CPL Theory
Human Factors (CHUF)

CHUF 4 – Hearing & Balance

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2. Amendment Record

Amendments made to this document since the previous version are listed below. All amendments to this document have been made in accordance with CAE OAA document management procedures.

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21	Point 3 change 40dB to 25dB	Robin Pickhaver Samantha Maguire	20/09/19

3. Disclaimer

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THE EAR

The Ear

- There are in fact two vital functions of the ear:

1. Mediates the sense of hearing

2. Mediates the sense of balance

- These functions are achieved through various components of the ear

- In fact, the ear is structured into three individual sections:

1. The Outer Ear

2. The Middle Ear

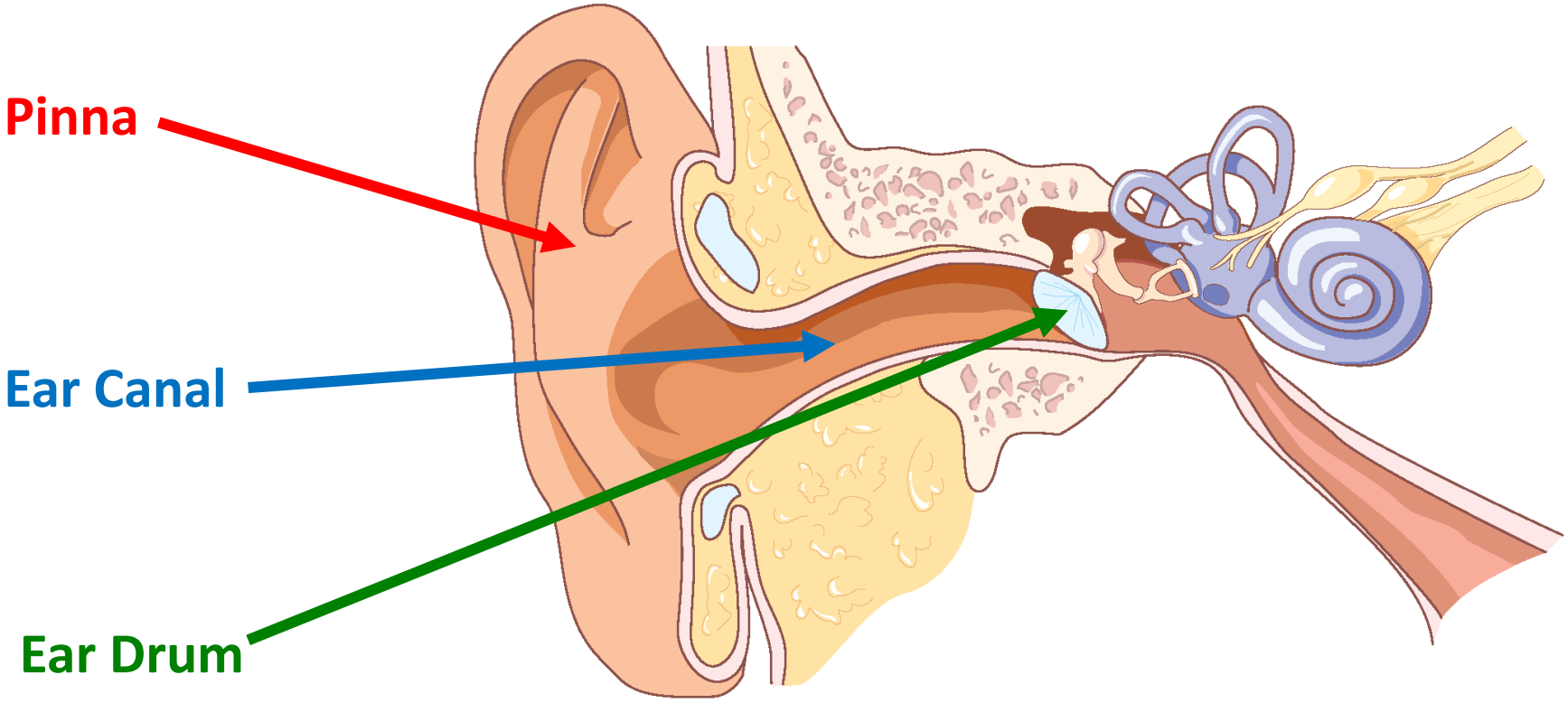
3. The Inner Ear

The Ear

The Outer Ear

- Also known as the Ear Canal is a passageway roughly 25mm in length

- The canal is filled with tiny hairs and wax-producing cells which protect the eardrum from intrusions such as insects or dust

