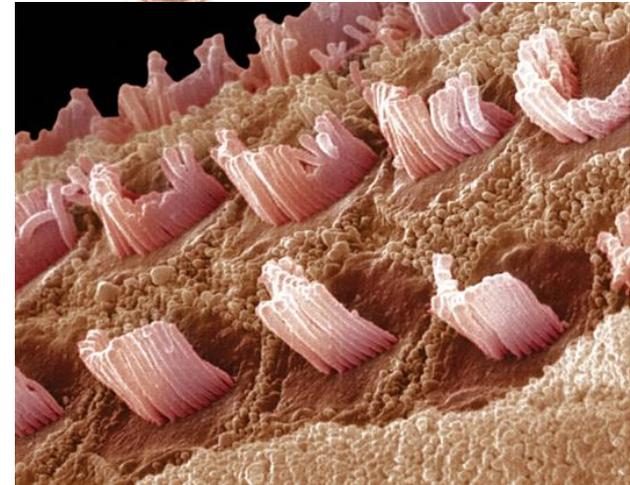
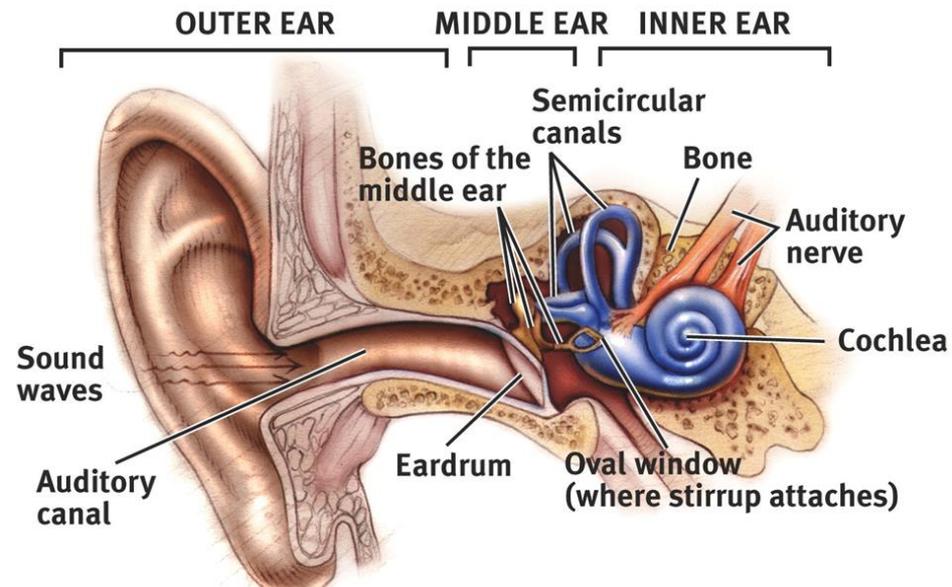


