Understandings:

1. Outline the different types of receptors.

- Sensory neurons must first be able to receive a signal. The way they do this is of course by receptors! Humans have four receptors.

1. Mechanoreceptors respond to mechanical stimuli (force and movements).

2. Chemoreceptors respond to molecules.

3. Thermoreceptors respond to heat.

4. Photoreceptors respond to light.

2. Explain the photoreceptors in humans.

- Our photoreceptors are in a layer called retina. To briefly explain how light enters; it enters through cornea and lens. These two are concaved structures so light is being focused into a point. When the light reaches the back of our eyeball, the first layer it will hit is retina (more below on how the eye looks like). We have two photoreceptors called rods and cones probviously (new word my significant other introduced) because they look like rods and cones.

3. Distinguish between rods and cones.

- Essentially, rods are for sensing light intensity while cones are for sensing light frequency. In other words, rods are for collecting light thus they are very useful in dark places but not for sensing color. Also, many rods share one bipolar cell which reduces resolution but increases sensitivity to light. **Co**nes on the other hand are for sensing different **co**lor. These have one bipolar cell each which enables color distinction but not fit for sensing light intensity.

Humans have three cones that sense three different colors: red, blue and green. Note that this is different from the primary colors which are red, blue and yellow so don't confuse them! (Maybe I confused you by bringing this up xD).

Characteristic	**Rod**	**Cone**
Location	Retina	Fovea
Detection of light intensity	In dark light	In bright light
Connection to bipolar cell	Many to one	One to one

4. Explain bipolar cells.
- Before we talk what bipolar cells do, I just want to make sure how light travels in the retina. I recommend you see the picture of retina further down. Light travels through both ganglion cells and bipolar cells to reach the rods and cones.

If no light: Rods and cones will be depolarized when there is no light (interesting huh) so they send inhibitory neurotransmitters to bipolar cells.

If light: Rods and cones will be hyperpolarized (a polarization below resting potential) and stops sending inhibitory messages so bipolar neurons are stimulated! These can then depolarize and send signals up to ganglion cells that can send impulses to the brain.

5. Explain ganglion cells.
- These are the bridge from retina to the brain. Thus the dendrites and soma is in the retina but the axon leads all the way to the occipital lobe.

The axons from ganglion cells make a gap in the eye since the nerves must reach the brain somehow. That gap where rods and cones are absent is what we call "blind spot" because we cannot see anything if light is focused at that point.

6. Explain how the information of vision is sent to the brain.
- As we know, there is a decussation nature in sensory perceptions. The crossing over that takes place by ganglion axons is called optic chiasma (chi means X in Greek so it makes sense. You knew that already probably).

These then travel to the visual cortex (which is in the occipital lobe).

7. Explain the structures in the middle ear.
- Ear drum is the doorstep from outer ear to the middle ear.

Then we meet malleus, incus and stapes respectively in order. What these do is to just amplify the sound by literally vibrating on each other. Sound is amplified up to 20 fold! That is something to the power of 20. But if the sound is too strong, the muscles contract to separate malleus and incus so fewer vibrations are transmitted.

Then we exit the middle ear through two doors called oval window and round window. This takes us to the inner ear.

8. Explain how cochlea works.
- Inside the cochlea there are special fluids called perilymph and endolymph (fluid with ions). There are also special sensory cells with cilia. Specific hair cells can identify specific wavelengths by resonating with the vibrations and the cells produce an action potential to send an impulse to the temporal lobe (auditory cortex).

The vibrations are possible because the round window is flexible. This enables the fluid inside the cochlea to be vibrated.

9. Explain how information of sound is sent to the brain.

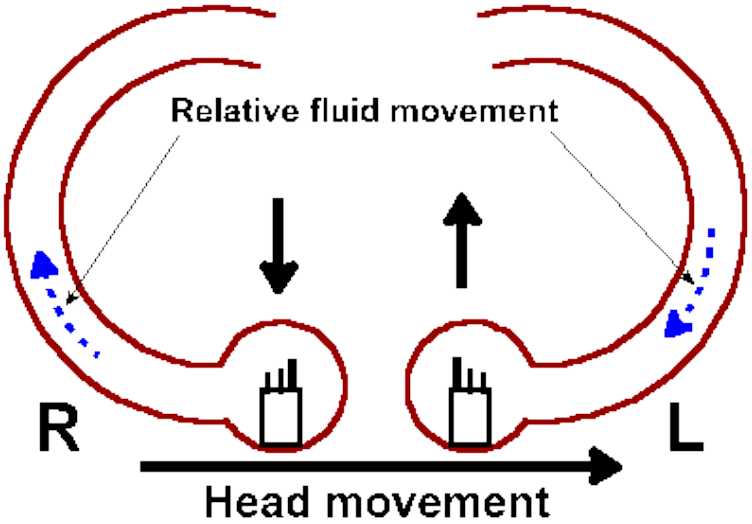
- Hair cells send signal to a sensory neuron to the auditory cortex.