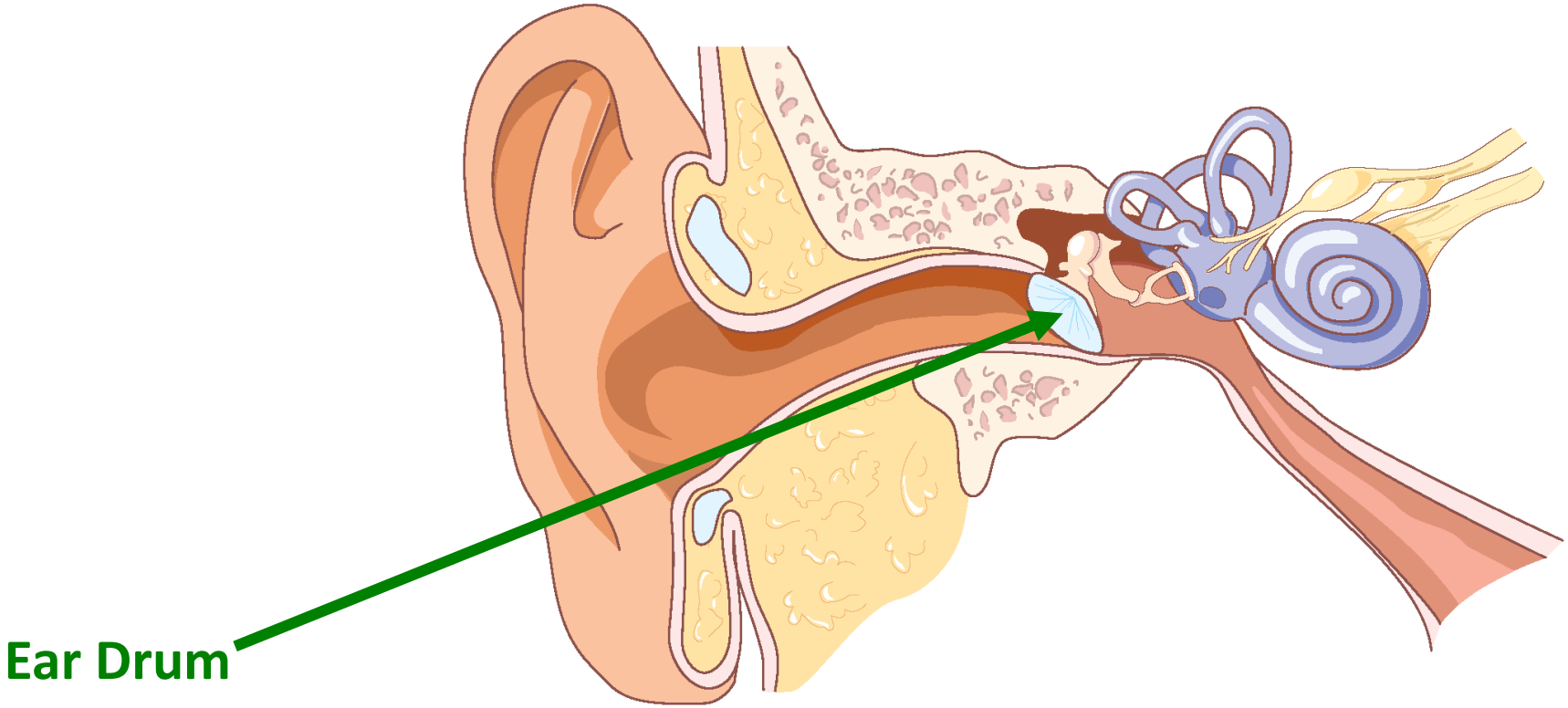


The Ear

The Middle Ear

- The eardrum is a flexible membrane forming an airtight seal, protecting the middle ear from intrusions