# The Ear

**Outer Ear:** Pinna. Collects sounds.

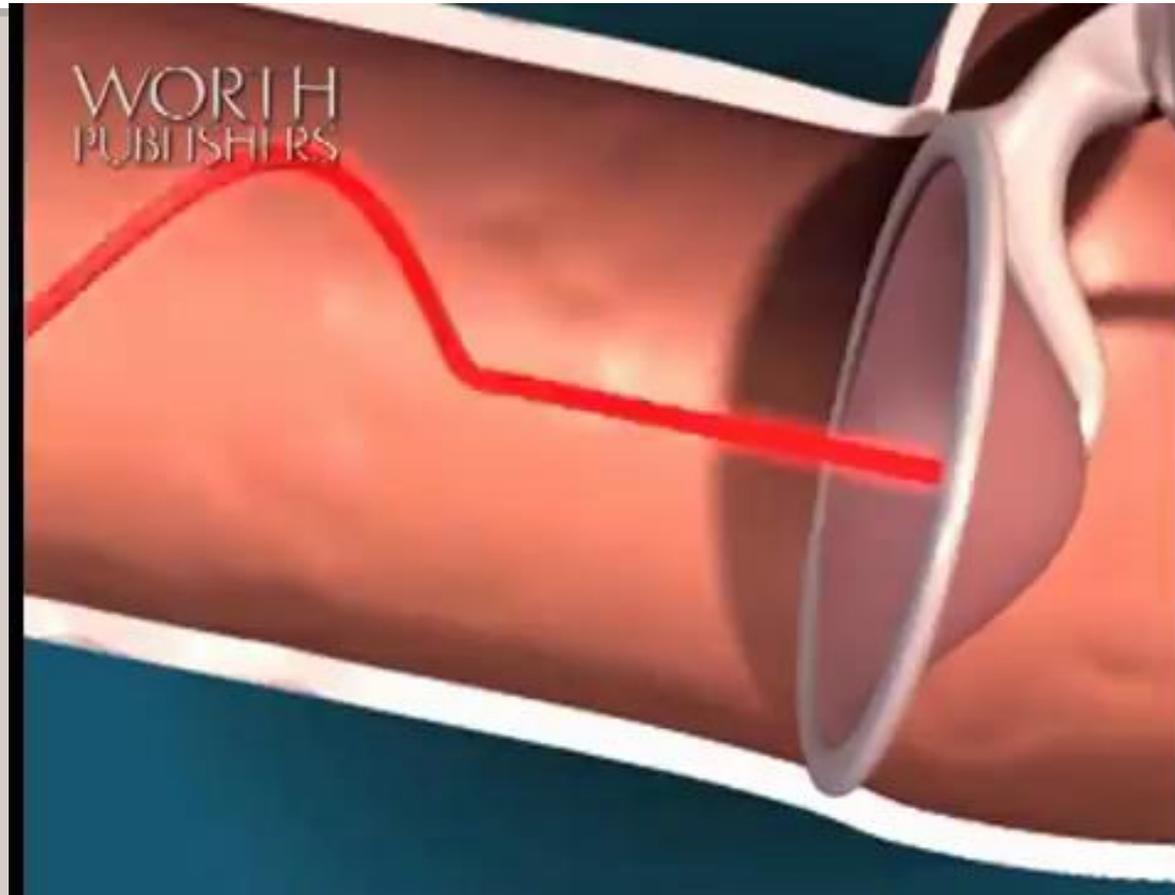
**Middle Ear:** Chamber between eardrum and cochlea containing three tiny bones (hammer, anvil, stirrup) that concentrate the vibrations of the eardrum on the cochlea's oval window.

**Inner Ear:** Innermost part of the ear, containing the cochlea, semicircular canals, and vestibular sacs.



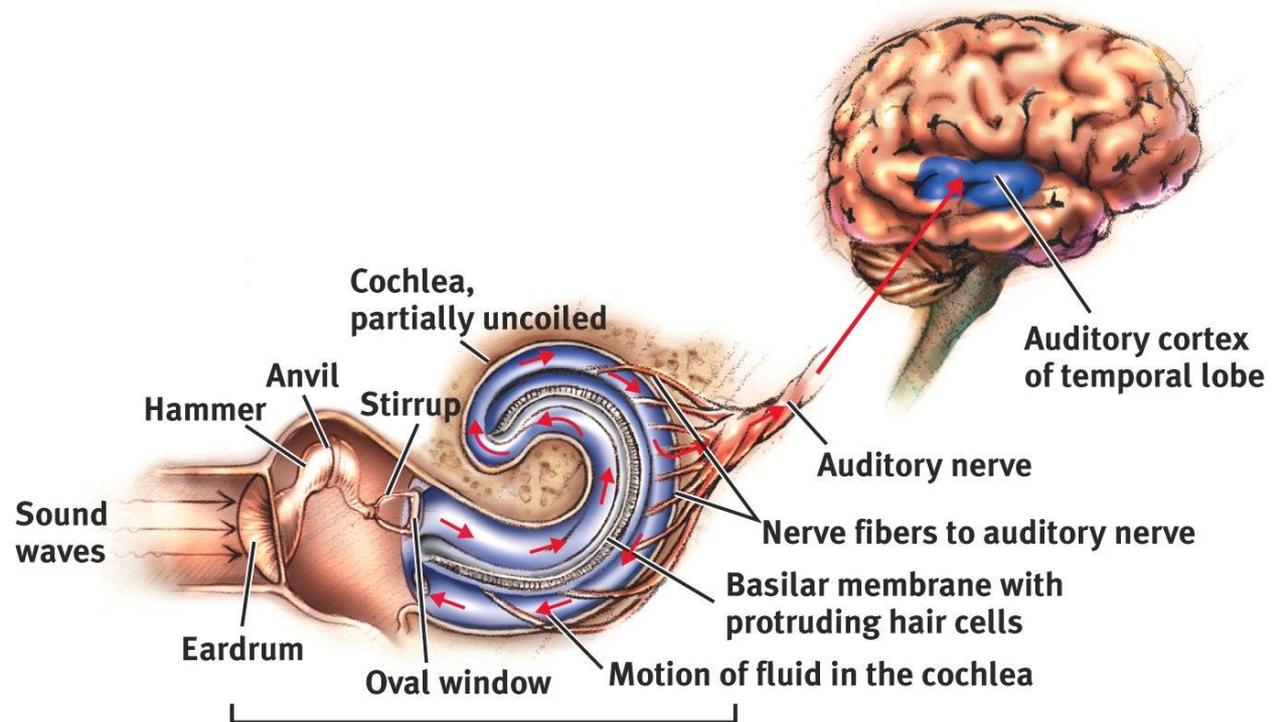
# Converting Sound Waves into Neural Signals, Part 1

