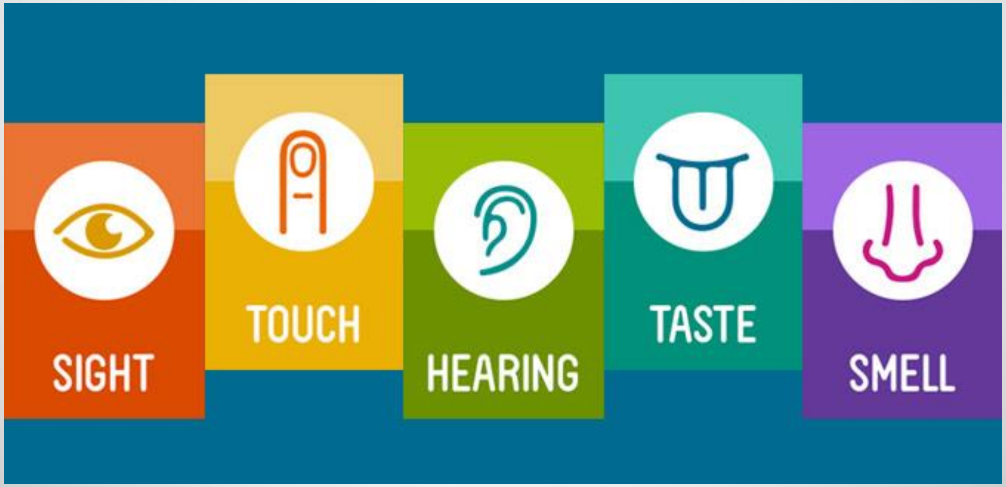
Chapter 5: Sensation

AP PSYCHOLOGY



Sensation vs. Perception

Sensation

The process by which our sensory receptors and nervous system receive and represent stimulus energies from our environment.

The brain receives input from the sensory organs.

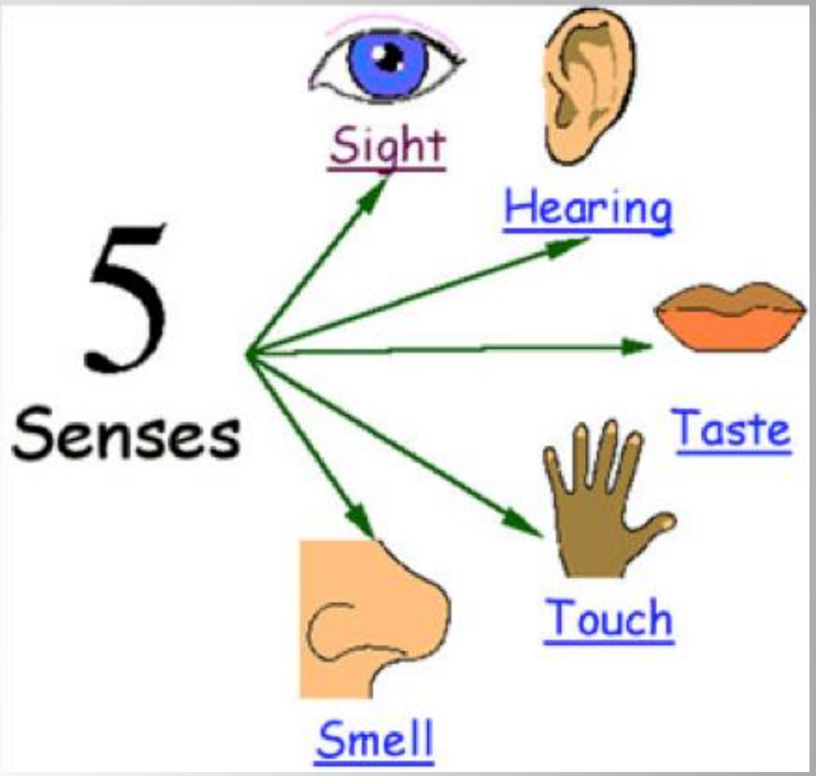
Perception

The process of organizing and interpreting sensory information, enabling us to recognize meaningful objects and events.

The brain makes sense out of the input from sensory organs.

Sensation

- A process by which our sensory receptors and nervous system receive and decode stimulus energy
- In order to represent the material in our head we must detect physical energy from our environment & encode it as a neural signals.



From Sensory Organs to the Brain

The process of sensation can be seen as three steps:

Reception-- the stimulation of sensory receptor cells by energy (sound, light, heat, etc)

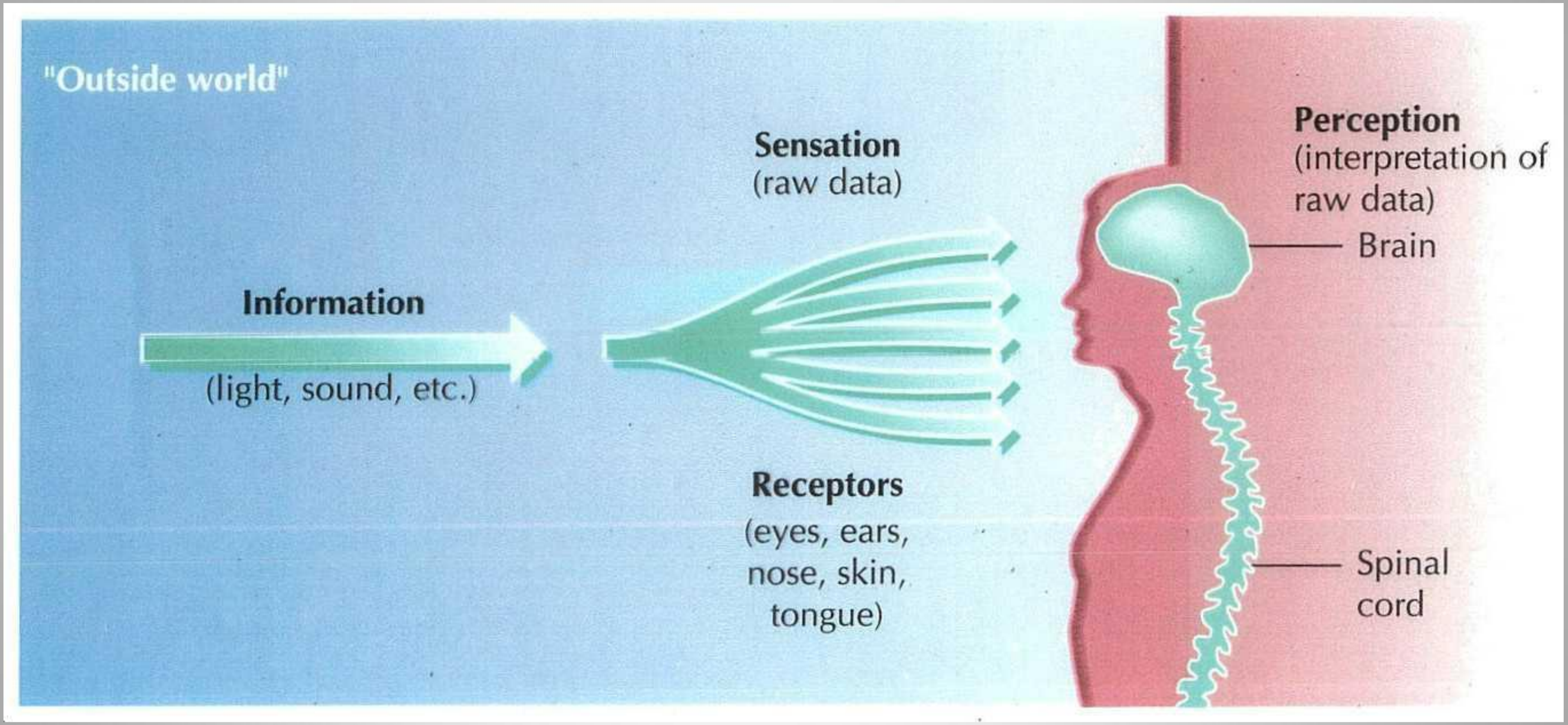
Transduction-- *transforming this cell stimulation into neural impulses*

Transmission-- delivering this neural information to the brain to be processed

Perception

- A process of organizing and interpreting sensory information, enabling us to recognize meaningful objects and events
- Raw information is constructed into our experiences
- Sensation & Perception blend into one continuous process

Sensation & Perception



Making sense of the world

What am I seeing?

Bottom-up processing:

taking sensory information and then assembling and integrating it

Top-down processing:

using models, ideas, and expectations to interpret sensory information

Is that something I've seen before?

Sensation

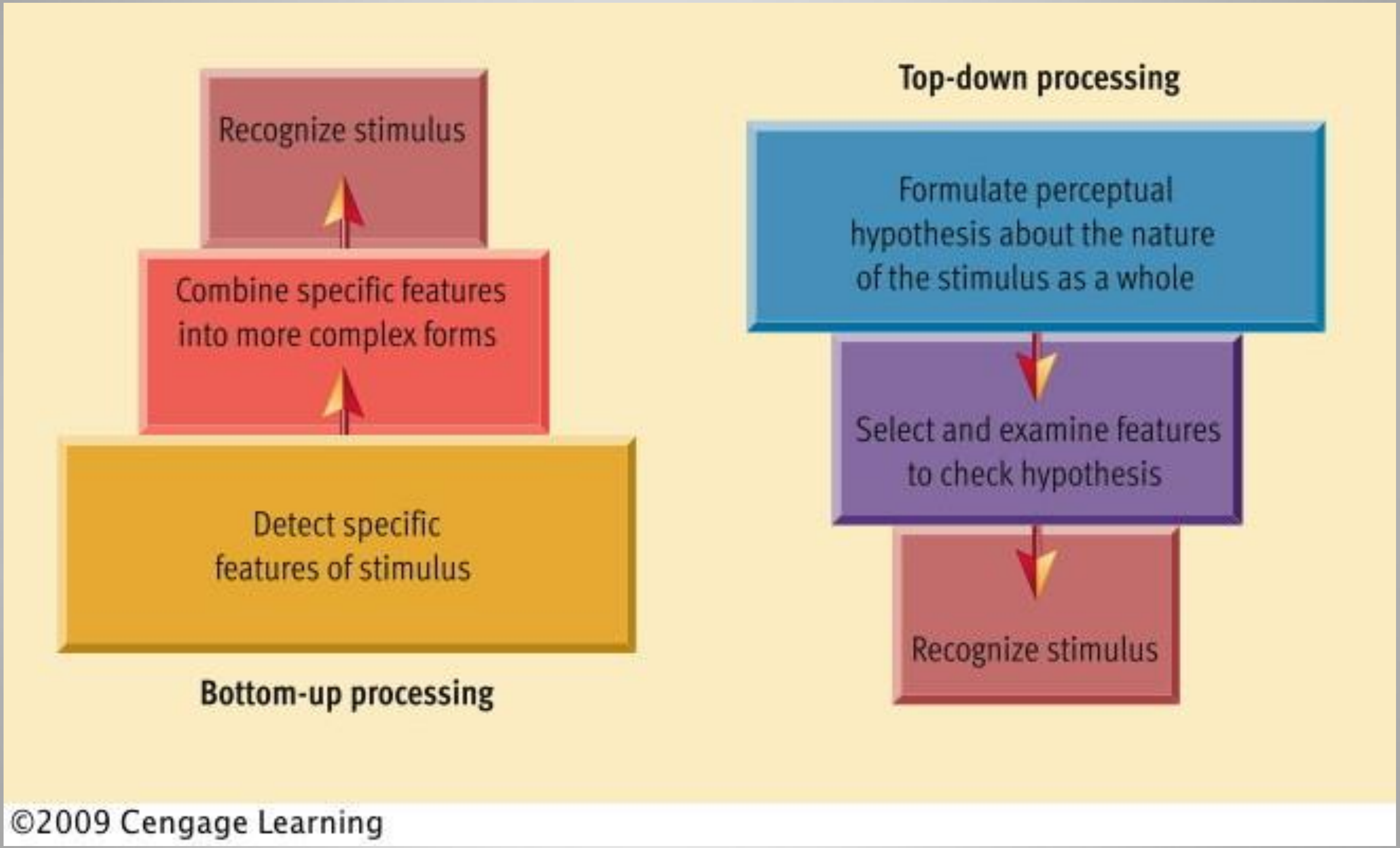
Bottom-Up Processing

- Analysis that begins with the sense receptors and works up to the brain's integration of sensory information
- We process this way when we have no prior knowledge; start at the bottom and work our way up.

Top- Down Processing

- Information processing guided by higher-level mental processes
- We construct perceptions drawing on our experience & expectations
- We process this way when we have prior knowledge, start at the top and work to process the details

Bottom-up vs. Top-down processing



Top-Down Processing

Can you read this?

Aoccdrnig to rscheearch at Cmabrigde Uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht the frist and lsat ltteer be at the rghit pclae. The rset can be a total mses and you can sitll raed it wouthit a porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe.

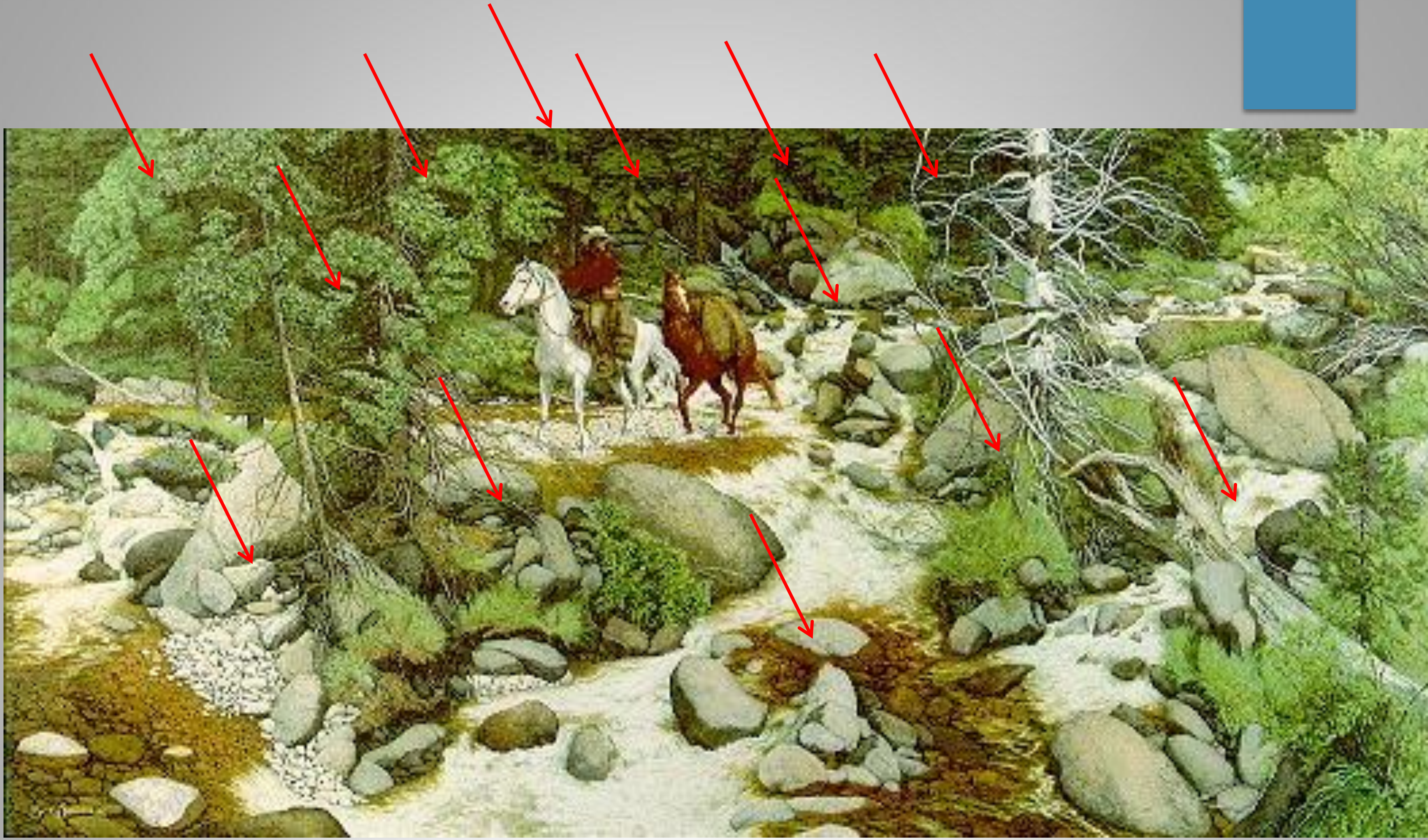
This is an example of Top-Down processing overriding Bottom-Up Processing

What do you see here?