- The eardrum vibrates to soundwaves arriving via the canal

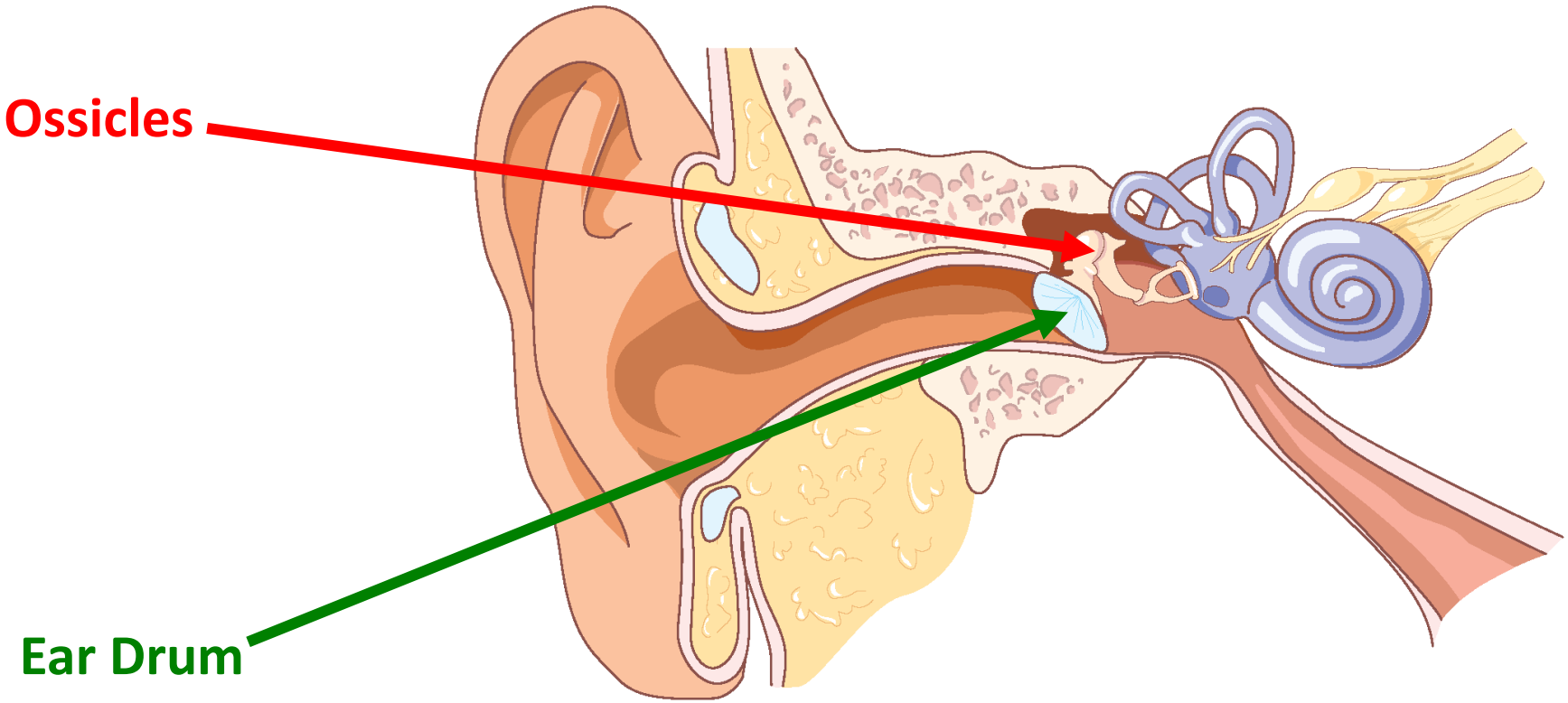


The Ear

The Middle Ear

- These vibrations are then amplified by three tiny bones known as ossicles

- Also known as the “hammer, anvil and stirrup,” they transfer the vibrations to the inner ear

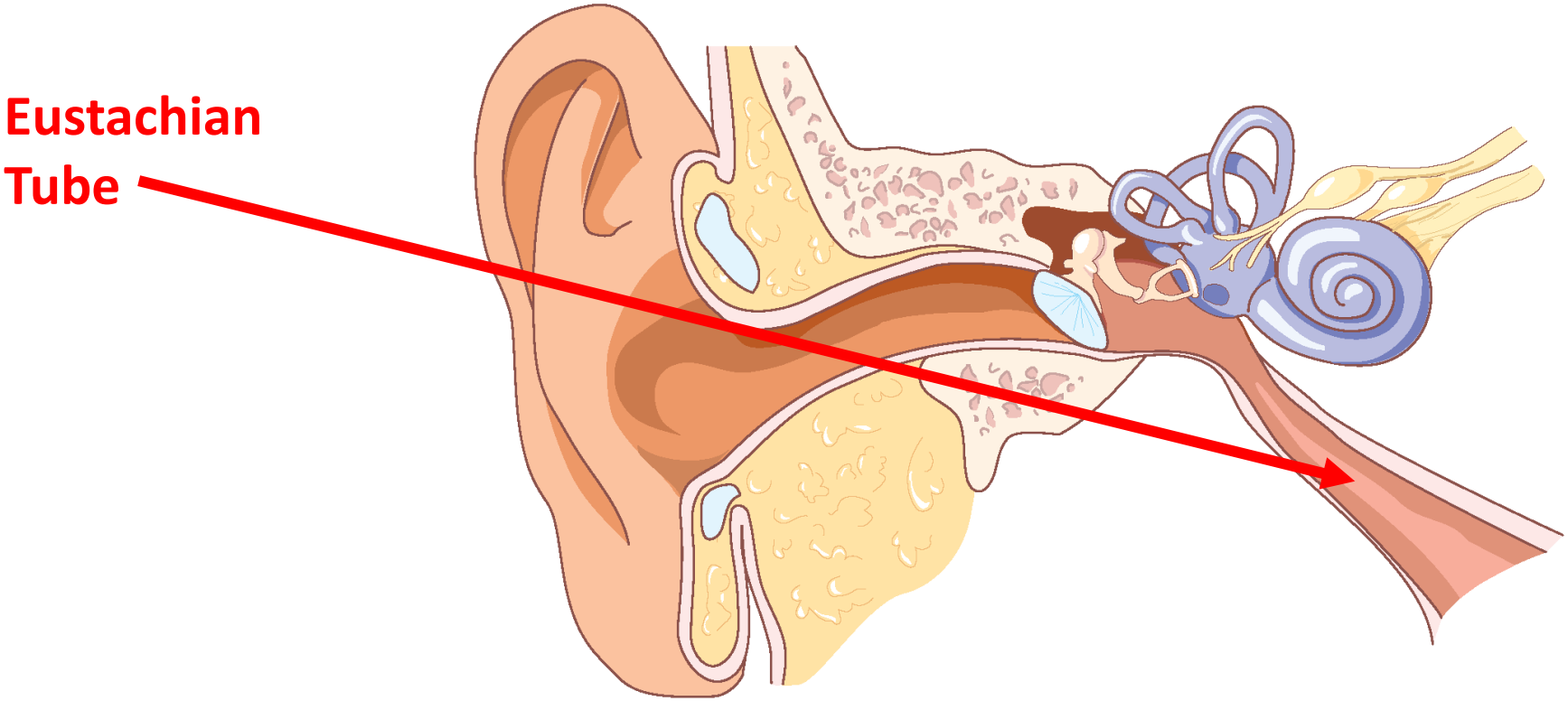


The Ear

The Middle Ear

- The middle ear is vented to the atmosphere via the **Eustachian tube**

- The Eustachian tube connects the middle ear to the throat cavity and allows pressure either side of the eardrum to be equalised



The Ear

The Middle Ear

- The Eustachian Tube may become blocked due to:

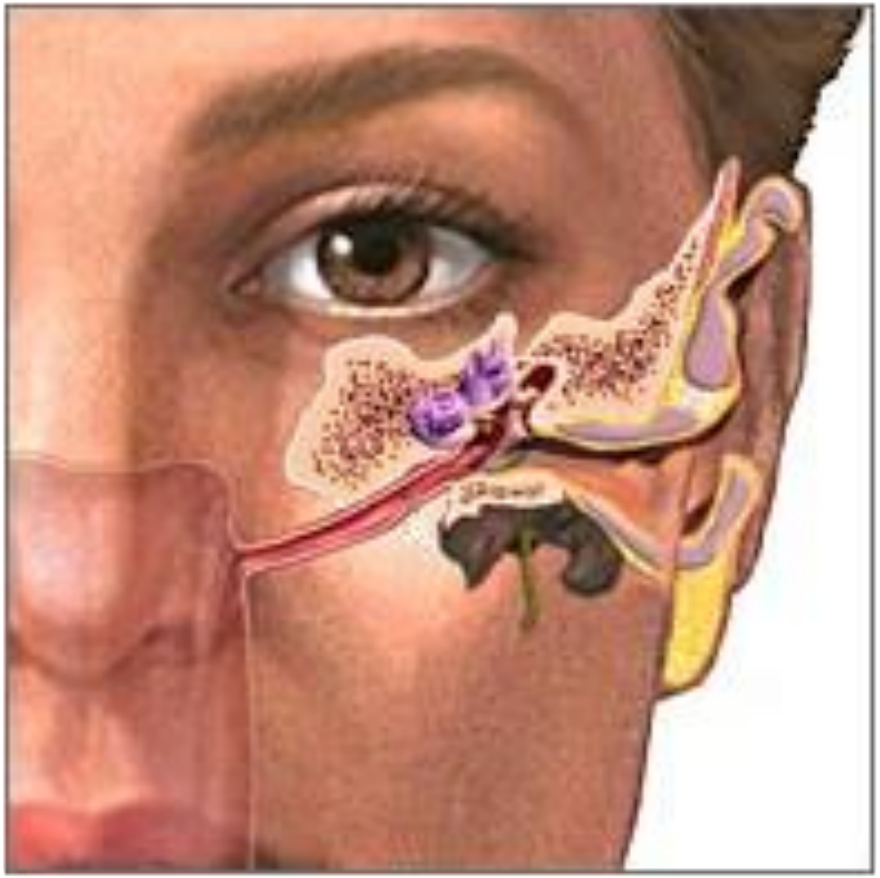
  1. Common Colds

  2. Hayfever

  3. Other sinus blockages

- It is such a blockage that may cause barotrauma – pain caused due to an imbalance of pressure on either side of the eardrum