*What happens to  
initiate neural  
signals for  
sound?*



# Cochlea

**Cochlea:** Coiled, bony, fluid-filled tube in the inner ear that transforms sound vibrations to auditory signals.



Enlargement of middle ear and inner ear, showing cochlea partially uncoiled for clarity

# How Sound Waves Become Auditory Sensations



Cochlea

*Basilar membrane* –  
Thin strip of tissue,  
contains hair cells  
that are sensitive to  
vibrations



# Hair Cells

- Cochlea has 16,000 hair cells
- Can turn neural current on/off 1000 times/second
- Cilia can whither or fuse in response to noise
- Brain detects loudness from # of cells responding
- Can still hear loud sounds if you lose sense of soft sounds
- Compressed sound - soft sounds amplified
- Most hearing loss comes from damage to hair cells
- Hair cells send neural messages to auditory cortex
- Auditory nerve created by bending of hair cells

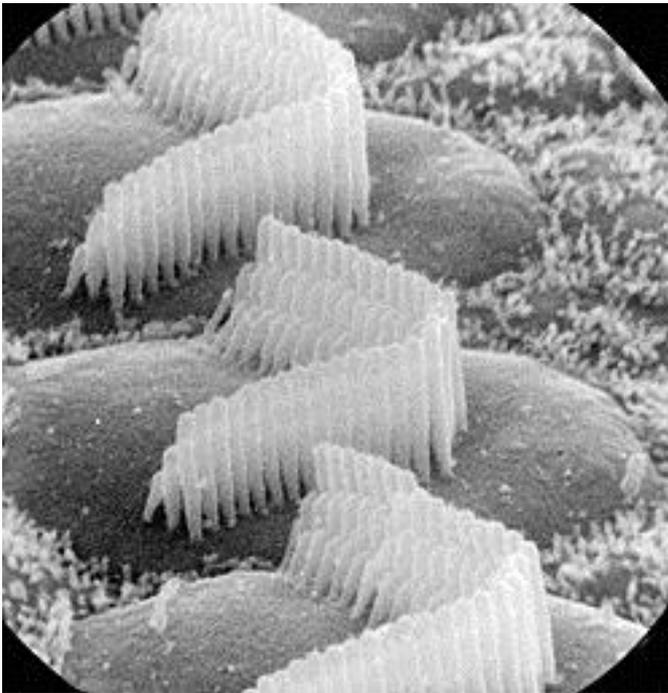
# Transduction in the ear

- Sound waves hit the **eardrum** then **anvil** then **hammer** then **stirrup** then **oval window**.
- Everything is just vibrating.
- Then the **cochlea** vibrates.
- The **cochlea** is lined with mucus called **basilar membrane**.
- In **basilar membrane** there are hair cells.
- When hair cells vibrate they turn vibrations into neural impulses which are called **organ of Corti**.
- Sent then to **thalamus** up **auditory nerve**.



It is all about the vibrations!!!