You may start to see something in this picture if we give your brain some concepts to apply:
"tree"
"sidewalk"
"dog"
"Dalmatian"

Bottom-up vs. Top-down

The Forest has Eyes – Bev Doolittle



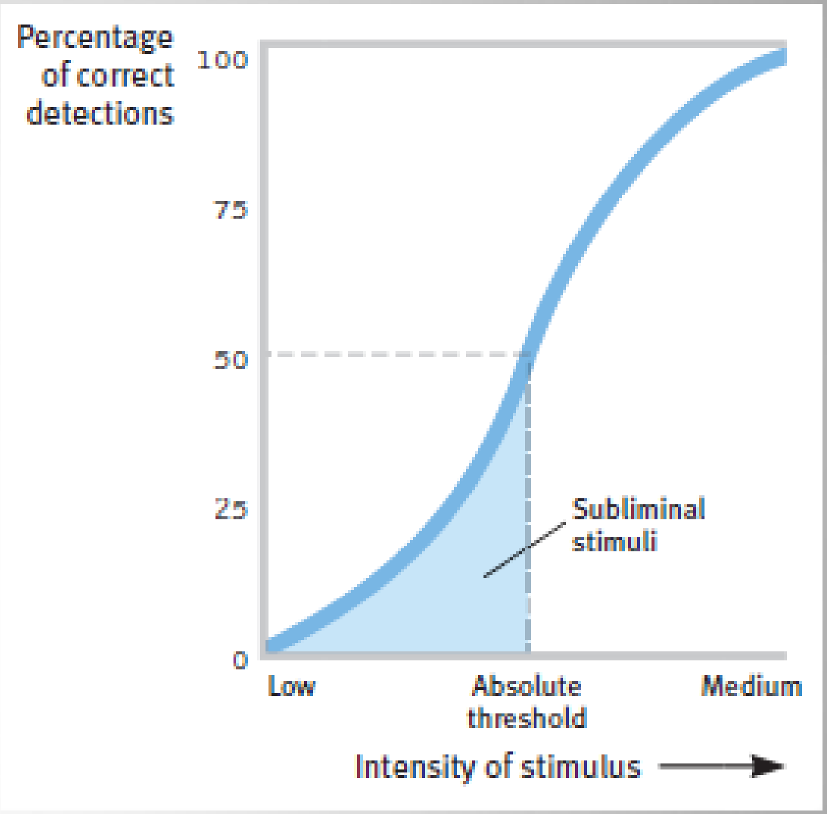
How do we study sensation?

Psychophysics: A study of the relationship between physical characteristics of stimuli and our psychological experience with them.

Physical World	Psychological World
Light	Brightness
Sound	Volume
Pressure	Weight
Sugar	Sweet

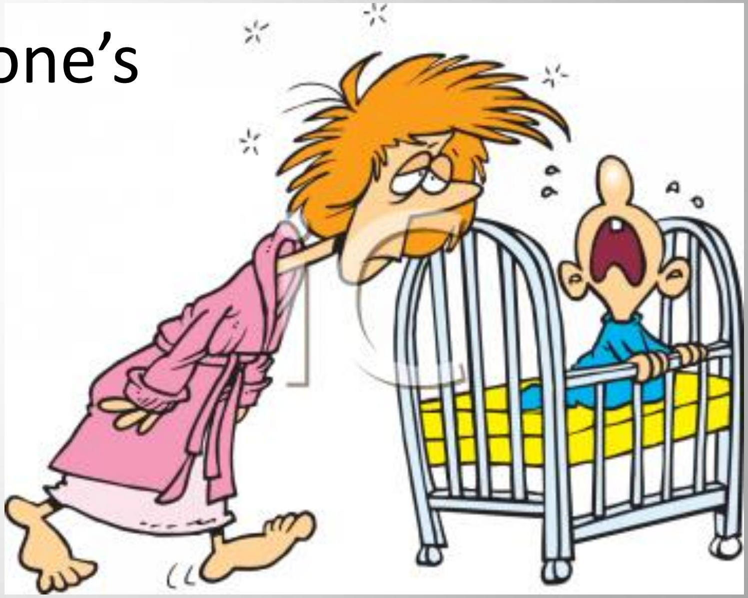
Thresholds

Absolute threshold - the minimum level of stimulus intensity needed to detect a stimulus 50% of the time.



Signal Detection Theory

- Predicts how and when we detect the presence of a faint stimulus (signal) amid background stimulation (noise)
- Assumes that there is no single absolute threshold for everyone
- Detection depends partly on one's
  - experience
  - expectations
  - motivation
  - level of fatigue



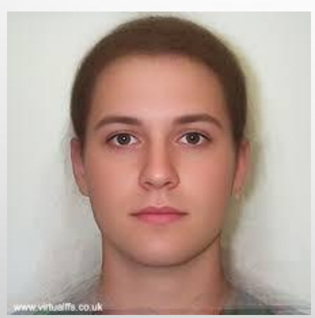
Subliminal Stimulation

- **Subliminal** – below one's absolute threshold for conscious awareness
  - Ex. Theaters flashing "eat popcorn" during a film
- Subliminal stimulation assumes we can sense things below the threshold
- We can process information without being aware of it, but we are not always manipulated or persuaded by it.

Priming

The activation, often unconsciously, of certain associations, thus predisposing one's perception, memory, or response.

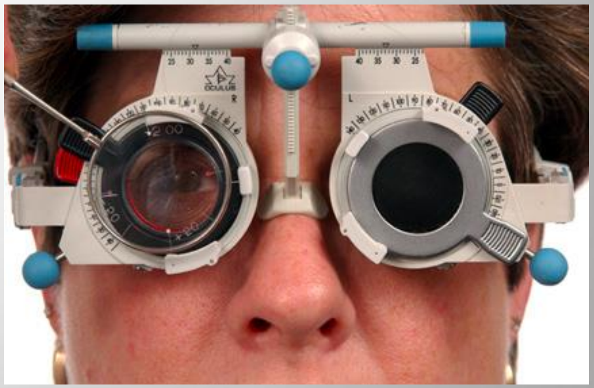
- Sometimes we can be manipulated or persuaded by priming
- Use a *masking stimulus*
- **Experiment:** positive or negative scenes flashed (priming), then shown regular slides of neutral people or faces (the masking stimulus), people rated the pictures positive or negative based on the priming flashed scenes



Difference Threshold

- At what point do we notice the difference between two similar stimuli? *(sounds, textures, tastes, smells, etc.)*
- **Difference threshold** – the minimum difference between any two stimuli required for detection.
- We experience the difference threshold as a ***just noticeable difference (JND) -*** the minimum difference between two stimuli required for detection 50% of the time

No No Yes

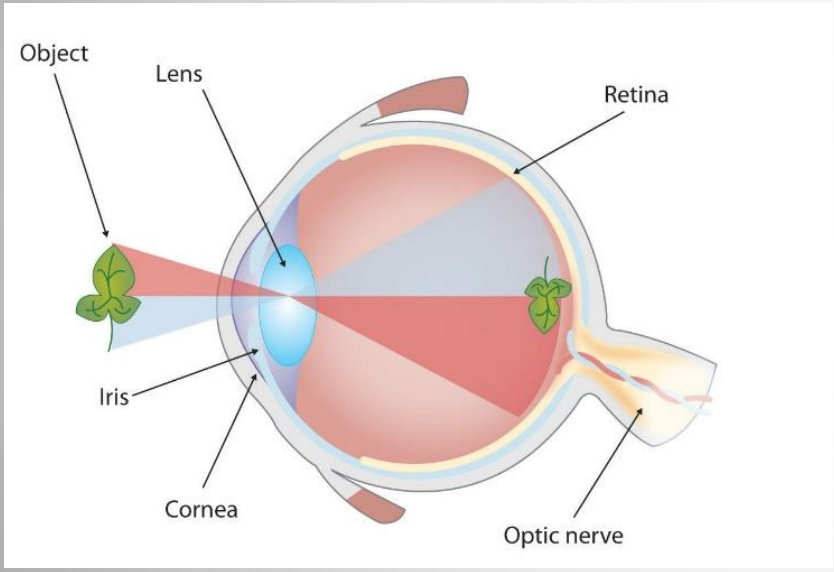


Difference Thresholds (JND)

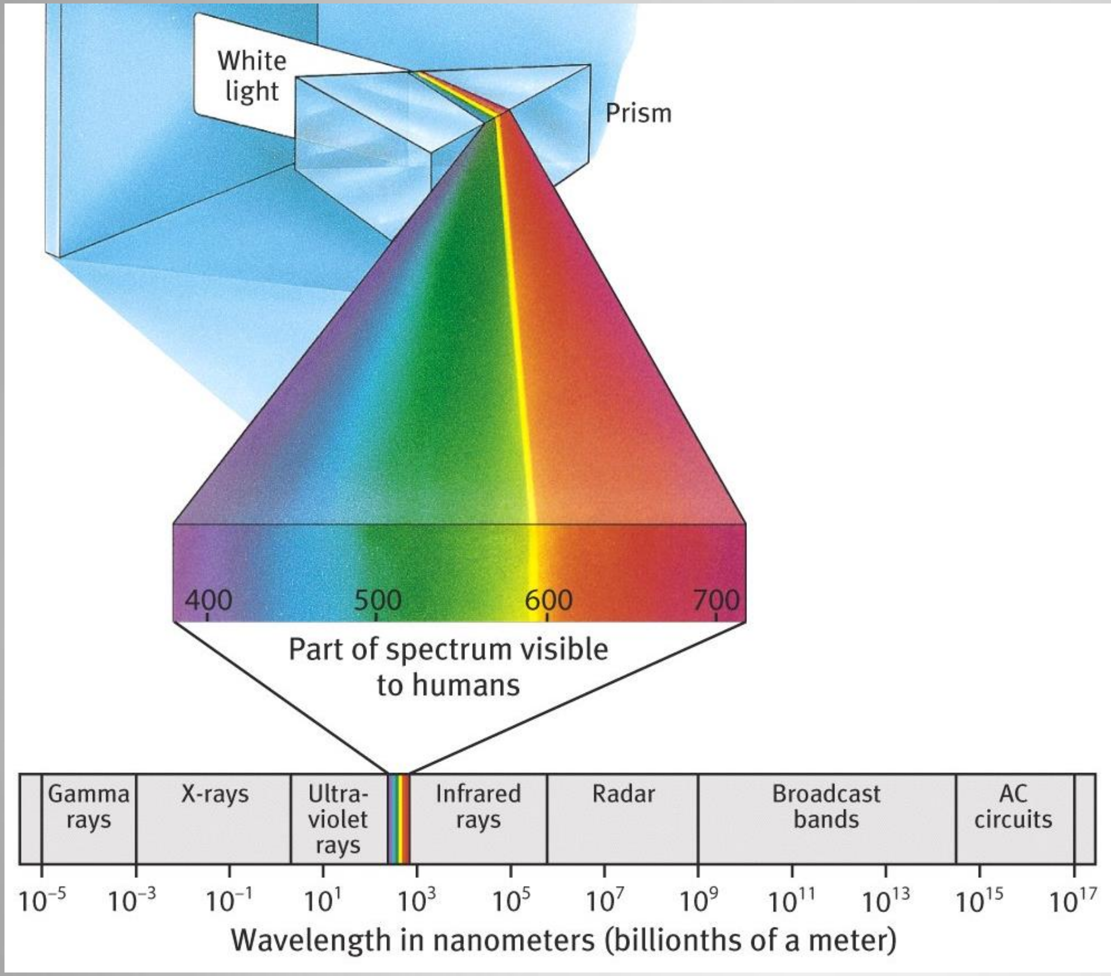
- **Weber's Law** - the principle that, to be perceived as different, two stimuli must differ by a constant percentage/ proportion (rather than a constant amount).
  - Our threshold for detecting differences are a roughly constant proportion of the size of the original stimuls.

Stimulus	Constant (k)
Light	8%
Weight	2%
Tone	0.3%

Vision



Vision



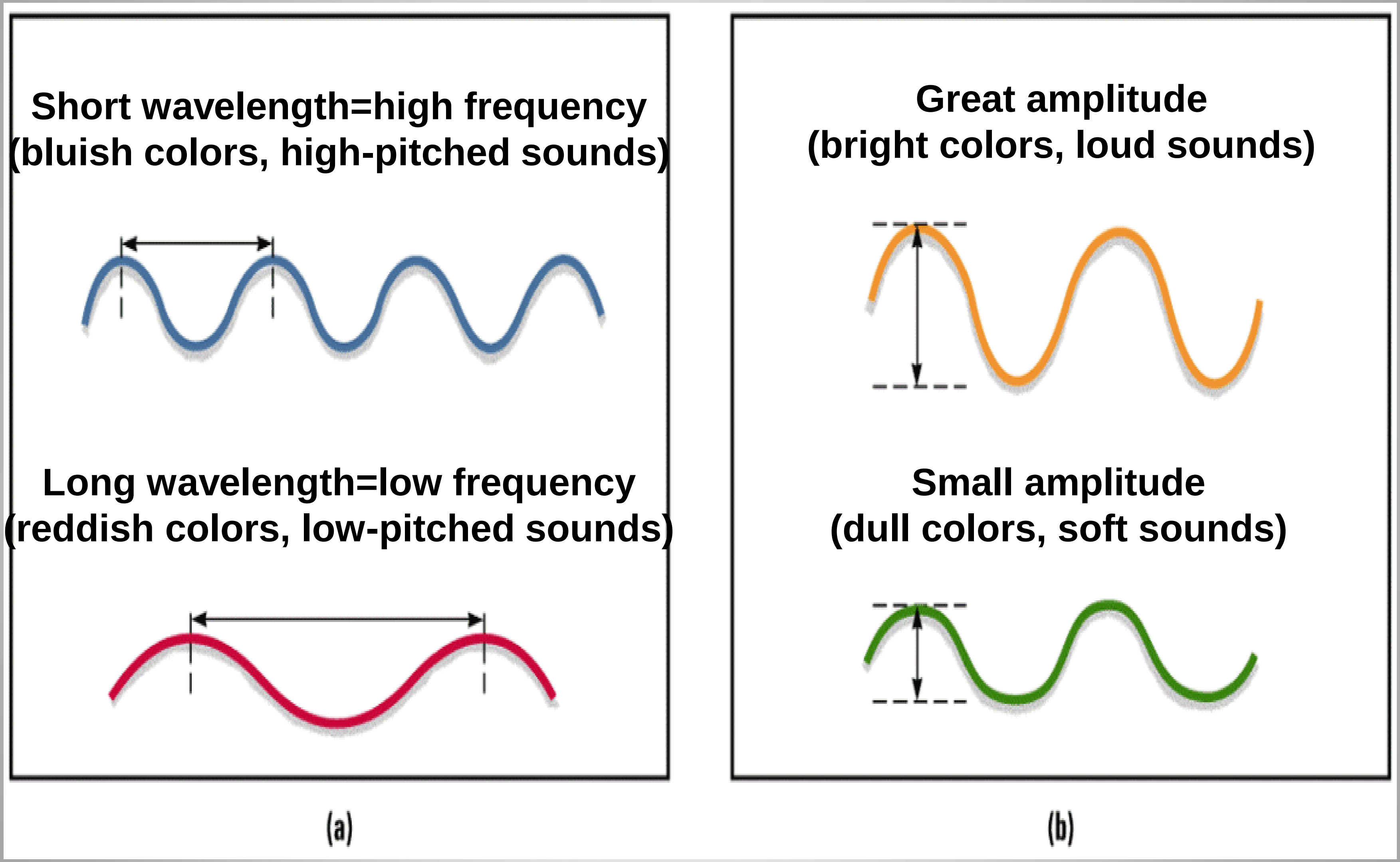
- We encounter waves of electromagnetic radiation.
- Our eyes respond to some of these waves.
- Our brain turns these energy wave sensations into colors.