- The blockage is most likely to occur in places where the tube bends

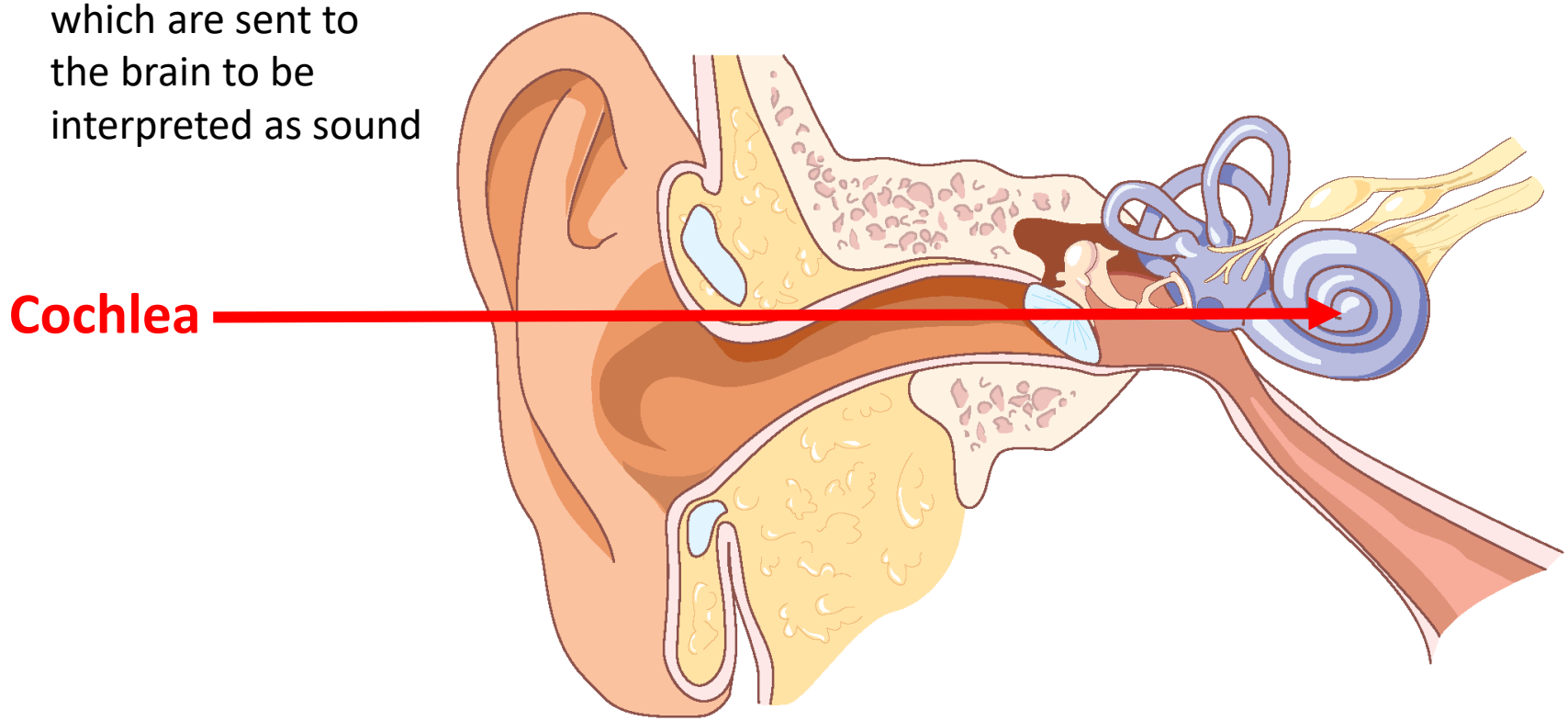


The Ear

The Inner Ear

- The vibrations from the ossicles eventually reach **the cochlea**, a small bony structure that looks like a snail's shell

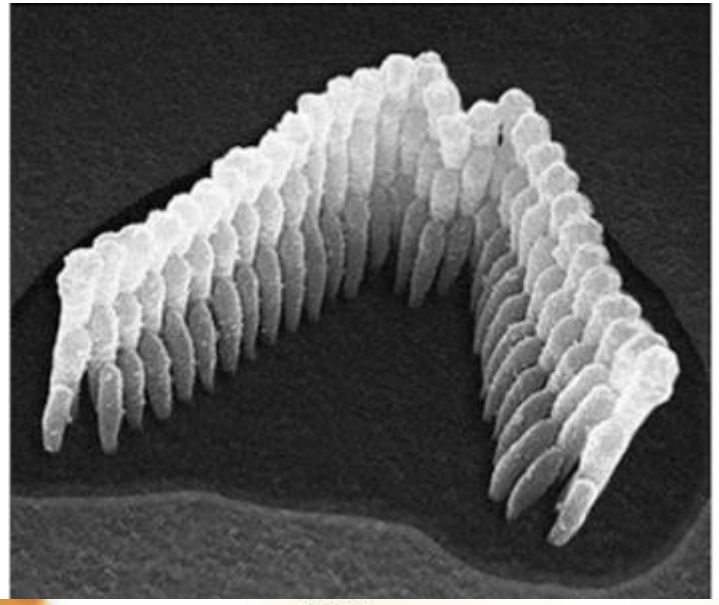
- The cochlea is responsible for converting the sound vibrations into **electrical impulses** which are sent to the brain to be interpreted as sound

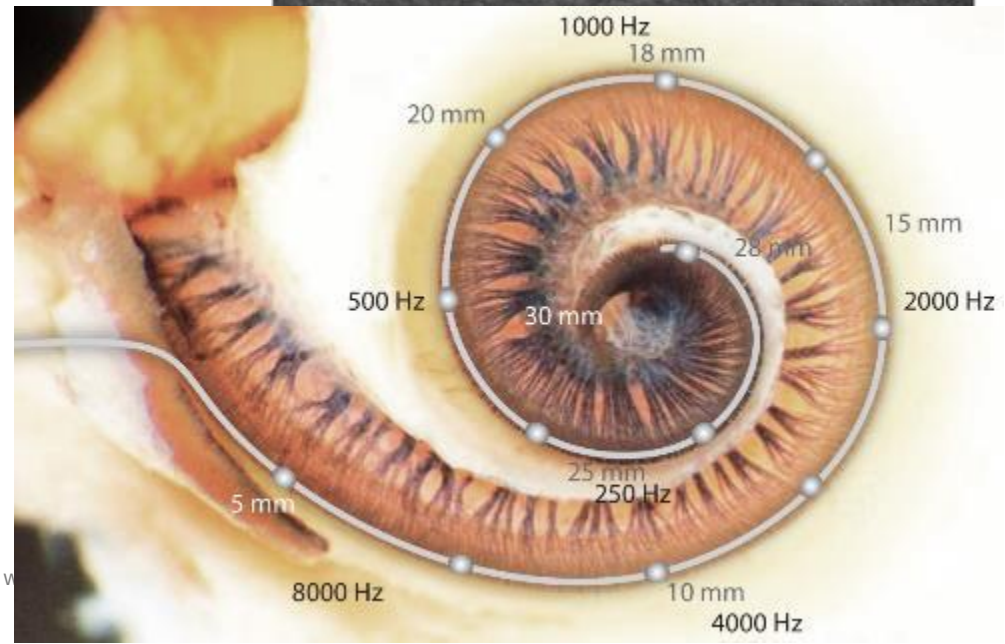


The Ear

The Inner Ear

- The cochlea is filled with a fluid called **endolymph**
- The cochlea also contains tiny **hair-like cells**
- Vibrations from the stirrup in the middle ear arrive at the **oval window** and enter the cochlea
- This creates pressure waves in the endolymph
- The hair-like cells respond to these pressure waves and generate nerve impulses which are interpreted by the brain
- The hair-like cells are of various widths each width is designed to resonate at certain frequencies