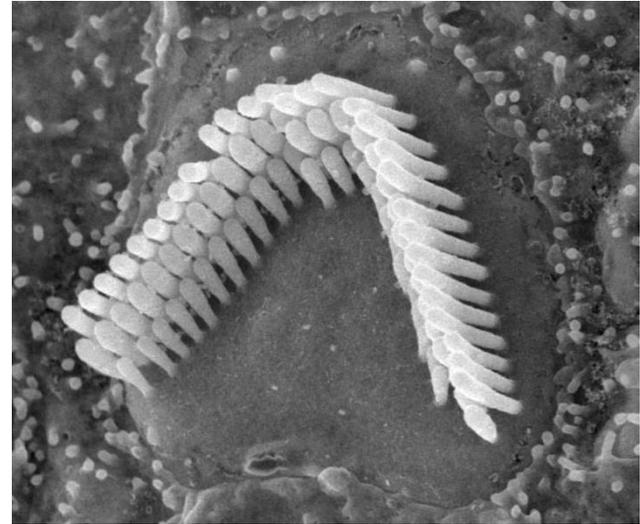
# Place Theory



- Different hairs vibrate in the cochlea when they process different pitches.
- So some hairs vibrate when they hear high and other vibrate when they hear low pitches.

# Frequency Theory

- All the hairs vibrate but at different speeds.