Vision

Transduction – process by which our senses encode stimulus energy as neural

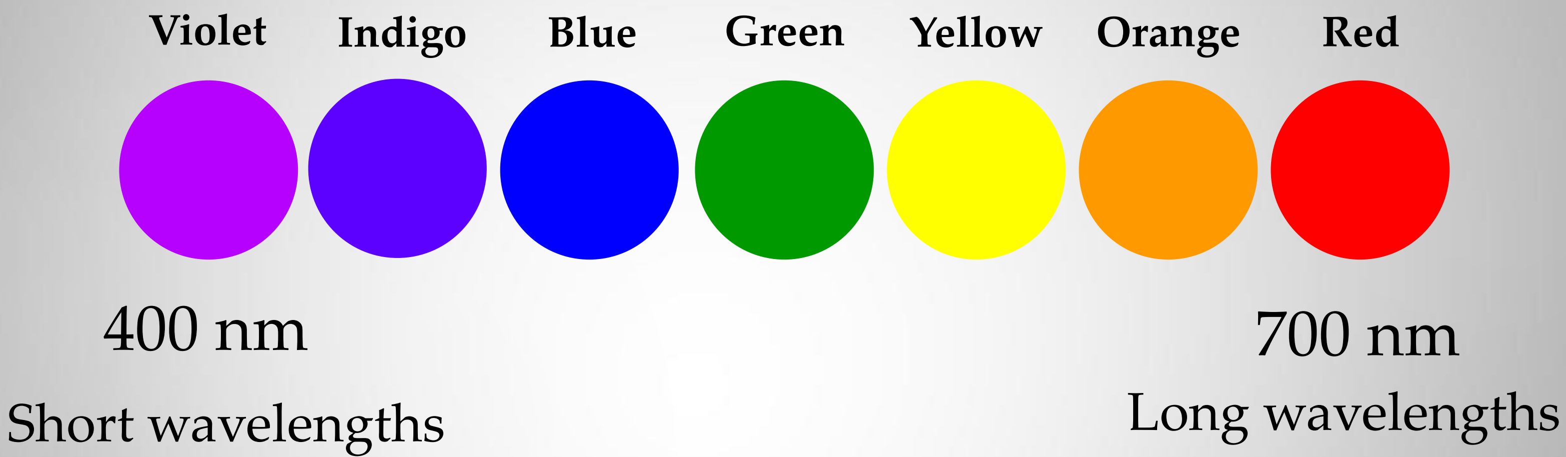
- **Physical characteristics of light** –
  - **Wavelength** - The distance from the peak of one wave to the peak of the next (determines the ***hue*** or color we experience)
  - **Intensity** – The amount of energy in light waves (determined by a wave's *amplitude* or height) – influences brightness

Vision - Physical Properties of Waves

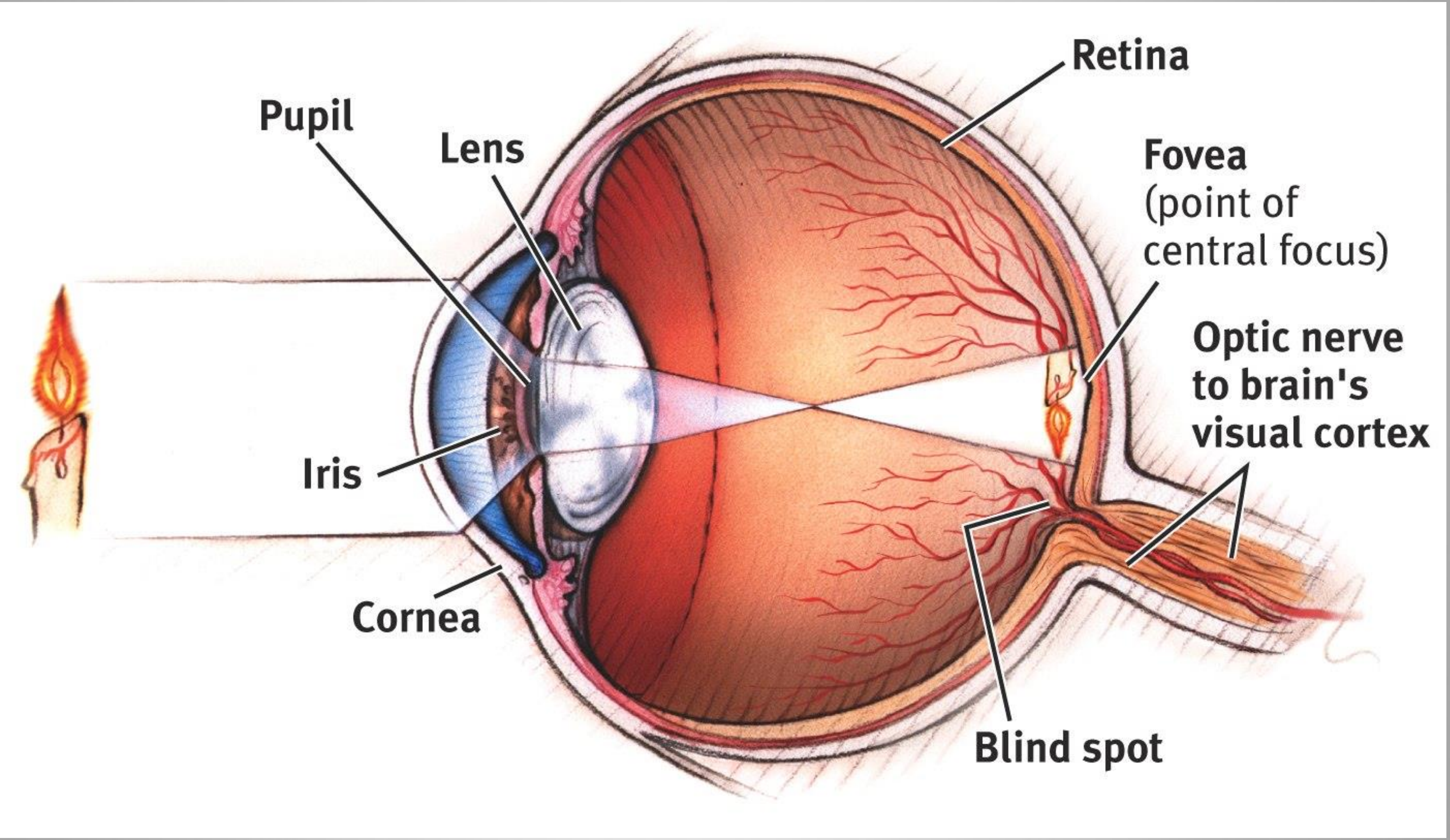


Wavelength (Hue)

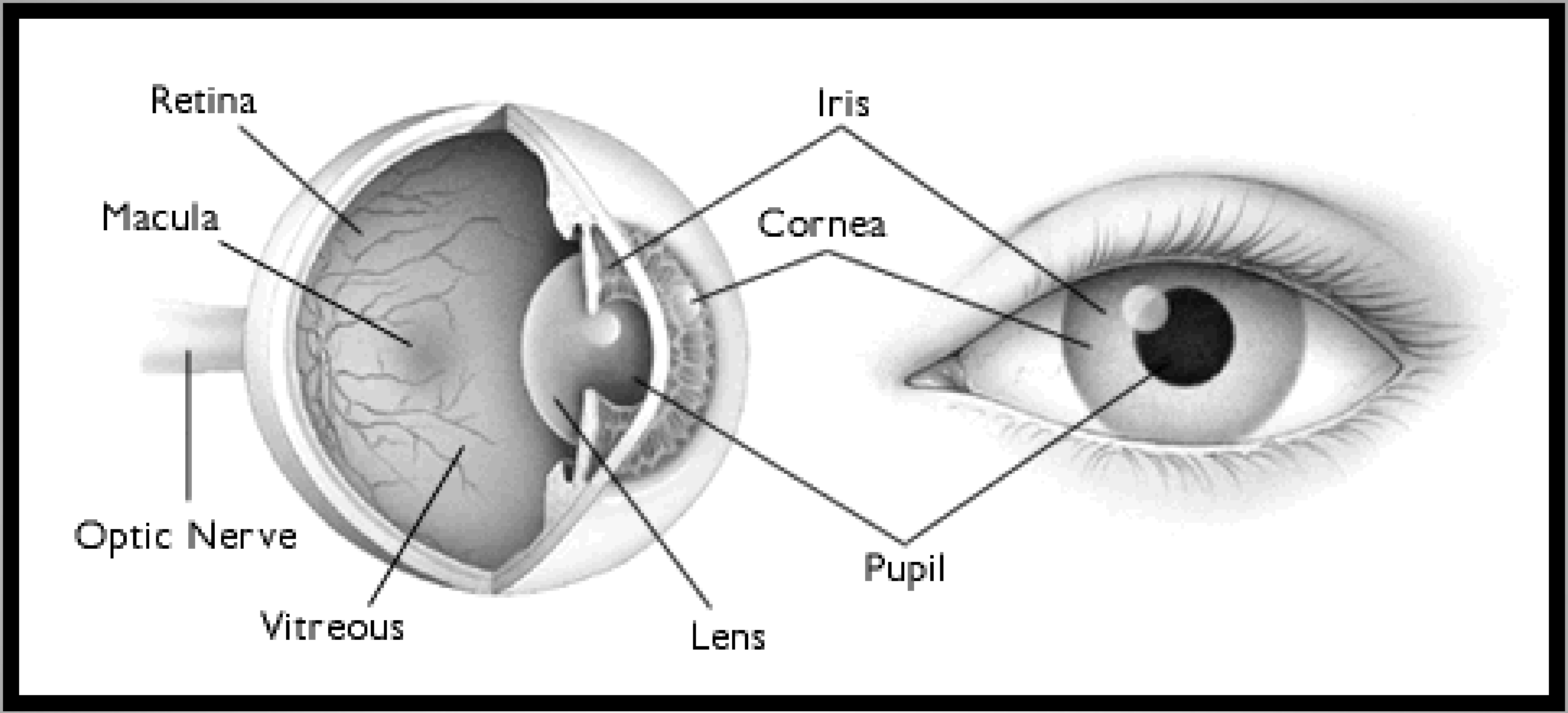
Different wavelengths of light result in different colors.



Structure of the Eye



Structure of the Eye



Structure of the Eye

Cornea: Transparent tissue that protects the eye & bends light to provide focus; light enters the eye here

Pupil: Small adjustable opening in the center of the eye through with light passes

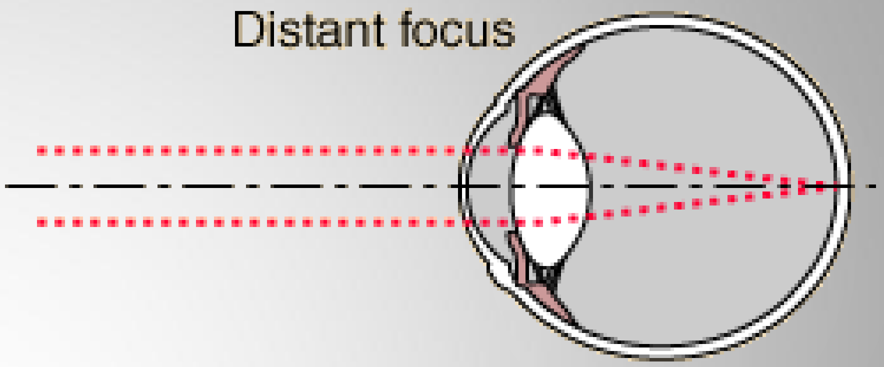
Iris: Muscle that expands and contracts to change the size of the opening (pupil) for light

Lens: Focuses the incoming light rays on the retina

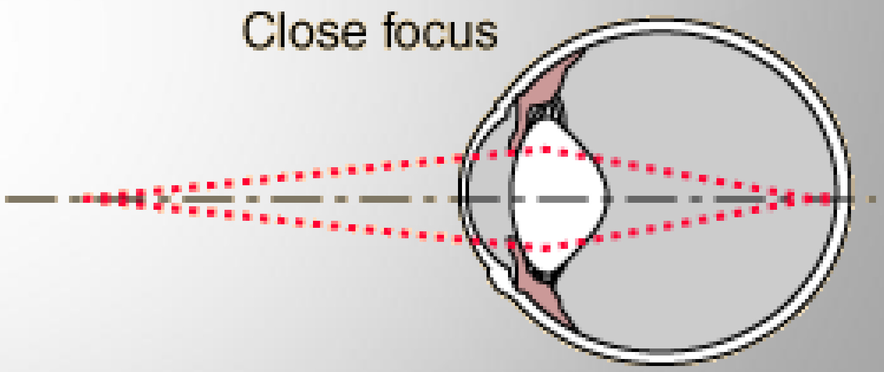
Retina: Contains receptor rods & cones that begin processing visual information and sends it to the brain

Structure of the Eye – The Lens

Lens: Transparent structure behind the pupil that changes shape to focus images on the retina.



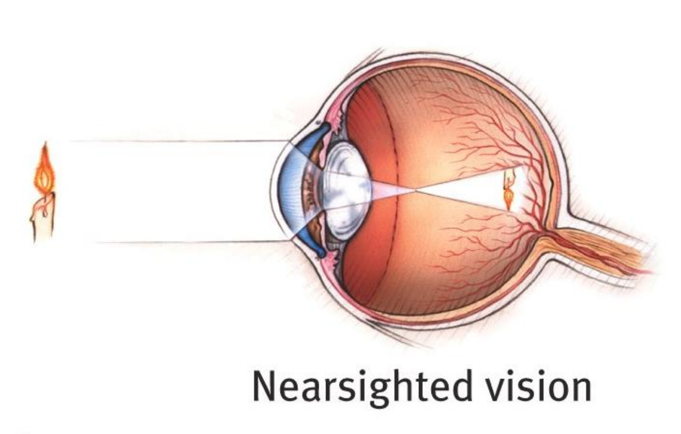
Accommodation: The process by which the eye's lens changes shape to help focus near or far objects on the retina.



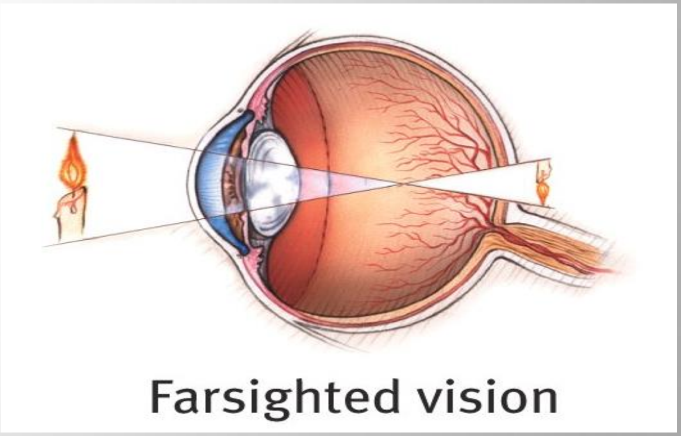
Structure of the Eye - The Lens

Acuity – refers to the sharpness of vision

Nearsightedness: condition in which nearby objects are seen more clearly than distant objects.