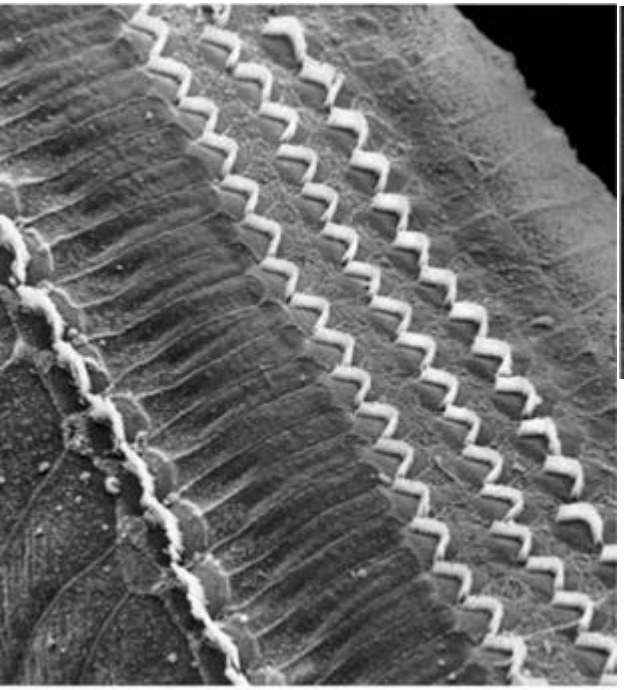


The Ear

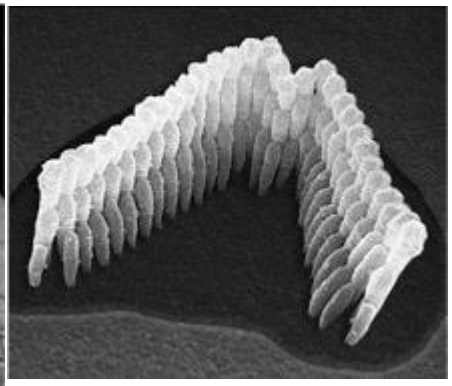
The Inner Ear

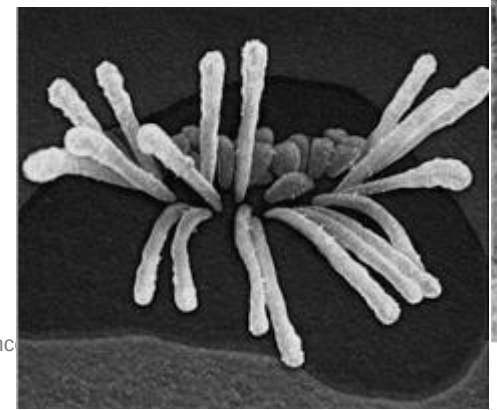
- Prolonged exposure to loud noise causes damage to the hair-like cells

- This damage is **irreversible**



Intact cochlea





Damaged cochlea

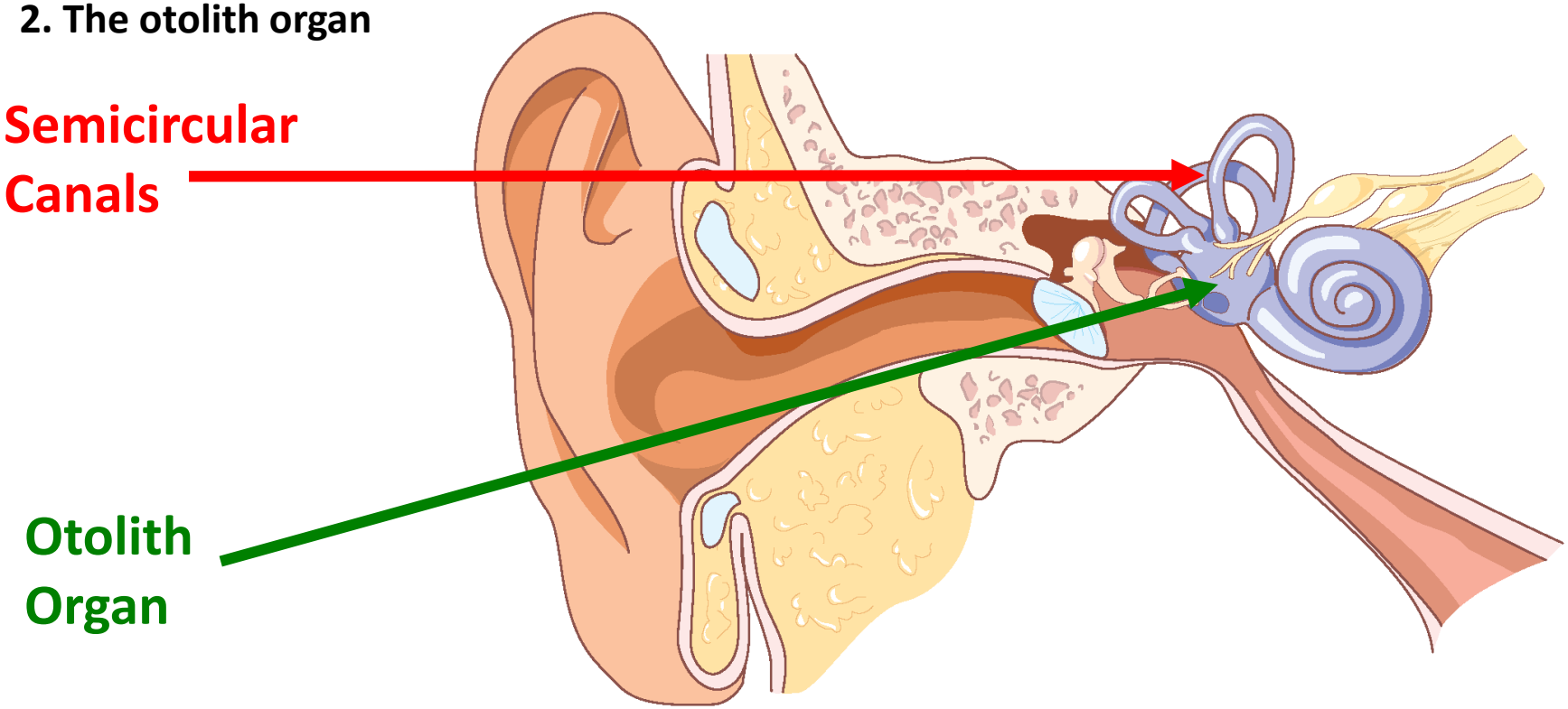
The Ear

The Inner Ear

- Just above the cochlea sits the **vestibular system,** comprised of:

1. The semicircular canals

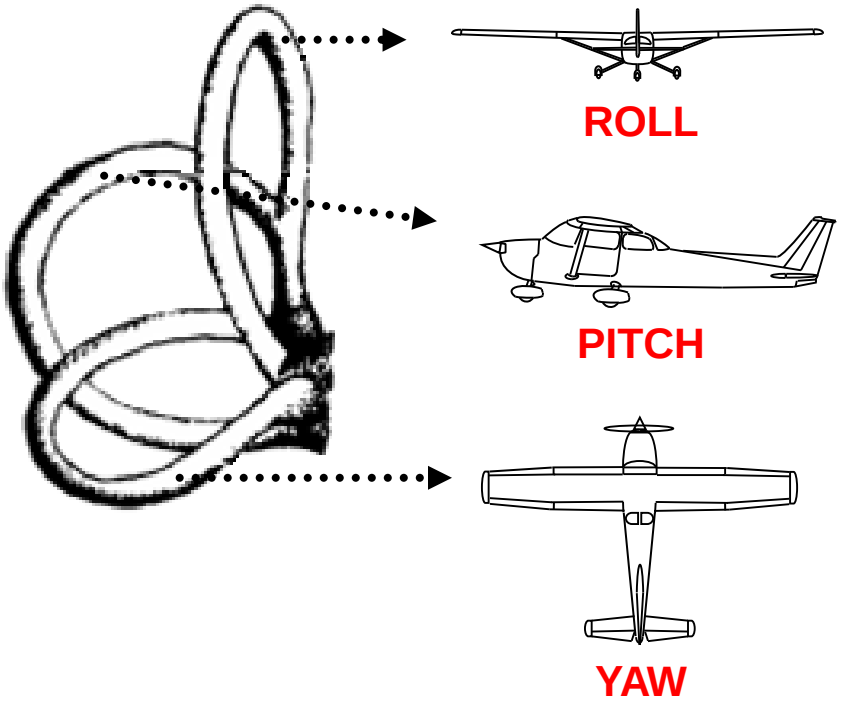
2. The otolith organ



The Ear

The Inner Ear

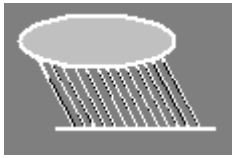
- **The Semicircular Canals** are responsible for sensing **angular acceleration** – in other words, acceleration in pitch, roll and yaw
- **The Semicircular Canals** are therefore responsible for **mediating sense of balance**
- The canals are made up of 3 loops – these contain **endolymph fluid** like the cochlea
- They also contain tiny hair-like cells called **cupula**
- As the head or body changes it speed or attitude in pitch, roll or yaw, the fluid washed over the cupula which sends nerve impulses to the brain to give a sense of orientation



The Ear

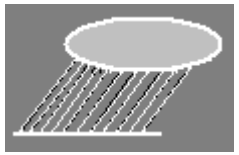
The Inner Ear

- Note that the cupula will only be deflected by the **initial change** in angular acceleration



Deceleration

Neutral – hairs in upright position



Acceleration

- So, any movement at **constant speed** or even **constant angular acceleration** will **not** deflect the cupula – **they will remain upright**

- Fun fact:

"Alcohol is able to pass from the blood into the semicircular canals. This changes the specific gravity of the endolymph and causes the cupula to bend – triggering a false sense of acceleration. This is why you become dizzy when you are drunk."

The Ear

The Inner Ear

- **The Otolith Organ** is responsible for sensing **linear acceleration** – in other words, straight line acceleration or deceleration