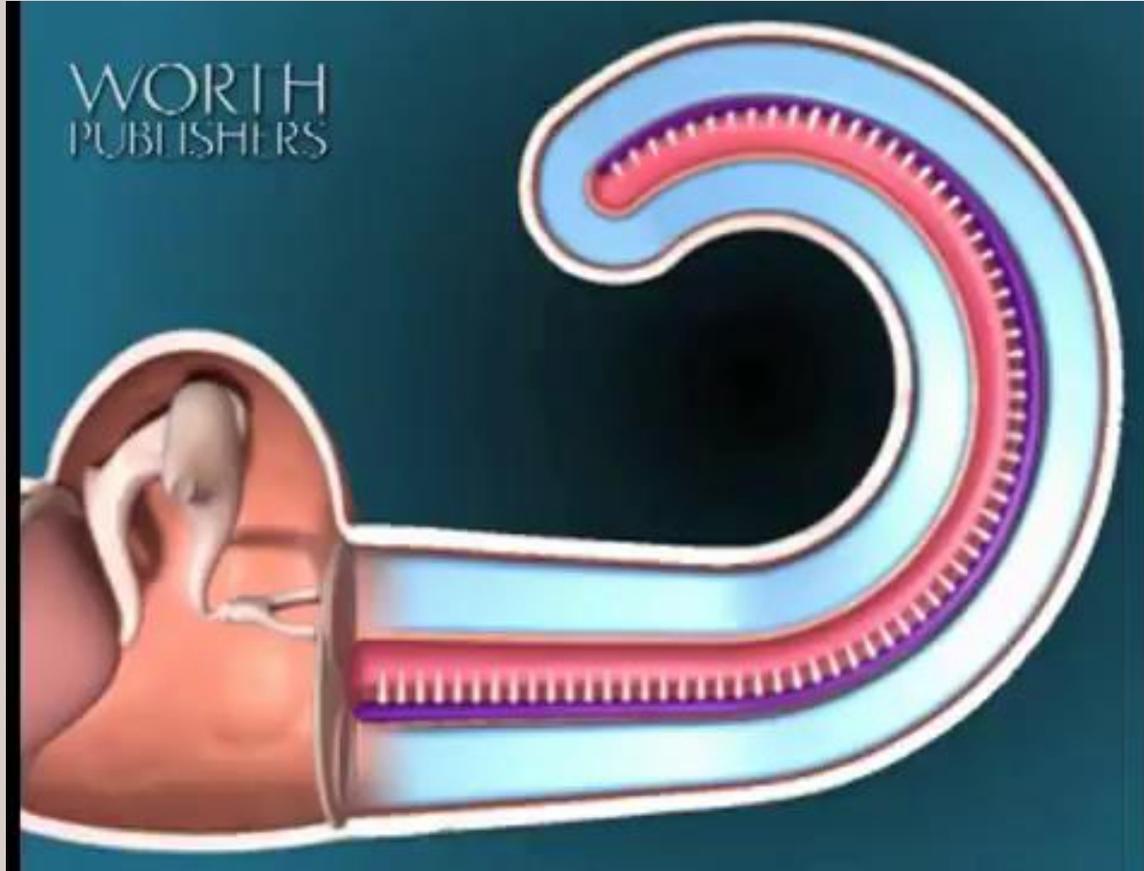
Sound  
Frequency  
200 Hz



Auditory Nerve  
Action Potentials

# Distinguishing Differences in Pitch

*What are the  
highs and lows of  
sound?*



# Deafness

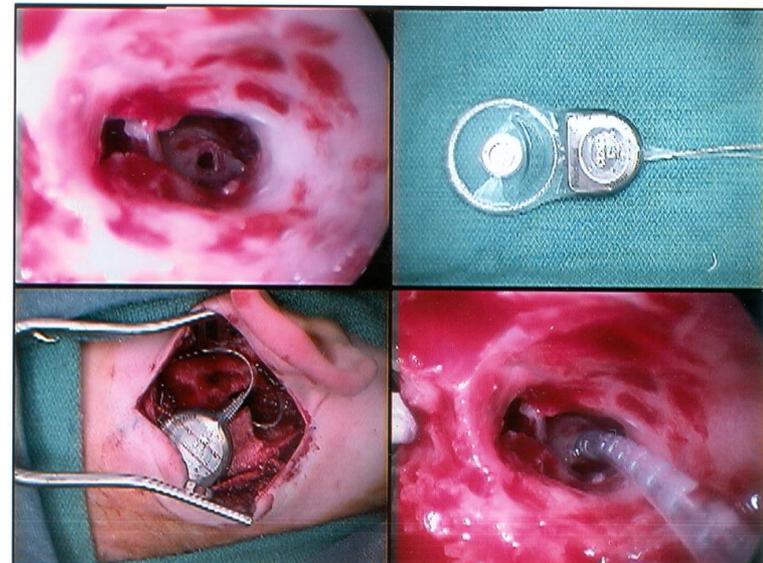
## Conduction Deafness

- Something goes wrong with the sound and the vibration on the way to the cochlea.
- You can replace the bones or get a hearing aid to help.



## Nerve (sensorineural) Deafness

- The hair cells in the cochlea get damaged.
- Loud noises can cause this type of deafness.
- NO WAY to replace the hairs.
- Cochlea implant is possible.