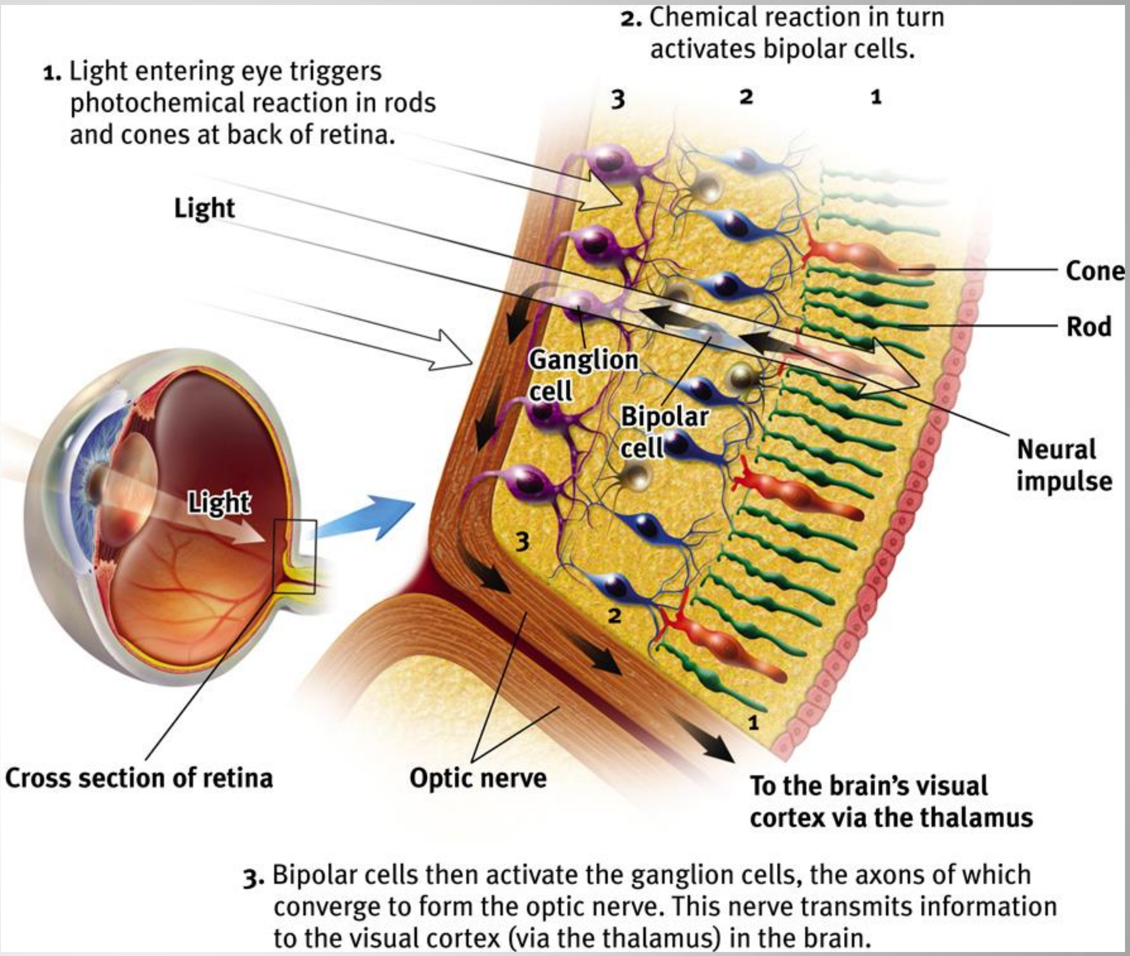


Farsightedness: condition in which faraway objects are seen more clearly than near objects.



Structure of the Eye – The Retina

- The light-sensitive inner surface of the eye
- Contains receptor rods and cones, in addition to layers of other neurons (bipolar & ganglion cells) that process visual information.



Structure of the Eye – The Retina

Rods

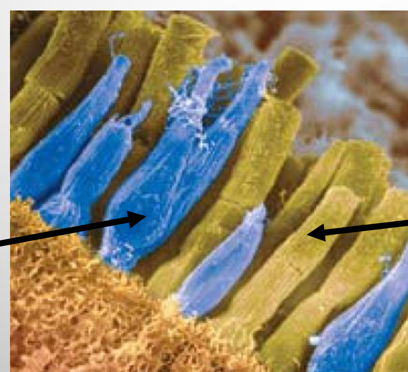
- peripheral retina
- detect black, white and gray
- twilight or low light

Cones

- near center of retina
- fine detail and color vision
- daylight or well-lit conditions

RECEPTORS IN THE HUMAN EYE

	Cones	Rods
Number	6 million	120 million
Location in retina	Center	Periphery
Sensitivity in dim light	Low	High
Color sensitive?	Yes	No
Detail sensitive?	Yes	No



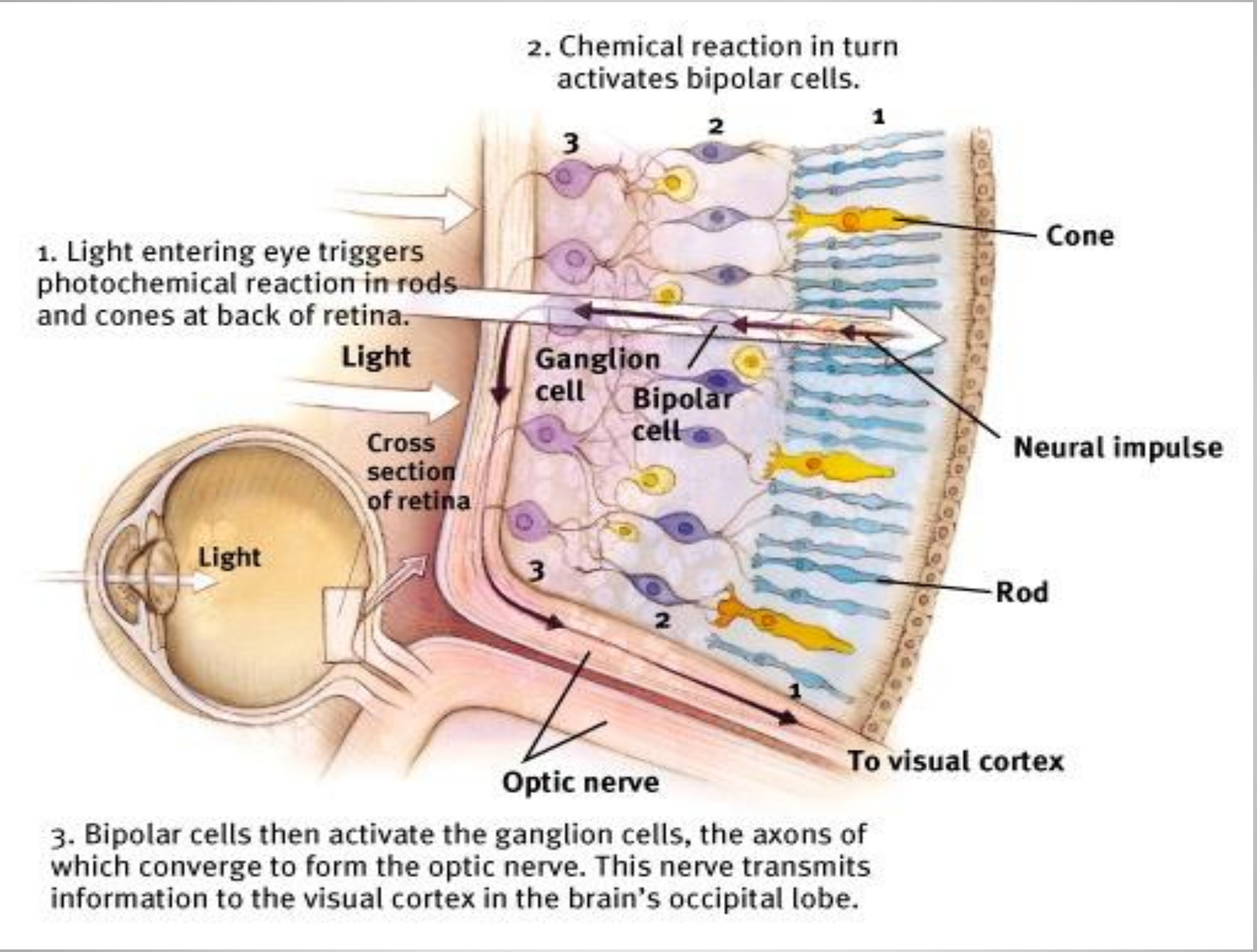
Rods

Cones

Structure of the Eye – The Retina

- **Bipolar cells** receive messages from photoreceptors and transmit them to ganglion cells
- **Ganglion cells -** converge to form the optic nerve (in terms of order, think PBG…like a PBJ ☺
- **Optic nerve** - carries neural impulses from the eye to the brain
- **Blind Spot** - point at which the optic nerve leaves the eye, creating a "blind spot" because there are no receptor cells located there
- **Fovea** - central point in the retina, around which the eye's cones cluster

The Retina's Reaction to Light

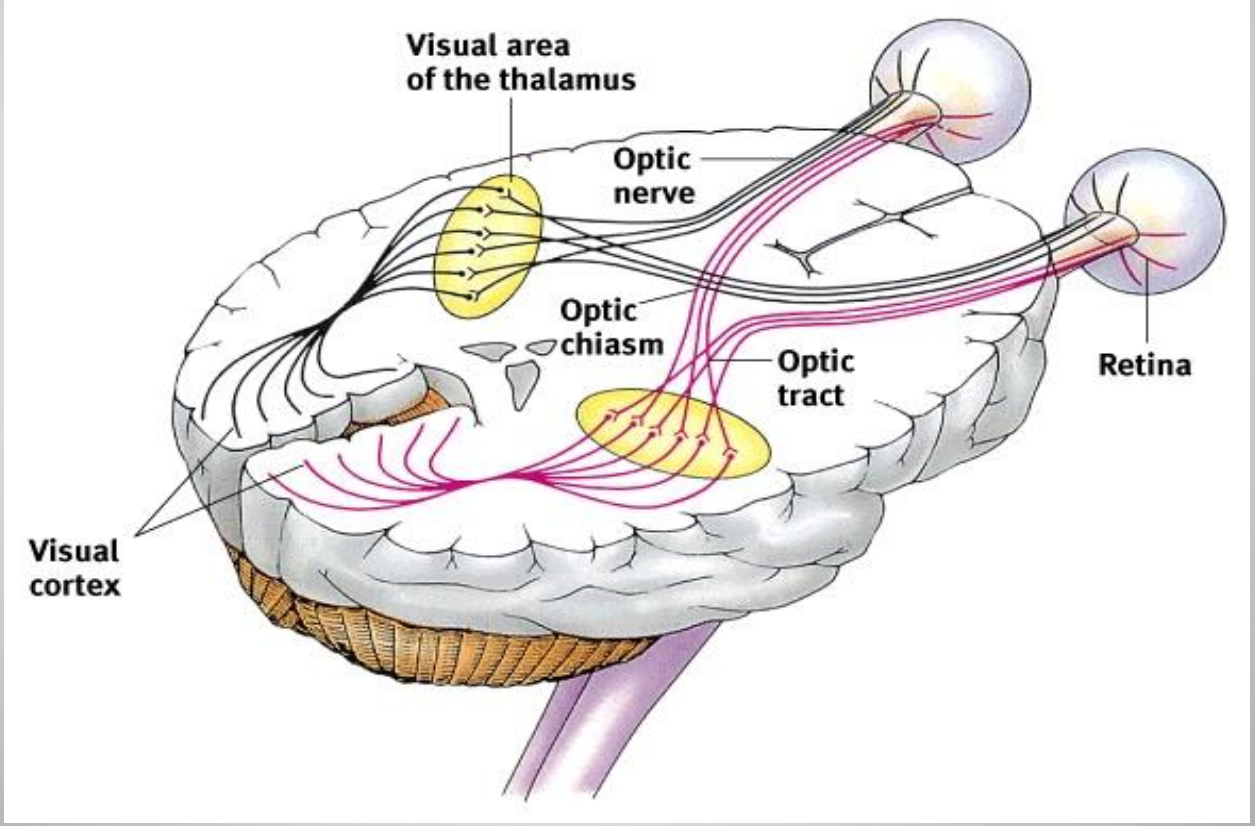


Test Your Blind spot

Use your textbook page 207. Close your left eye, and fixate your right eye on the black dot. Move the page to a distance of about a foot from your face. At some point the car on the right will disappear due to a blind spot.

Pathway to the Visual Cortex

Optic nerves connect to the **thalamus** in the middle of the brain, and the thalamus connects to the **visual cortex**.



How the Human Eye Sees

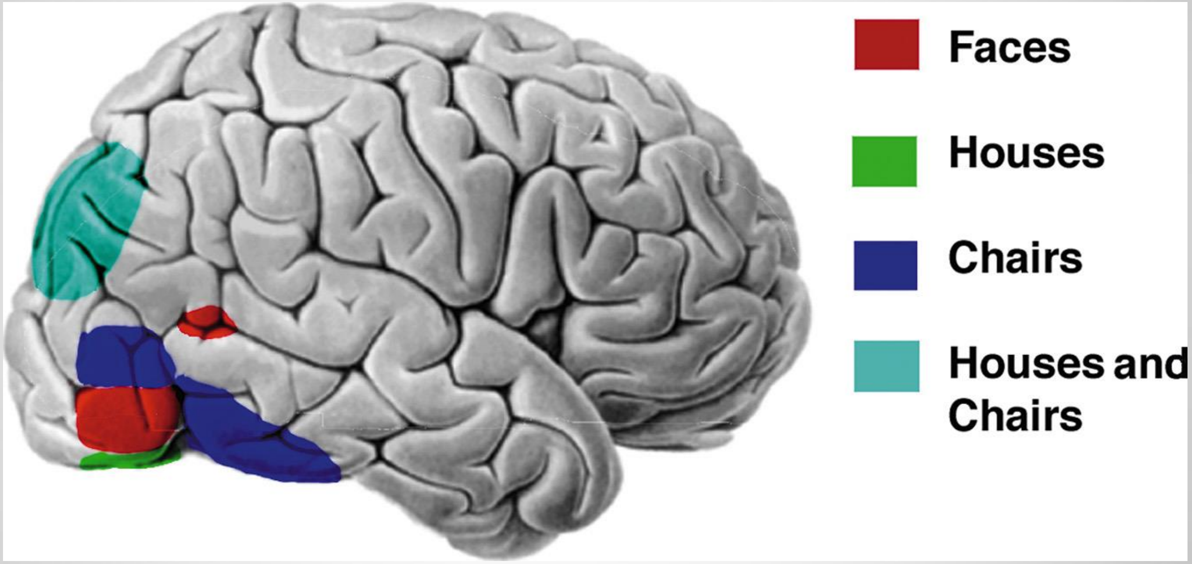
- Light waves pass through the _________, _________ and ____________
- The___________ controls the amount of light entering the eye by controlling the size of the pupil.
- The ________ changes shape or _________________ to focus the incoming light onto the ____________.
- As the light strikes the _______________, the light energy activates the _________ and _________, the central area where the _______and _________ cluster is the __________.
- Signals from the__________ and __________ and collected by the ______________, which transmit the information to ______________. The __________________ axons are bundled together to form the ________________, which transmits information to the _________________ and then ___________________in the brain.
- The _______________ leaves the eye, creating a "____________" because no receptor cells are located there.

How the Human Eye Sees

- Light waves pass through the __lens__, __cornea__ and __pupil__
- The__iris__ controls the amount of light entering the eye by controlling the size of the pupil.
- The __lens__ changes shape or __accommodates__ to focus the incoming light onto the __retina__.
- As the light strikes the __retina__, the light energy activates the __rods__ and __cones__, the central area where the __rods__and __cones__ cluster is the __fovea__.
- Signals from the__rods__ and __cones__ and collected by the __bipolar cells__, which transmit the information to __ganglion cells__. The __ganglion cells__ axons are bundled together to form the __optic nerve__, which transmits information to the __thalamus__ and then __visual cortex__in the brain.
- The ______________ leaves the eye, creating a "__blind spot__" because no receptor cells are located there.

Visual Information Processing

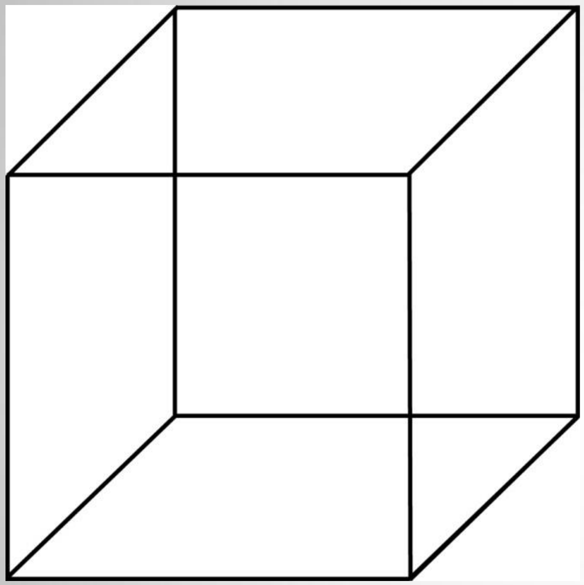
Feature Detectors – specialized neurons in the visual cortex that react to the strength of visual stimuli, responding to shapes, angles, edges, lines and movement in our field of vision.

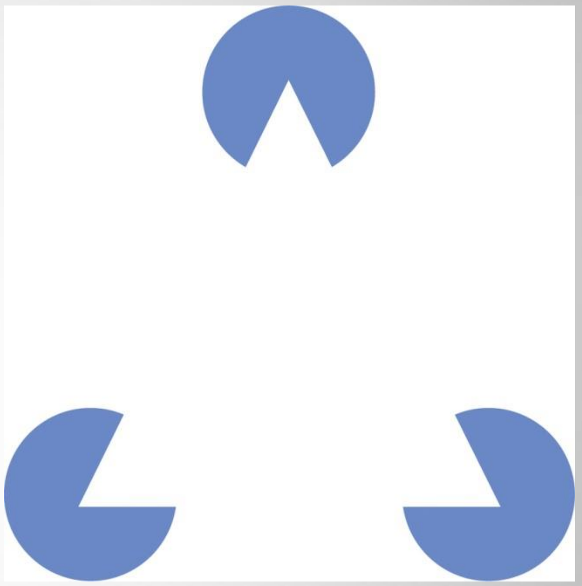


Specific combinations of temporal lobe activity occur as people look at shoes, faces, chairs and houses.

