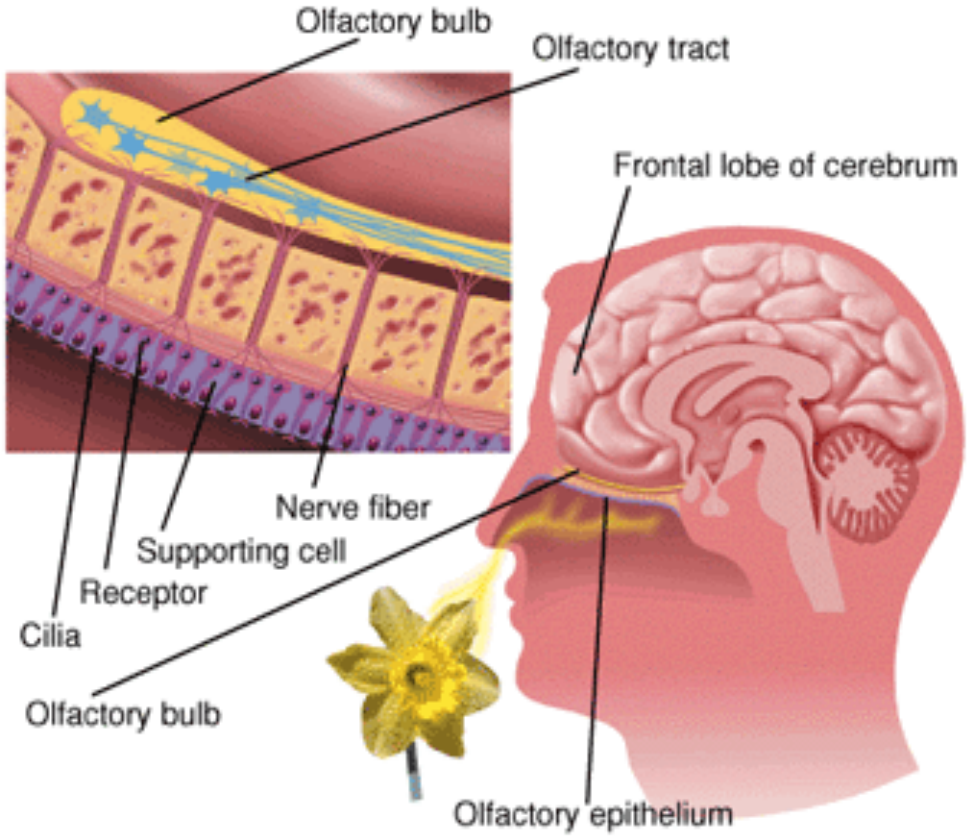
- Insects have taste receptors on their legs



Smell

- **Humans can distinguish 10 000 different smells**
- **Chemicals attach to olfactory receptors in the nose and nerve impulses are sent to the temporal lobe**
- these are 3000x more sensitive

  than taste receptors



Olfactory Epithelium

A catacomb at the back of the nasal passage houses sensory receptors.

Humans	*Dogs*
1 in² surface area	**30 in²** surface area
~6 million receptors	**~250** million receptors

cross section

Olfactory Bulb

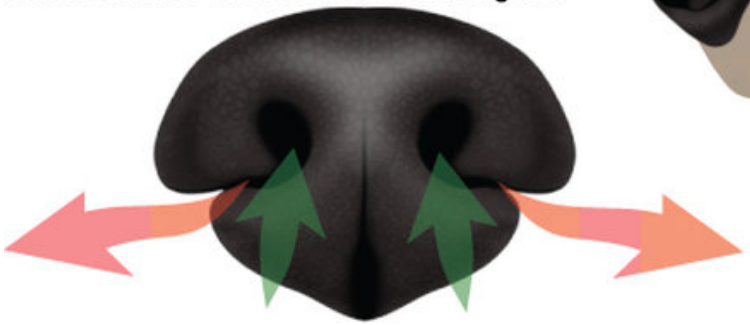
A brain region that processes signals from the olfactory epithelium. Canine olfactory bulbs are **3 times larger** than those of humans, even though their brains are **10 times smaller**.

Vomeronasal Organ

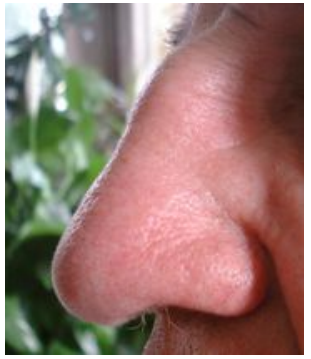
A sensory organ that detects pheremones picked up by a dog's wet nose.