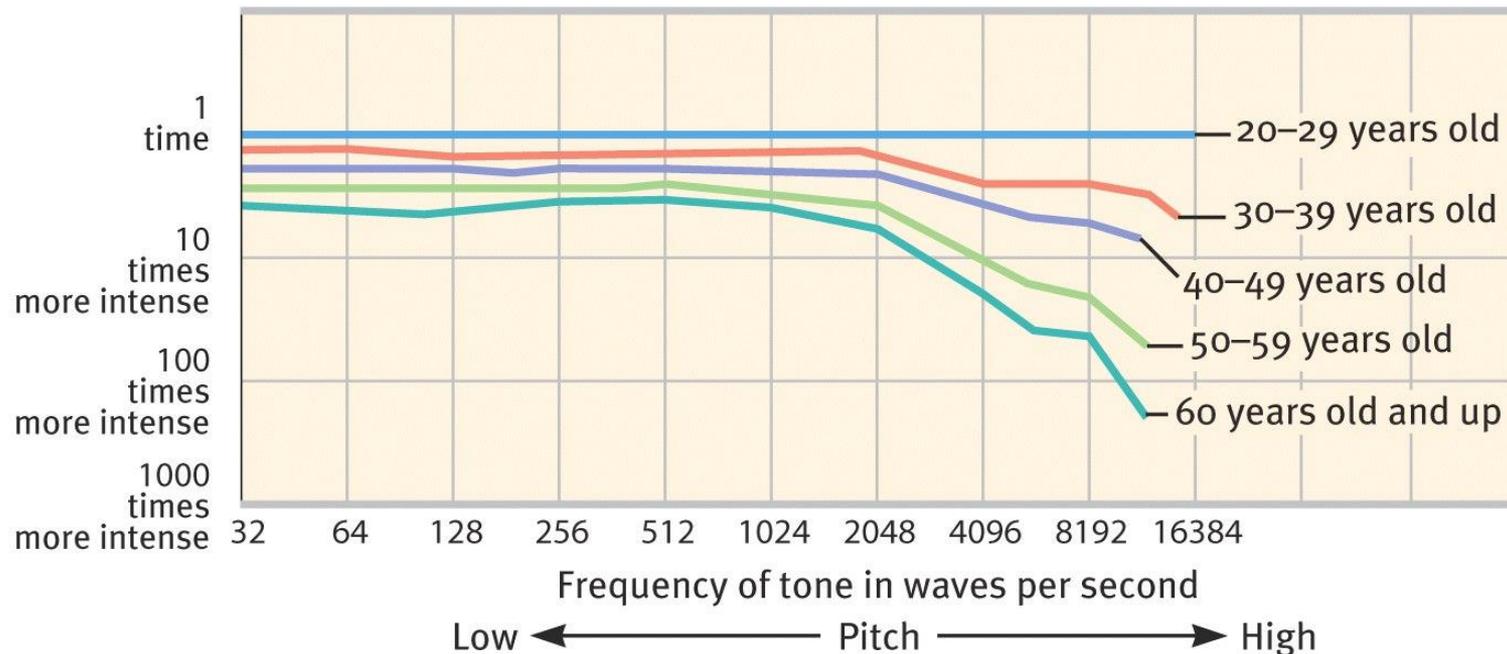


# Hearing Deficits



Older people tend to hear low frequencies well but suffer hearing loss when listening for high frequencies.

Amplitude (intensity) required for perception relative to 20–29-year-old group



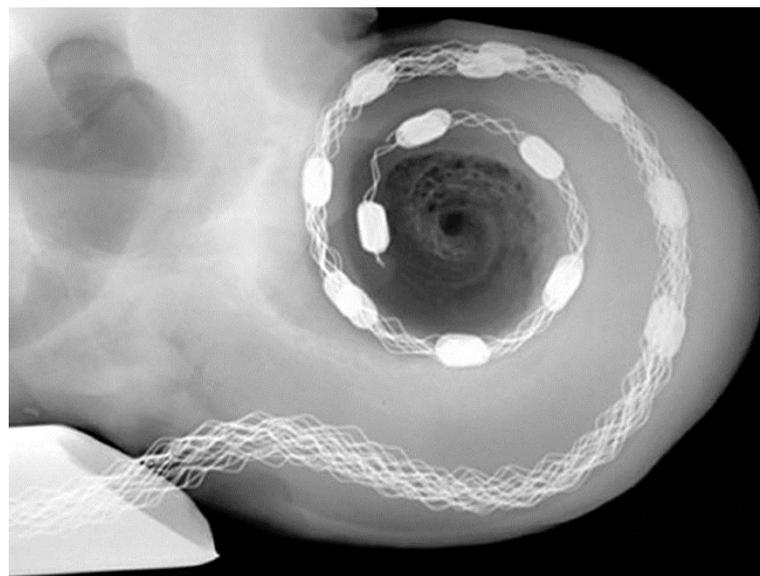
# Deaf Culture

Cochlear implants are electronic devices that enable the brain to hear sounds.

## **DEBATE:**

-90% of parents of deaf children support the use of cochlear implants.

-Proponents of deaf culture do not, as they believe that deafness is not a disability



Cochlear Implant

Wolfgang Gstotner. (2004) *American Scientist*, Vol. 92, Number 5. (p. 437)

## **Sensory Compensation**

# Cochlear Implants



# Synesthesia: what is it?

- Means “joined sensations”
- Synesthesia is a naturally-occurring condition whereby certain individuals experience information that is usually experienced in one modality (say, a sound) in a different modality (e.g. a visual pattern)
  - Example: listening to tones or looking at numbers evokes colors.
  - URBAN LEGEND – Jimi Hendrix and Purple Haze

# History

- It is estimated that 1 in every 25,000 are born with it. Some do not realize until later in life.
- Females outnumber males 6 to 1
- It seems to run in families
- It has been first introduced in 1880
- Psychologists ignored it until 1980's
- With new understandings, it is popular again