Perception in the Brain

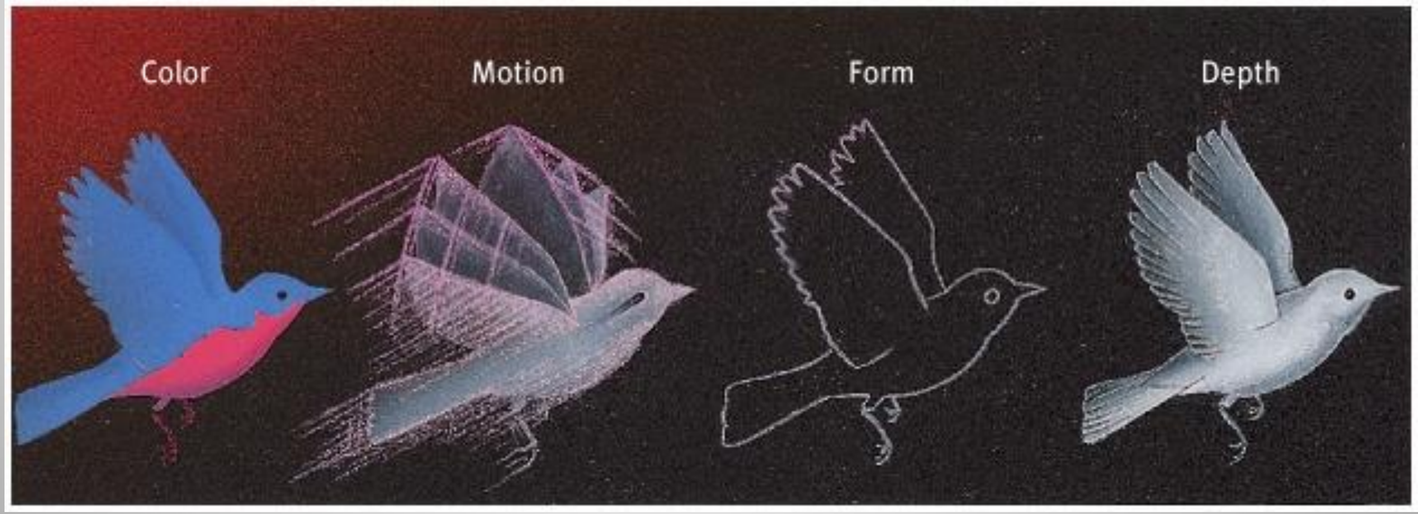
Our perceptions are a combination of sensory (bottom-up) and cognitive (top-down) processes.



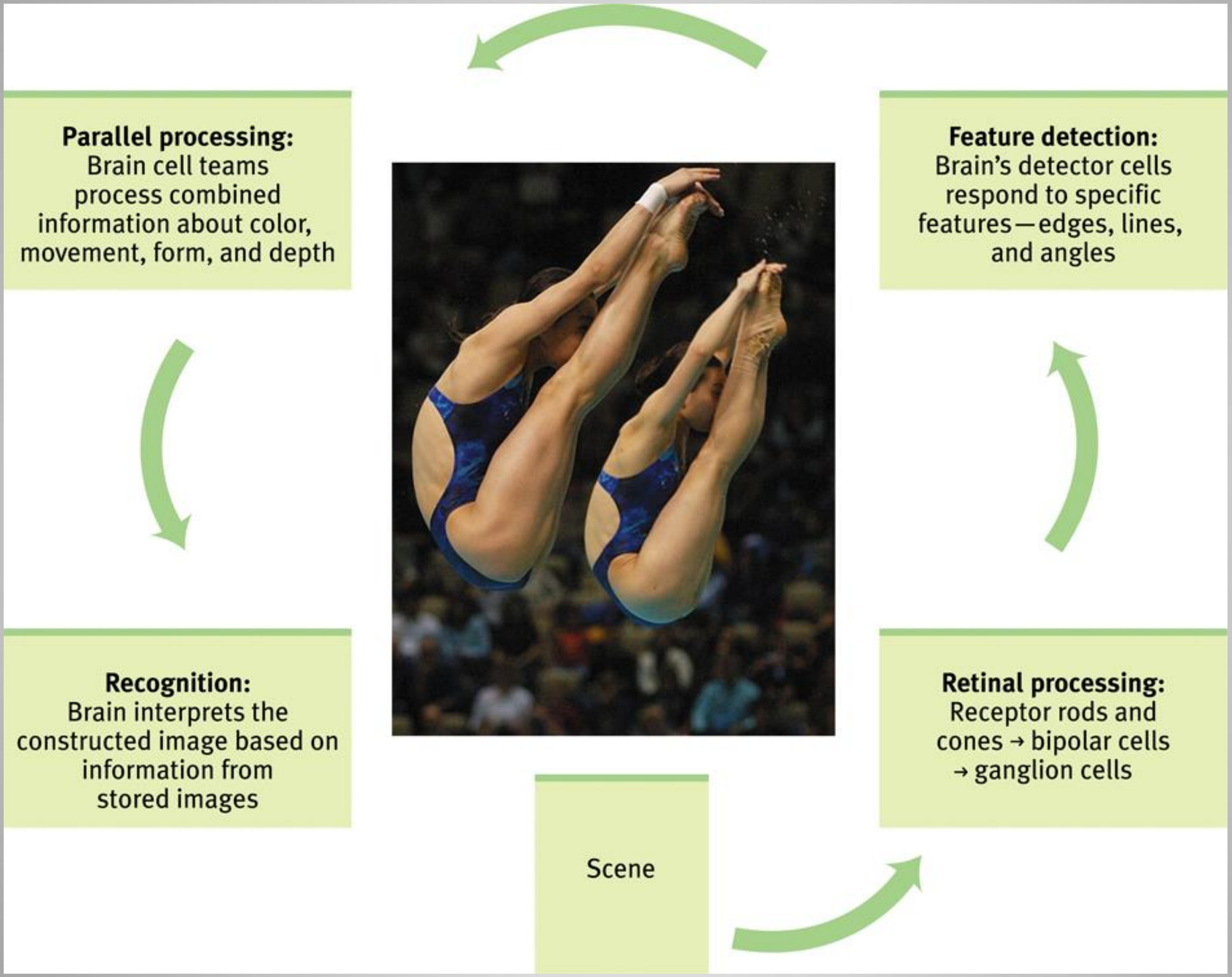


Parallel Processing

- The processing of many aspects of a problem simultaneously
- The brain delegates the work of processing color, motion, form, & depth to different areas and then constructs our perceptions by integrating these together



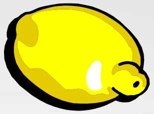
From Sensation to Recognition



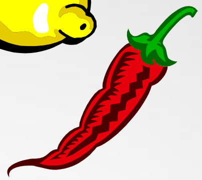
Color Vision

Do objects possess color?

- Is a lemon yellow?



- Is a chili pepper red?



- Color is a mental construction. Wavelengths don’t have color; our brain constructs the color.
- We can discriminate some 7 million different color variations.
- 1 person in 50 is color-deficient – usually male.

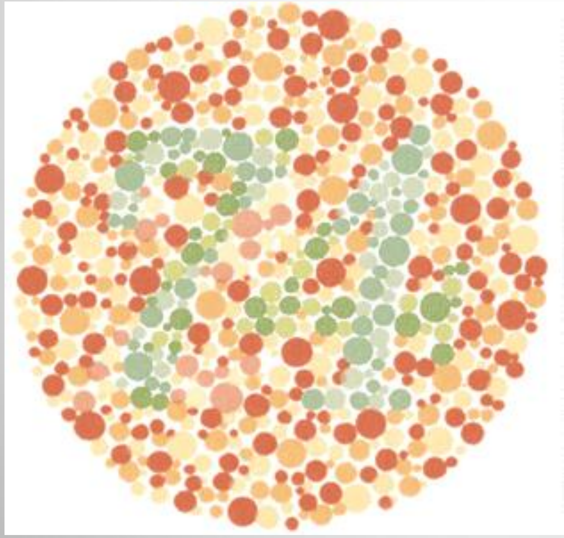
Color Vision

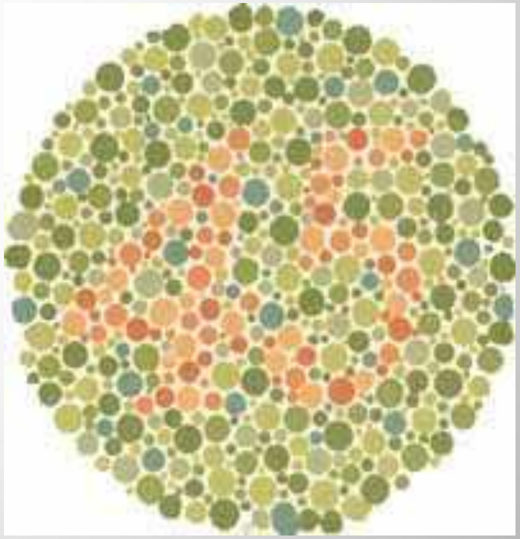
Young-Helmholtz Trichromatic (Three-Color) Theory

According to this theory, there are three ***types*** of color receptor cones – red, green, and blue. All the colors we perceive are created by light waves stimulating combinations of these cones.

Color Blindness

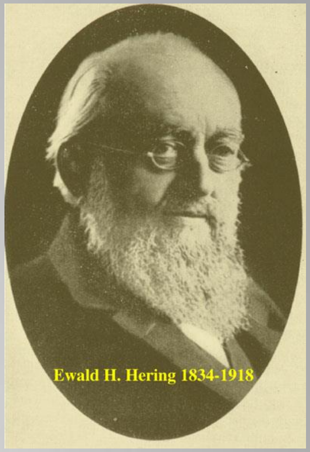
- Genetic disorder in which people are blind to green or red colors. This supports the Trichromatic theory.
- Monochromatic vision, dichromatic vision – deficiency in nubmer of cones, don't see all 3 colors, (true name for being "colorblind")
- Guys are more often color blind





Opponent-Process Theory

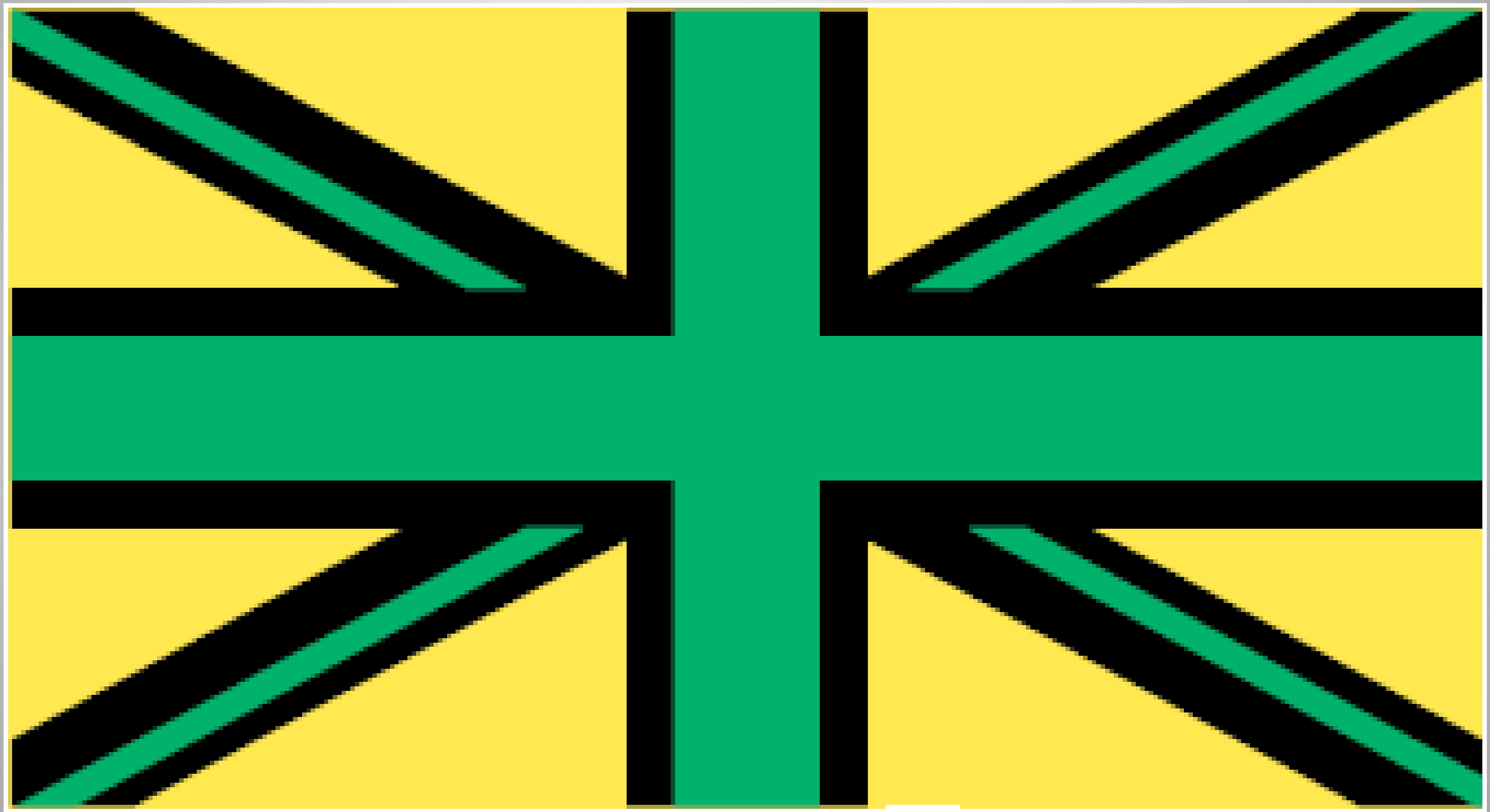
- Why doesn't mixing red and green paint make yellow?
    - It seems like more of a pure color, unlike purple which seems like a mix of blue and red?
- E. Hering – Felt there must be additional color processes at work
- **Opponent Process Theory -** opposing retinal processes (red-green, yellow-blue, white-black) enable color vision.
    - For example, some cells are stimulated by green and inhibited by red; others are stimulated by red and inhibited by green.



Opponent Colors

Stare at the middle of this flag for about 30 seconds.

Then quickly go to the next slide and stare at the dot. Do you see Britain's flag?



Opponent-Process Theory

- Opponent processes explain afterimages, such as in the flag demonstration.
- After tiring your neural responses to black, green, & yellow, you should see their opponent colors.

"ON"	"OFF"
red	green
green	red
blue	yellow
yellow	blue
black	white
white	black

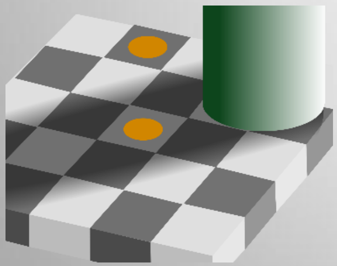
Color Vision

The present solution to color vision is that it occurs in two stages:

- Young-Helmholtz trichromatic (three color) theory – the retina's red, green, and blue cones respond in varying degrees to different color stimuli
- Their signals are then processed by the nervous system's opponent process cells en route to the visual cortex.