Nostrils

Air is exhaled through the side slits, so it doesn't dilute the scent of incoming air.



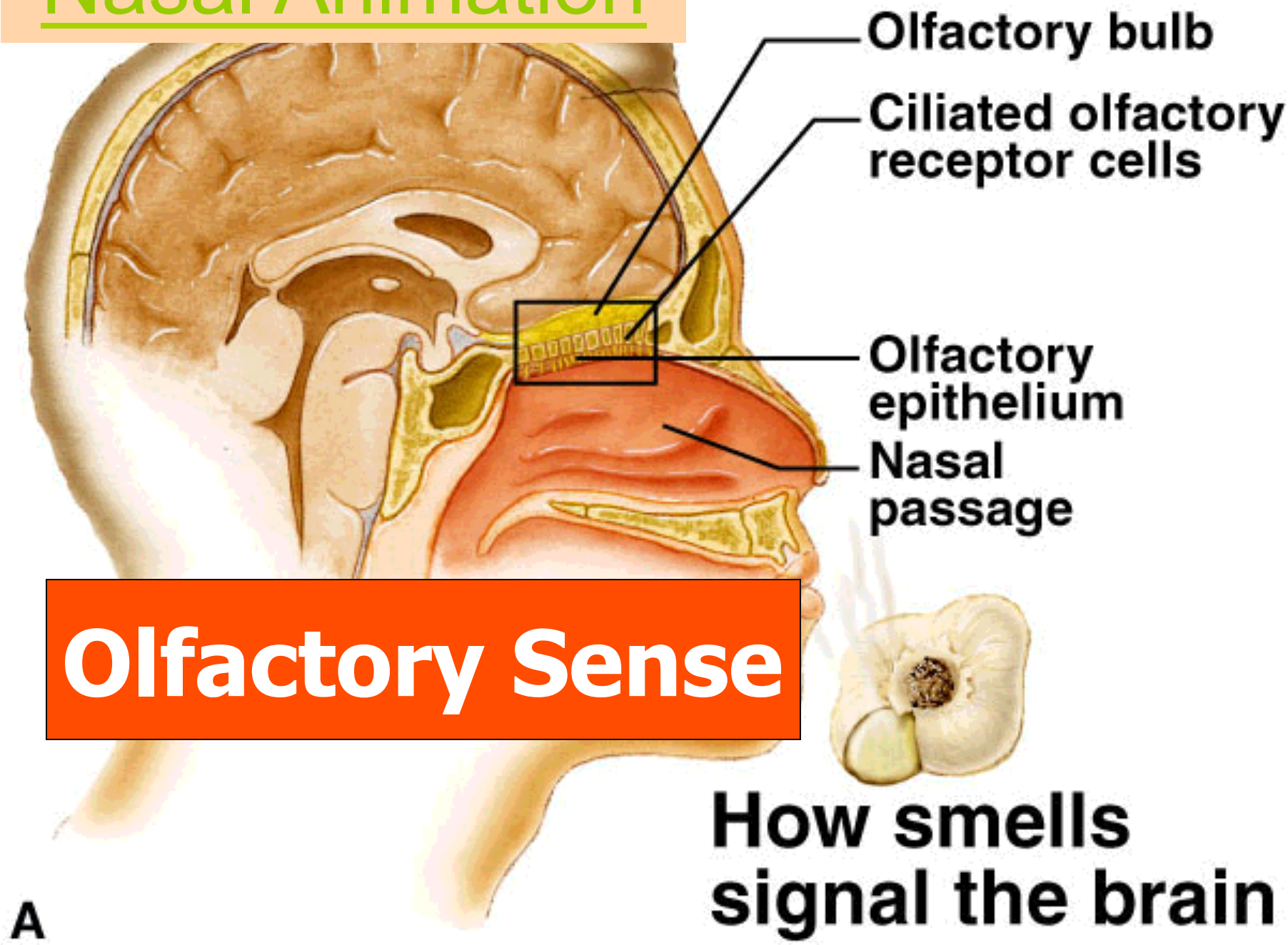
Smell



- It has been proposed that there are 7 basic odors…
  - Camphoric (moth balls), musky (perfume), floral, peppermint, etheral (cleaner), pungent (vinegar) and putrid (rotten eggs)
- Does having a cold reduce the taste of food?
  - When your sick, olfactory cells are blocked
  - Taste and smell work together, so smell affects the taste of food

"It's only Wednesday but something in the air makes me obsess about the weekend!"

Nasal Animation



Olfactory Sense