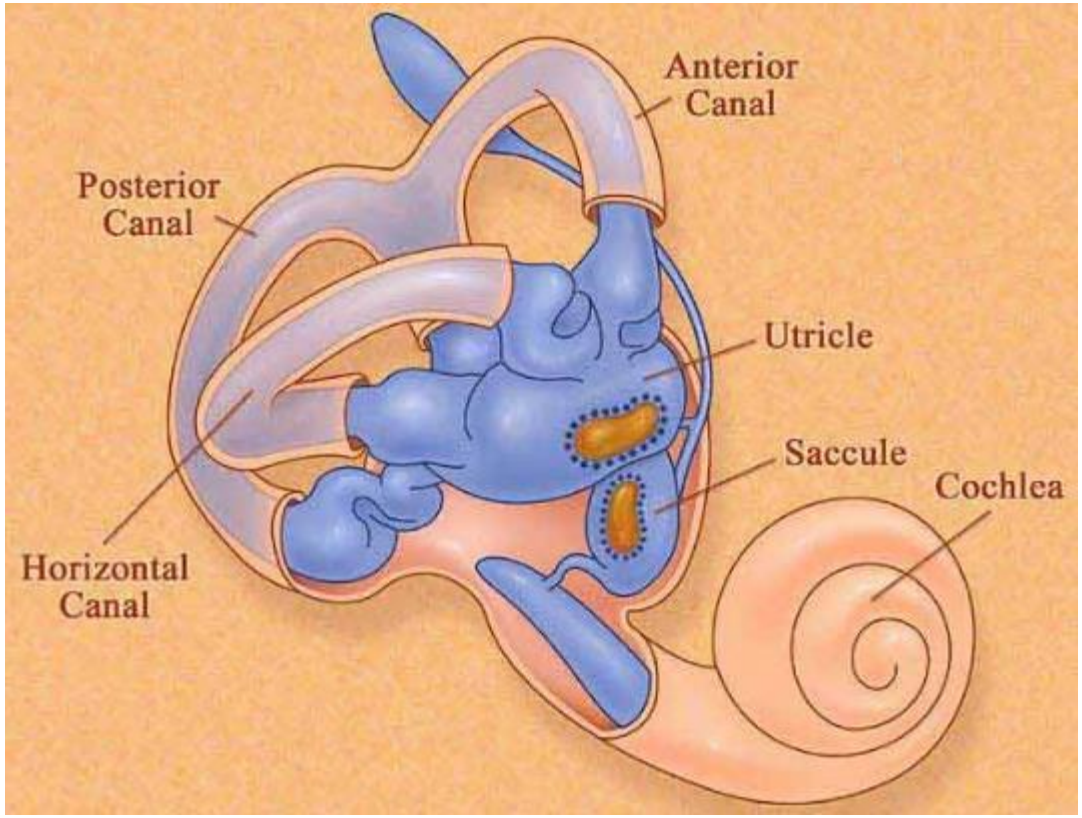
- It is made up of two parts:

  1. The utricle

  2. The saccule

- The **utricle** lies horizontally and detects **horizontal acceleration**

- The **saccule** lies vertically and detects **vertical acceleration**



MEASURING NOISE

Measuring Noise

- Noise or sound intensity or “loudness” is measured in **decibels (dB)**

- Below are some dB levels for various scenarios:

1. **Whisper** **15dB**
2. **Normal conversation** **30dB – 40dB**
3. **A busy street** **60dB – 80dB**
4. **A light aircraft cockpit** **80dB – 100dB**
5. **Roar of a jet engine from a few feet away** **140dB**

- Note that every increase of **10dB** indicates a **tenfold increase** in sound intensity
  E.g. 80dB is ten times louder than 70dB

EFFECTS OF EXCESS NOISE

Effects of Excess Noise

- An excessive level of noise can cause discomfort and even physical pain

- Furthermore, exposure to high noise levels can result in temporary or permanent hearing loss – usually the **higher frequencies will be lost first**

- Below are two important figures to remember:

1. Prolonged exposure to 85dB and above will cause discomfort and temporary or permanent deafness. Hearing protection is recommended to be worn above this level.

2. 140dB is the minimum noise intensity that would result in the sensation of pain to the ears

Effects of Excess Noise

- A pilot's best defence against excess noise is a **good headset**
- It is strongly recommended that headphones are worn at all times during flight
- A good headset can **reduce noise by up to 25dB**
- Remember, hearing protection is recommended for **above 85dB**. The C172 may produce the following noise levels:
  - 75 dB when landing
  - 89 dB in the cruise
  - 94 dB at take-off

Effects of Excess Noise

- If headphones are unavailable, ear plugs can reduce noise by up to **25dB**

- A practical test to assess whether hearing protection should be worn:

  "If two people standing 0.5m away need to shout to be heard"

- Fun facts on noise:

  1. Noises of 100dB in the frequency range below 100Hz will cause the body to vibrate

  2. Research has shown that in remote tribal communities, hearing is not affected by age

MOTION SICKNESS

Motion Sickness

- Motion Sickness is suffered by many people
- It can occur in any moving vehicle and sometimes also in closed spaces such as simulators, or even a cinema where vigorous motion is displayed

Motion Sickness

- Motion Sickness occurs when different sensors send conflicting information to the brain (it is a symptom of disorientation)

- The three primary systems involved in maintaining body equilibrium include:

1. The visual system – the dominant force

*i.e. The pilot can **see** the horizon*

2. The vestibular system – part of the inner ear that mediates balance

*i.e. The pilot's **semicircular canals***

3. The proprioceptive system – nerves of the muscles, skin etc.

*i.e. The pilot can **feel** their feet on the pedals (postural cues)*

- Although sight dominant, input from all systems is necessary for an accurate picture

Motion Sickness

- However, **when information coming from one system doesn't match the information coming from another**, the brain becomes confused, leading to motion sickness

- In other words, there is **a confusion of sensory information sent to the brain**

*Example: A pilot flying may **see** movement outside the cockpit – **a visual indication of movement**. However, he/she is sitting **stationary** in the seat – a **proprioceptive indication of non-movement**. This conflict could cause a feeling of **disorientation or nausea.***

Motion Sickness

- We can deal with Motion Sickness using one or more of the following techniques:

1. Cold air can help

2. A higher cruising level may rid the flight of turbulence

3. Vomiting often eases the symptoms

4. Concentrate on the horizon or aircraft instruments (best answer!)

5. Keep your head as still as possible

6. Ask your DAME to prescribe a medication (BE CAREFUL! Drowsiness can often be a side effect of these medications!)