Visual Information Processing

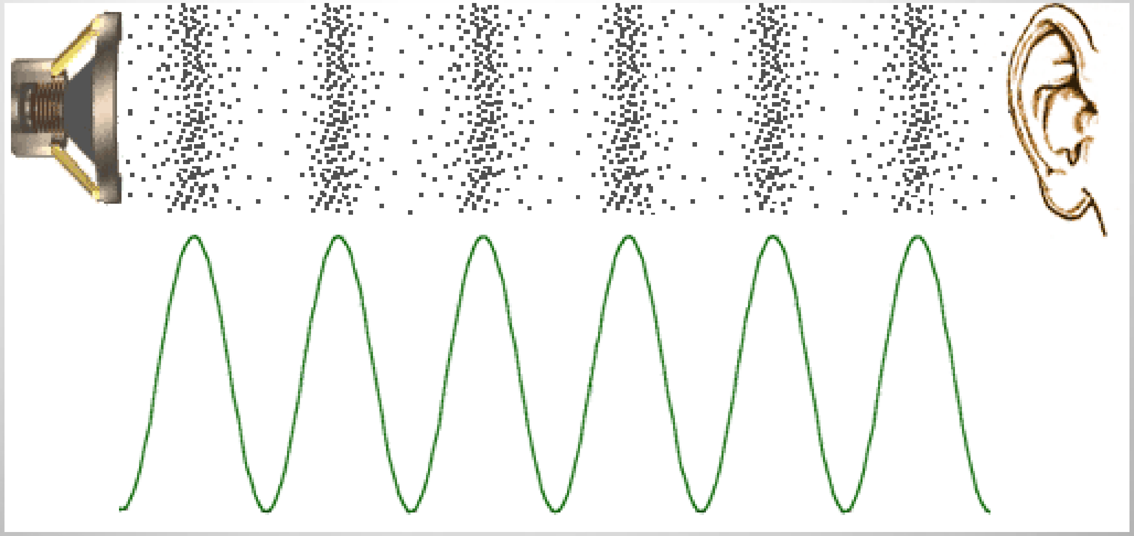
- Our experience of color also depends on the surrounding context
- Color Constancy - Perceiving familiar objects as having consistent color, even if changing illumination alters the wavelengths reflected by the object



Hearing

Hearing

- **Audition** – the sense or act of hearing
- All sound travels in waves. Sound waves are like jostling molecules of air, each bumping into the next, like a shove of a line, ripples in a pond.
- These waves consist of compressing and expanding air molecules. Our ears detect these air pressure changes.
- Vibrating air is changed into neural impulses

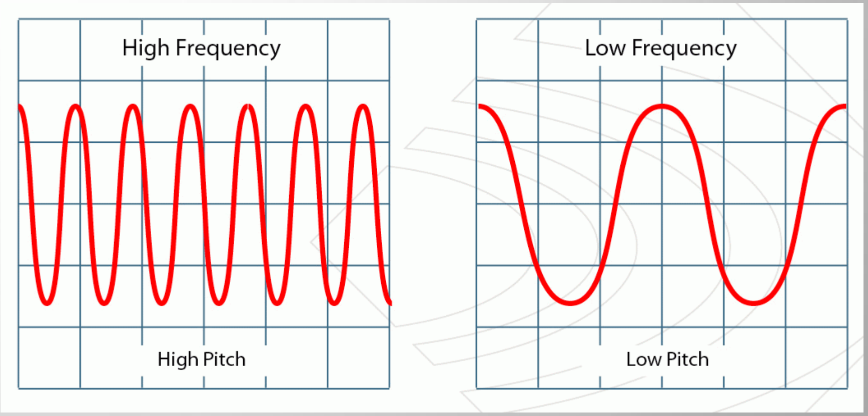


Sound Waves

- Our hearing is highly adaptable. We can hear a wide range of sounds.
- We are very sensitive to faint sounds and differences in sounds.
- **Amplitude** – refers to the strength of the sound waves; loudness is determined by the size of amplitude

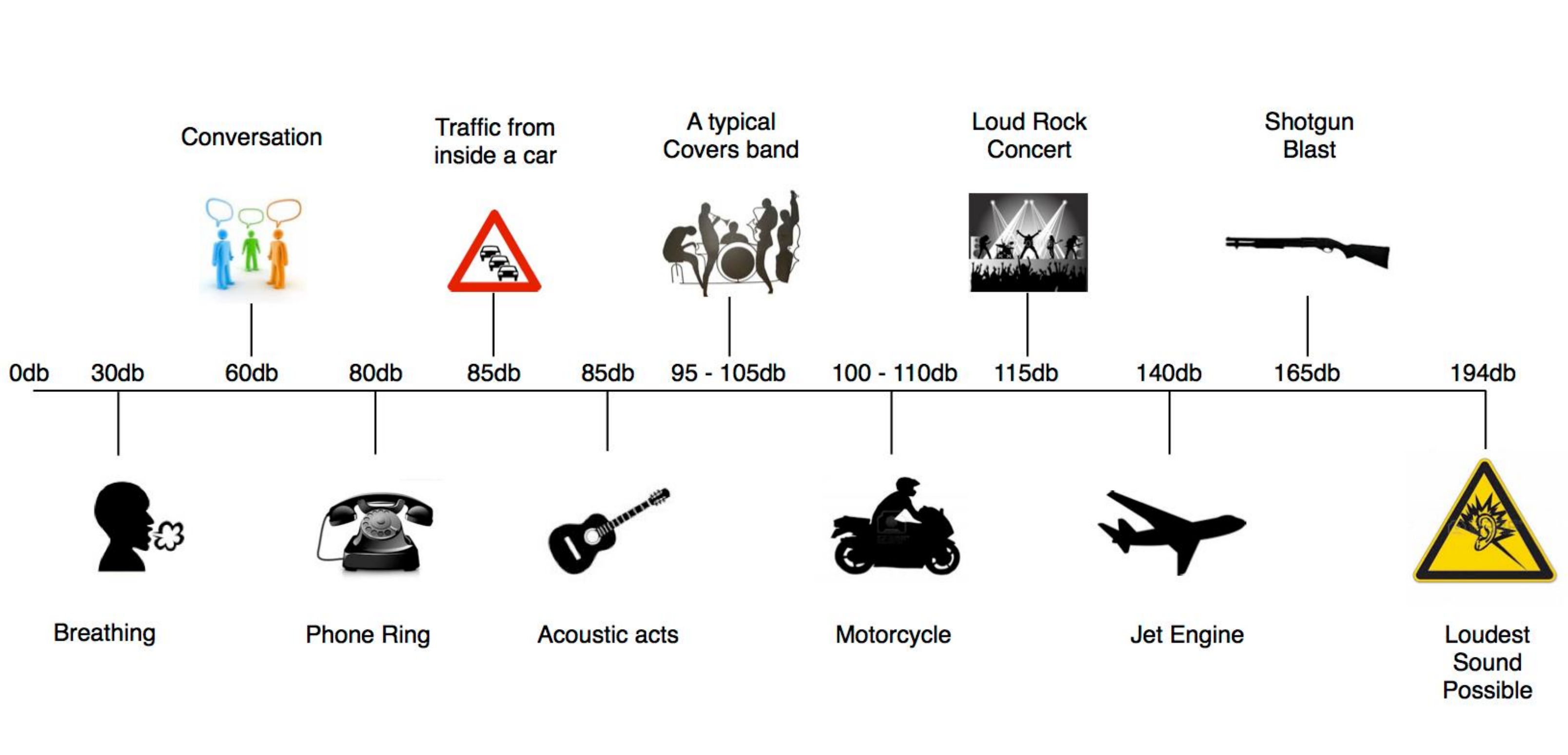
Sound Waves

- **Frequency** - the number of complete wavelengths that pass a point in a given time (i.e. per second).
  - *Older people tend to hear low frequencies well but suffer hearing loss for high frequencies*
- **Wavelength** – The distance from the peak of one wave to the peak of the next.
  - **Long waves** – low frequency & low pitch
  - **Short waves** – high frequency & high pitch
- **Pitch** - a tone's experienced highness or lowness; depends on frequency.



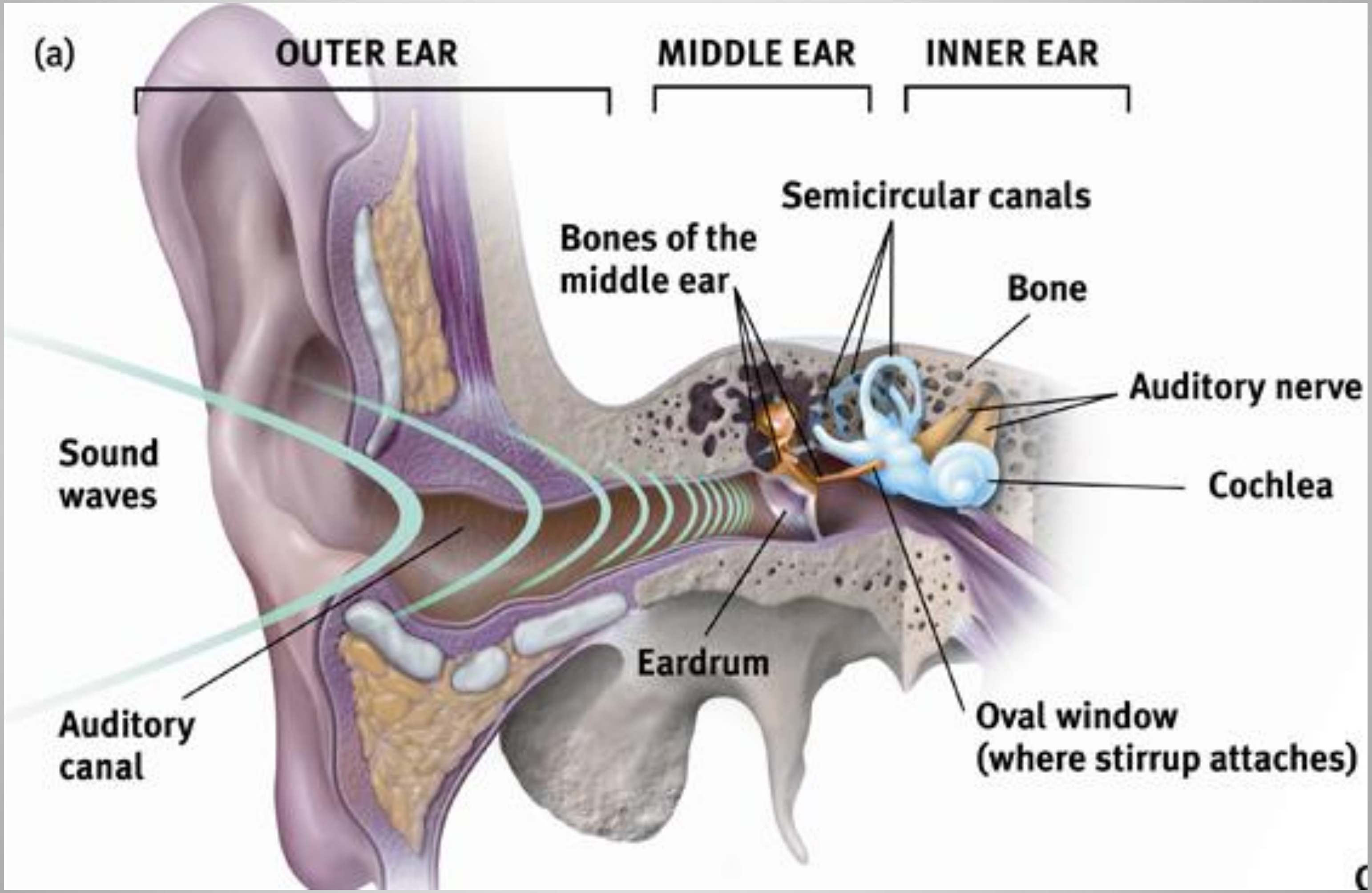
Sound Intensity

- **Decibels** – measuring unit for sound energy
- Every 10 decibels = tenfold increase in sound
- Prolonged exposure to sounds above 85 decibels can produce hearing loss.



Structure of the Ear

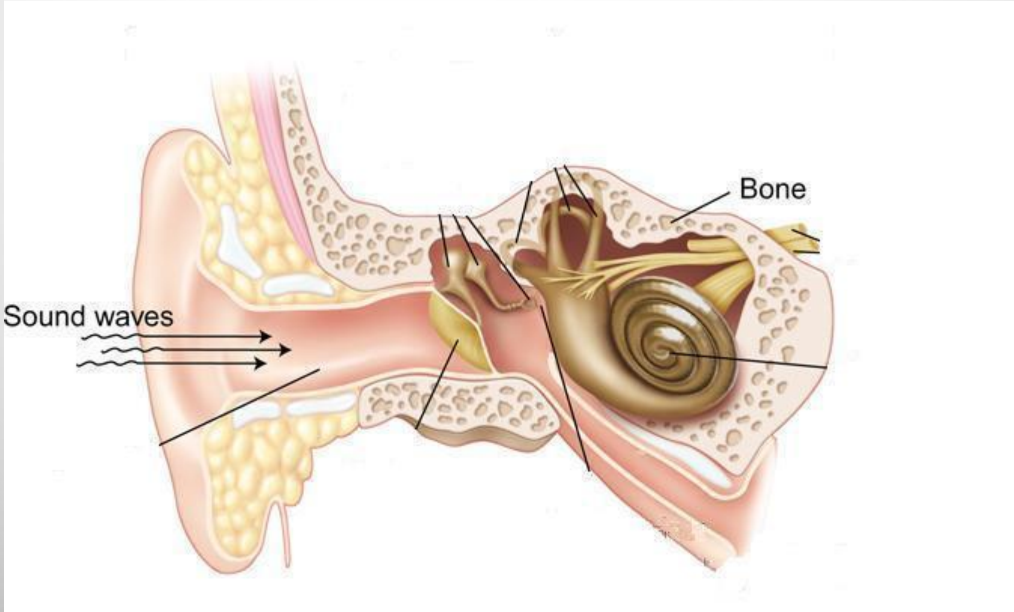
The ear is divided into the outer, middle and inner ear.



Structure of the Ear – Outer Ear

Outer Ear: Collects and sends sounds from the auditory canal to the eardrum that vibrates with the waves.

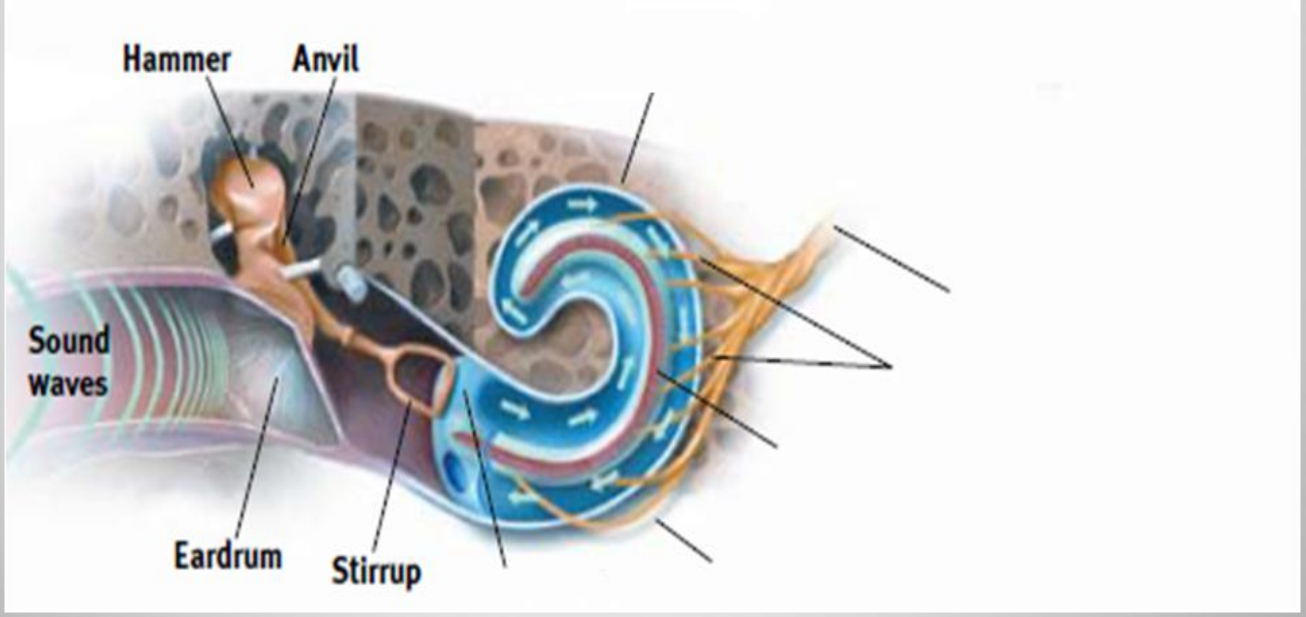
- **Auditory canal** - the opening through which sound waves travel as they move into the ear for processing; ends at the eardrum (tympanic membrane)
- **Eardrum** - The tissue barrier that transfers sound vibration from the air to the tine bones of the middle ear