# Synesthesia or associations?

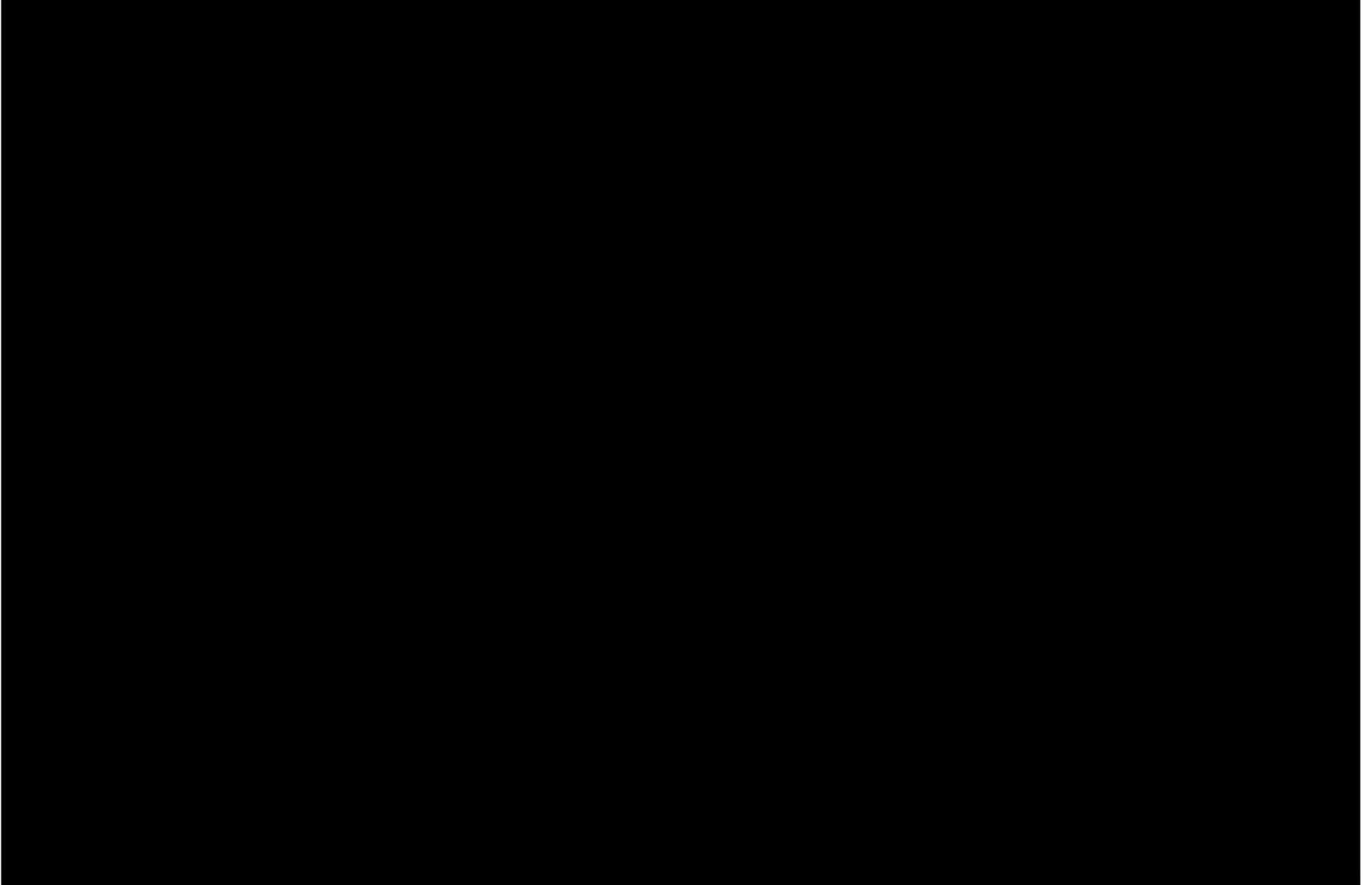
Most people would connect the word 'sunset' with an orange-red color for the following reason:

- First, the **word** "sunset" connects with the **concept** of a sunset.
- Next, the **concept** of a sunset connects with a **mental picture** of a sunset.
- Finally, the **mental picture** of the sunset fills the mind with an orange-red glow.

# Synesthesia – Is It Real?

- Metaphorical?
    - A “loud” shirt, or a “sharp” cheddar cheese?
  - Experience childhood memories and associations?
    - Do you *feel cold when you see an ice cube?*
- (you think cold)!*

# Synesthesia



# Are you synaesthetic?

We will be able to test to see if you are a synaesthetic... This tests for number-color synaesthesia.

Here is how it works:

- Colors are obvious.
- If you look at a collection of black things and some of them are red you don't need to search - the red things just jump out at you.
- Your job will be to look at a collection of black symbols, and spot the red colored ones.