Structure of the Ear – Middle Ear

Middle Ear: Chamber between eardrum and cochlea

Contains three tiny bones (hammer, anvil, stirrup) that act like a piston to transfer the vibrations of the eardrum to the cochlea's membrane (oval window)



Structure of the Ear – Inner Ear

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

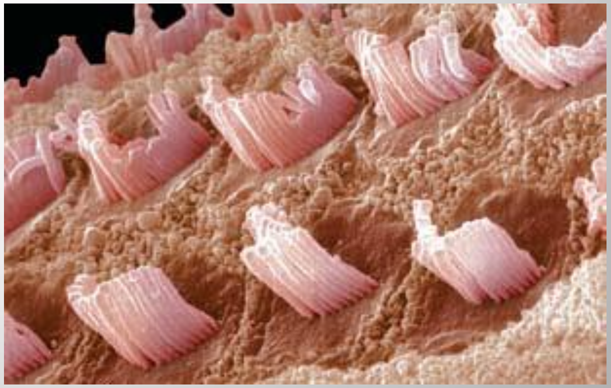
Oval window – cochlea's membrane, where the stirrup connects to the cochlea. This vibrates, which moves around the fluid in the cochlea

Cochlea – (looks like a snail) a coiled, bony, fluid-filled tube in the inner ear. Fluid vibrates causing the basilar membrane to ripple and the hair cells to bend

Structure of the Ear – Inner Ear

Hair cells (Cilia) – line the surface of the basilar membrane; each hair has a corresponding nerve cell which is triggered by movement

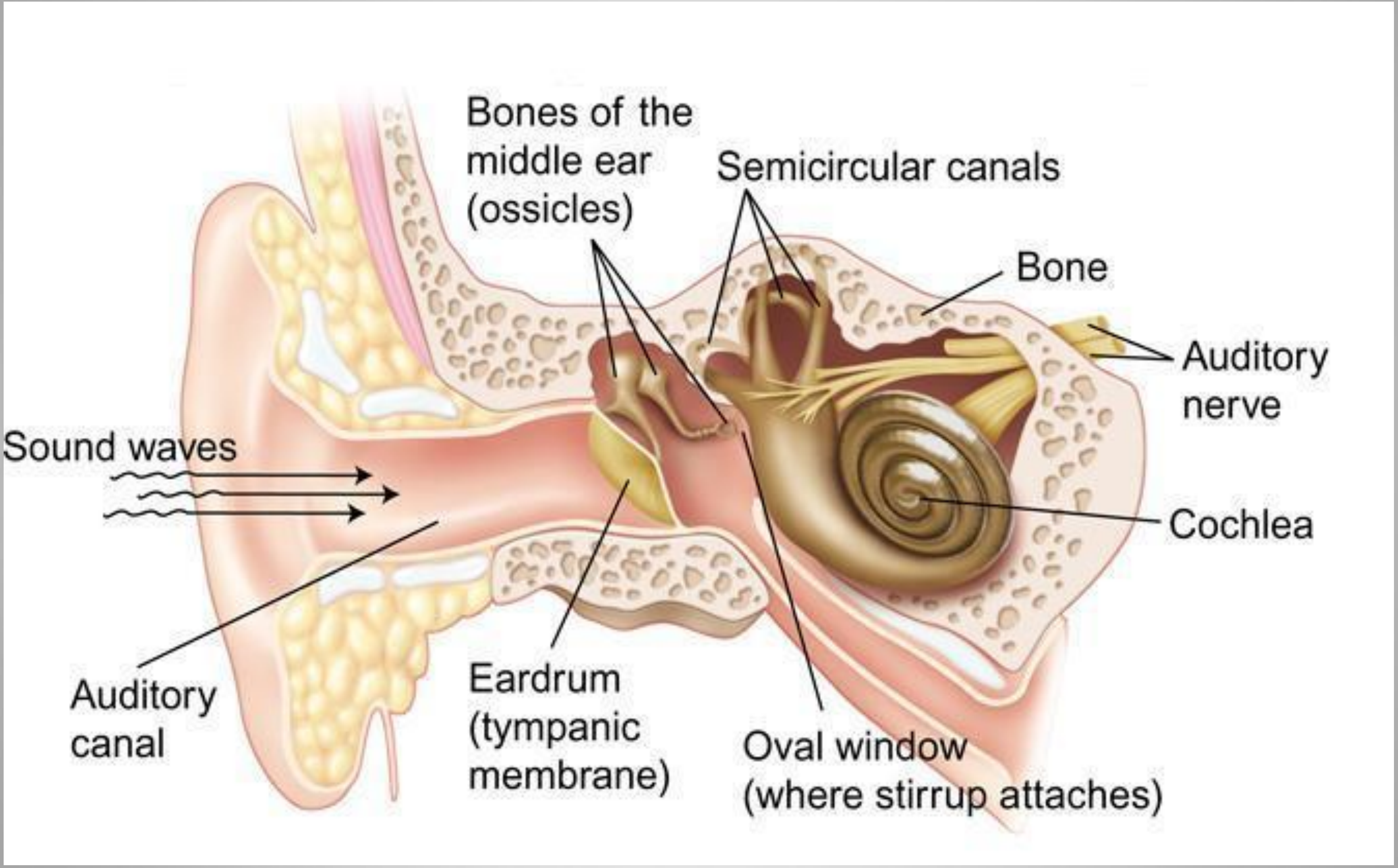
- The receptor cells for hearing (similar to the rods and cones in the eye)
- Responsible for changing sound vibrations into neural impulses
- Brain can interpret loudness from the number of activated hair cells
- Very delicate & fragile



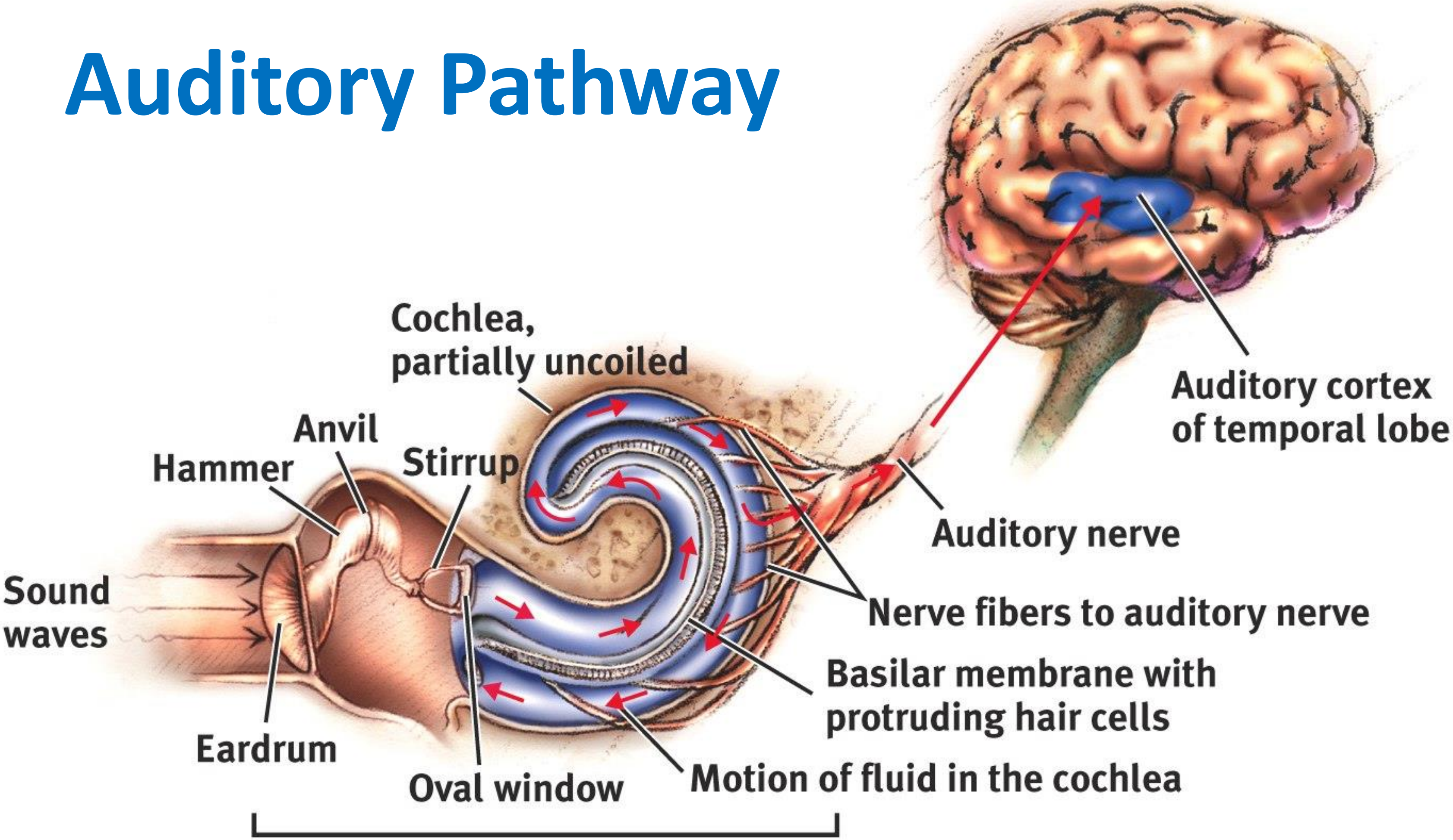
Structure of the Ear – Inner Ear

- **Semicircular Canals** - organs in the inner ear used in sensing body orientation and balance (vestibular sense)
  - Relies on fluid in the canals
  - Spinning in circles disrupts the fluid
- **Auditory Nerve** – the nerve that carries sound information from the ears to temporal lobe's auditory cortex

Structure of the Ear



Auditory Pathway



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

Perceiving Pitch

Place Theory - pitch is determined by the point of maximal vibration (place) on the cochlea's basilar membrane.

- Helps to explain how we hear HIGH-pitched sounds, but doesn't explain how we hear low-pitched sounds

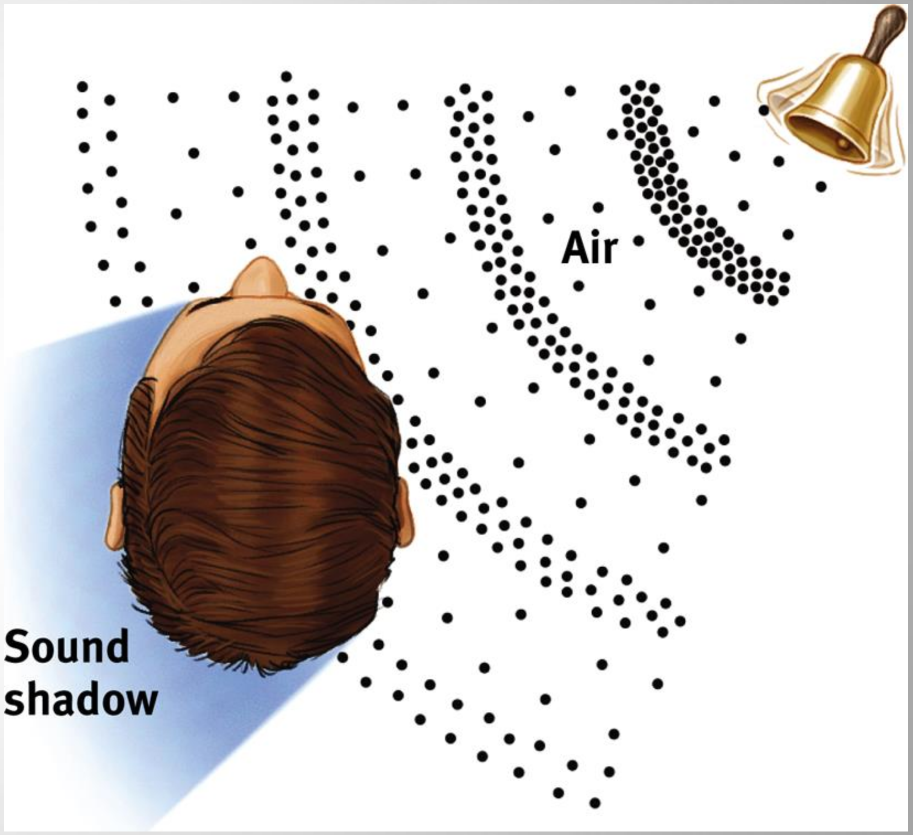
Frequency Theory – the rate of nerve impulses traveling up the auditory nerve matches the frequency of a tone, enabling us to sense its pitch is

- Helps explain how we hear LOW pitch sounds

How do we locate sound?

Because we have two ears, sounds that reach one ear faster than the other ear cause us to localize the sound.

What about hearing from straight ahead, behind, above, beneath?
NOT that well…
Because sounds hit both ears simultaneously



Types of Hearing Loss

Conduction Hearing Loss - caused by damage to the mechanical system (eardrum or bones in the middle ear) that conducts sound waves to the cochlea.

Sensorineural Hearing Loss – (nerve deafness) caused by damage to the cochlea's hair cell receptors or their associated nerves.

- Most common type of hearing loss - often caused by heredity, aging, prolonged exposure to loud noise or music

Cochlear implants – helps convert sounds into electrical signals & stimulate the auditory nerve through electrodes threaded into the cochlea

Touch

The sense of touch is a mixture of four distinct skin senses—

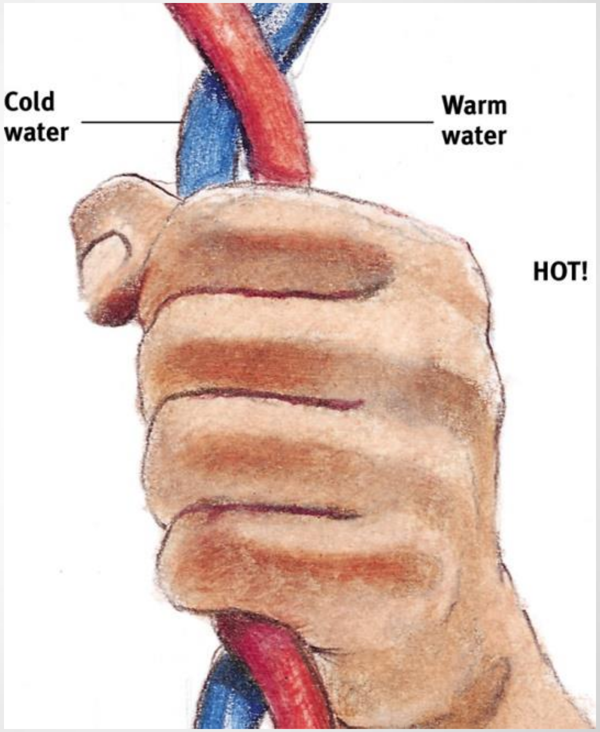
- pressure
- warmth
- cold
- pain

- Touch is essential for proper development
- The development of premature babies is stimulated by touch.

Skin Senses

Only pressure has identifiable receptors. All other skin sensations are variations of pressure, warmth, cold and pain.

Outside in winter, come in and run hands under warm water…..what do you feel?



Burning hot

Pain

- Pain tells the body that something has gone wrong.
- It tells you to change your behavior immediately
- Some people are born without the ability to sense pain while some others live with constant pain.
- There is no *one* type of stimulus that triggers pain, and there are no special receptors for pain

Biological Influences of Pain

Gate-Control Theory (Melzak & Wall)

- Theory that the spinal cord contains a neurological "gate" that blocks pain signals or allows them to pass on to the brain
- "Gate" opened by the activity of pain signals traveling up small nerve fibers
- "Gate" closed by activity in larger fibers or by information coming from the brain
- Treat chronic pain by stimulating gate-closing activity such as massage, acupuncture, rub the area near the pain

Biological Influences of Pain

Brain to spinal cord message can block pain:

- Endorphins – natural painkillers (biological influence) combined with being distracted from pain (psychological influence) and we can feel much less pain
- Think about sports injuries not really hurting until after the game…

Biological Influences of Pain

- The brain can also create pain: *Phantom limb sensations* – pain in nonexistent limbs
- You have phantom vision every night – when you see images in your dreams without sensory stimulation…
- *Tinnitus* – phantom sounds – ringing in the ears in people w/ hearing loss
- Phantom sites – hallucinations (non-threatening) – people w/ loss of sight

Psychological Influences on Pain

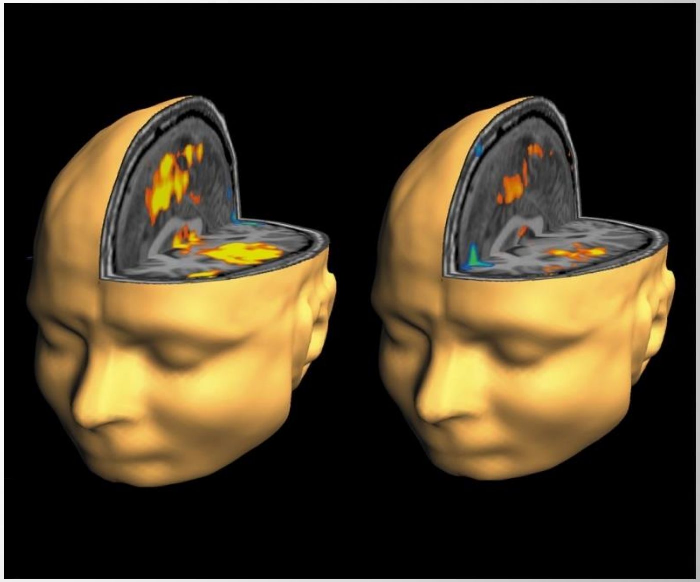
- Psychological effects of distraction (the athlete who plays through pain)
- Rubber-hand illusion – bending fake fingers - can create pain, too
- Memories of pain – we overlook pain's duration & intensity

Socio-Cultural Influences on Pain

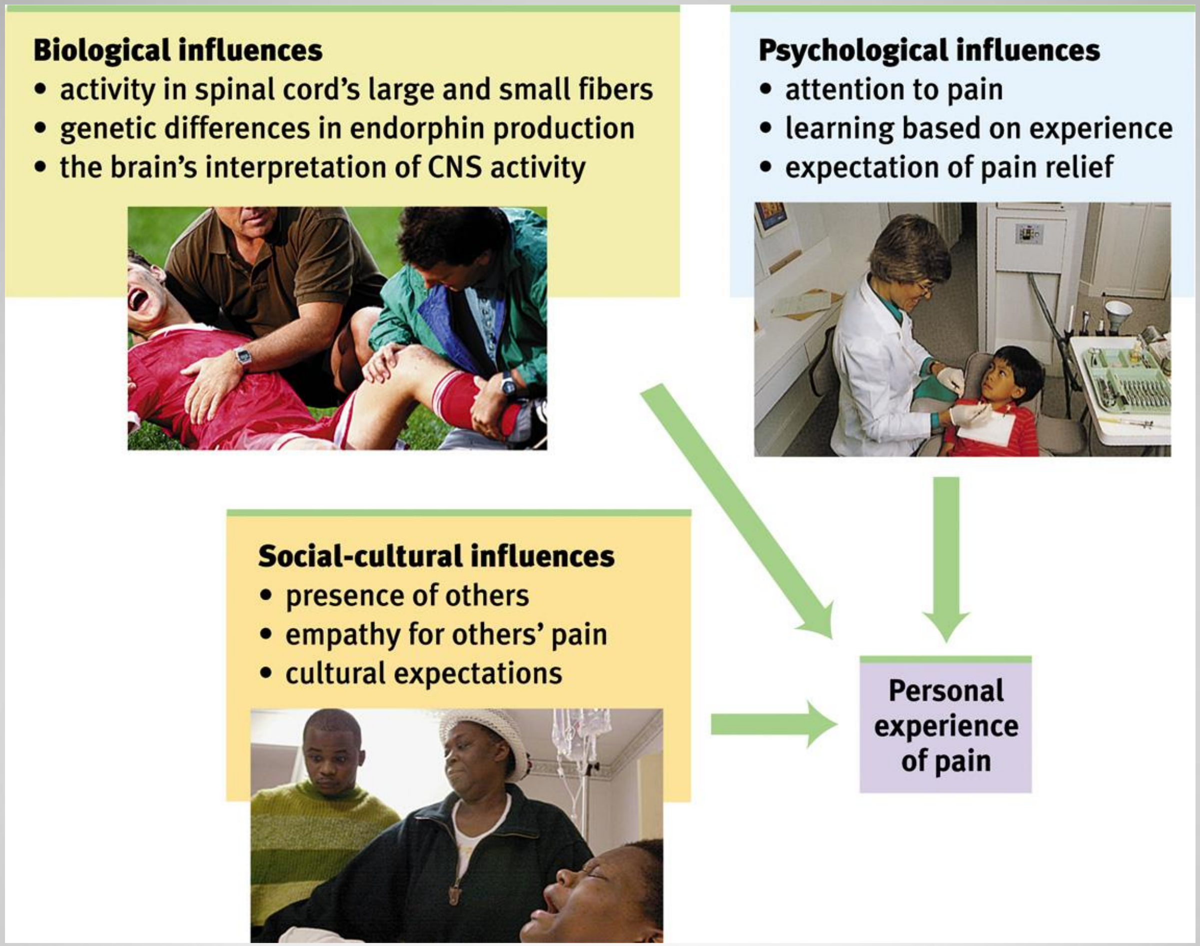
- We feel more pain when others do
- When feeling empathy for other's pain, our brain might mirror that pain
- When you see another person get hurt– don't you feel it a little bit, too?
- Thus, pain is biopsychosocial

Pain Control

Pain can be controlled by a number of therapies including, drugs, surgery, acupuncture, exercise, hypnosis, and even thought distraction.



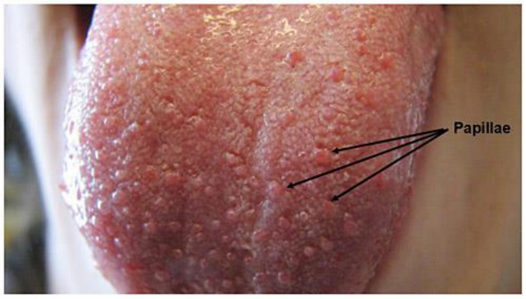
Biopsychosocial Influences on Pain



Pain is a property not only of the senses of the region we feel it, but of our brain and our expectations as well.

Chemical Senses - Taste

- Taste (*gustation*) is a chemical sense
- Taste buds contain pores that catch food chemicals – antenna-like hairs sense food molecules
- Basic taste sensations: sweet, sour, salty and bitter
- 5th taste sense *umami* = savory meat (monosodium glutamate)
- Purpose = survival; not just pleasure
- Every week or two, taste receptors reproduce
- Fewer taste buds as you get older



The Survival Functions of Basic Tastes

Taste	Indicates
Sweet	Energy source
Salty	Sodium essential to physiological processes
Sour	Potentially toxic acid
Bitter	Potential poisons
Umami	Proteins to grow and repair tissue

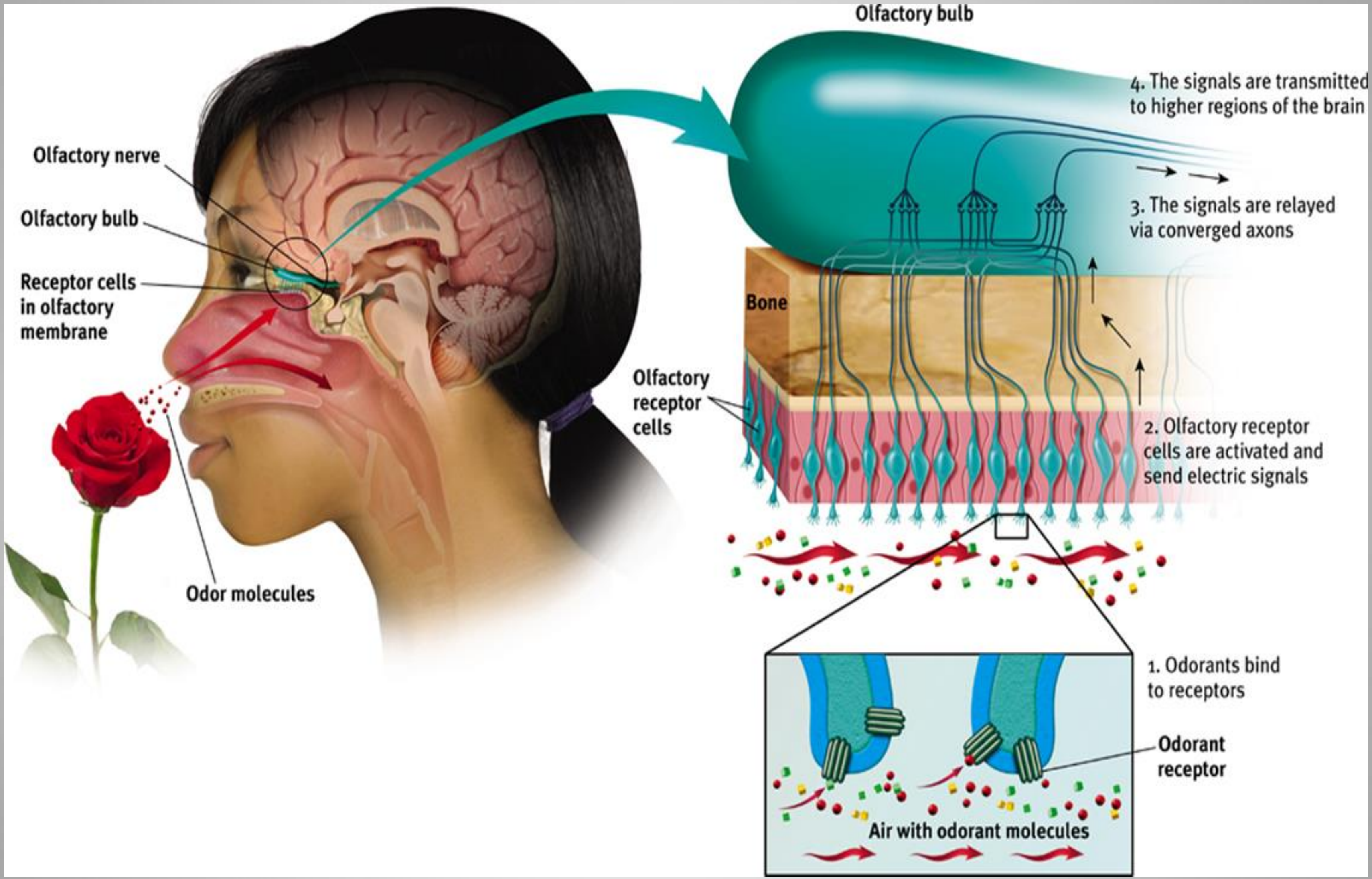
Sensory Interaction

- Seeing, hearing, tasting, touching, & smelling are not totally separate channels; the brain blends their inputs.
- **Sensory interaction** - one sense may influence another
  - EX. Taste of strawberry interacts with its smell and its texture on the tongue to produce flavor.

Smell

- Like taste, smell (*olfaction*) is a *chemical sense*.
- Unlike taste, there are many different forms of smell.
- Molecules in the air reach cluster of 10-20 million receptor cells at the top of each nasal cavity.
- Olfactory receptor cells in nasal cavity wave around and respond selectively to alert the brain
- Olfactory Bulb - smell is registered and converted into neural messages
- Olfactory Tract- takes information to different parts of brain (Smell does not go to the thalamus like other senses)
  - Limbic System emotional significance is associated
  - Temporal Lobe - recognition of smells

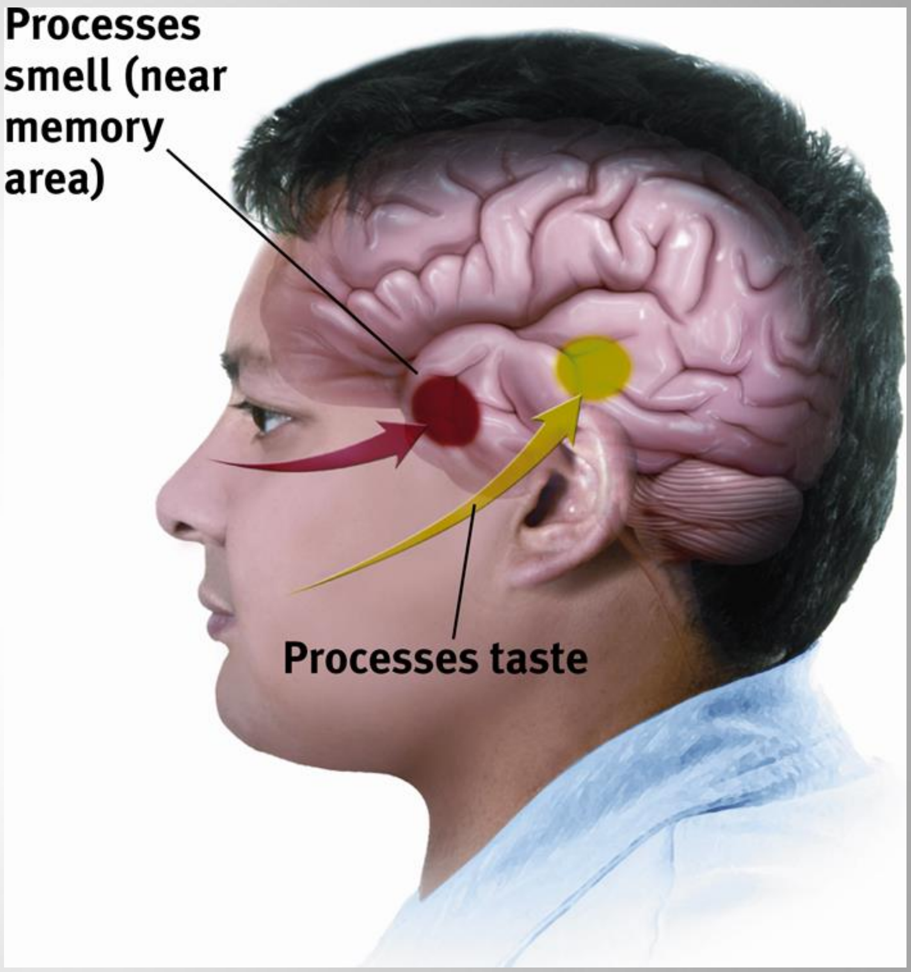
Smell



Olfactory nerve
Olfactory bulb
Receptor cells in olfactory membrane
Odor molecules
Olfactory bulb
4. The signals are transmitted to higher regions of the brain
3. The signals are relayed via converged axons
Bone
Olfactory receptor cells
2. Olfactory receptor cells are activated and send electric signals
1. Odorants bind to receptors
Odorant receptor
Air with odorant molecules

Smell and Memories

The brain region for smell (in red) is closely connected with the brain regions involved with memory (limbic system). That is why strong memories are made through the sense of smell.



Summary of the Senses

Table 3.4

Summary Table of the Senses

Sense	Stimulus	Sense Organ	Sensory Receptor Cells
Hearing (audition)	Sound waves	Ear	Hair cells in cochlea
Vision	Light waves	Eye	Rods and cones in retina
Color vision	Different wavelengths of light	Eye	Cones in retina
Smell (olfaction)	Airborne odor molecules	Nose	Hairlike receptor cells at top of nasal cavity
Taste (gustation)	Chemicals dissolved in saliva	Mouth	Taste buds
Touch	Pressure	Skin	Pacinian corpuscle
Pain	Tissue injury or damage; varied	Skin, muscles, and organs	Nociceptors
Movement (kinesthetic sense)	Movement of the body	None; muscle and joint tissue	Proprioceptors in muscle and joint tissue
Balance (vestibular sense)	Changes in position, gravity	Semicircular canals and vestibular sacs	Hairlike receptor cells in semicircular canals and vestibular sacs

Body Position and Movement

"Sixth sense" – We need to be able to know the current position of our body parts and then be aware of their changing positions as they move

- **Kinesthesis** – the system for sensing the position (movement, posture, & orientation) of individual body parts
- Kinesthetic senses are embedded in muscle fibers and joints

Body Position and Movement

- **Vestibular sense -** monitors the head & body's position by sending messages to the cerebellum enabling us to maintain balance.
  - contributes to balance and the sense of spatial orientation

- **Semicircular canals** – fluid in your inner ear moves when your head moves, stimulates hair-like receptors which send messages to your cerebellum, maintaining balance
  - **Dizziness** - Spin then abruptly stop – the fluid in your semicircular canals keeps moving a little, causing dizziness

Body Position and Movement

- **Proprioception** – sense of the position of parts of the body in relation to other body parts (more tactile)
- The vestibular sense tells us whether our head (and hence usually our body) is tilted, moving, slowing down, or speeding up. It works in concert with the kinesthetic senses to coordinate proprioceptive feedback.