10. Explain the role of hair cells in the semicircular canals.

- Semicircular canals are for our balance. Semicircular canals are made of three semicircles that are right angled to each other to cover a three dimensional plane.

Inside the each canal, there is a bulb at the end with hair cells fixated on a gel. This structure is called capula. Easy so far.

The balance is regulated by the hair cells through the detection of fluid. The picture below shows what will happen if the head moves forward. Due to inertia, water in the back would move back and will stimulate hair cells.



Let me propose an experiment to demonstrate this fluid movement. If you stand up and spin your body fast clockwise, fluid will move to the left wall (due to centripetal acceleration and inertia). Then stop spinning and hold your feet together and stand still. You will probably tilt left. This is because the fluid wants to be perpendicular to gravity and it can achieve that by you tilting, or just wait until the fluid is back to place. Try opposite direction and see where you tilt.

But please…don't do this right after a meal…I take no responsibility of pukes!

Applications and skills:

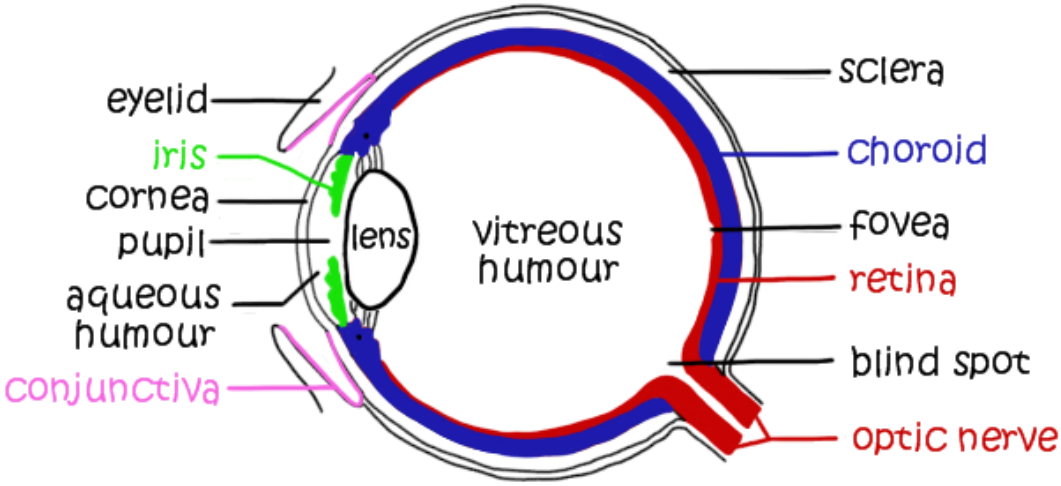
1. Explain red-green color-blindness as a variant of normal trichromatic vision.
- When a person has got any defect in their red/green receptors, they have a red-green color-blindness. This is X-linked recessive so males are more prone to get it especially if the mom is a carrier (then their male babies have 50% of color blindness). So if you are color-blind, blame your mom (in a playful way).

2. Explain how olfactory receptors work.
- Olfactory receptors are a type of chemoreceptors that are located in the upper part of the nose. Once receptor is for one chemical so imagine how many dogs have! Humans have a low number of receptors compared to dogs.

To tell you an interesting story, there was an article in BBC around September 2015 about a woman who could *smell* Parkinson's disease. Isn't that amazing? This means that a certain disease may release certain molecules that are detectable *before* the onset. A future method for diagnosing patients might be through chemoreceptors! Who knows?

3. Explain cochlear implants in deaf patients.
- People with non-functioning cochlea may have a cochlear implant. Basically, what it does is that it transmits the vibrations from surroundings to the auditory nerves directly. This makes the fluid and the hair cells redundant.

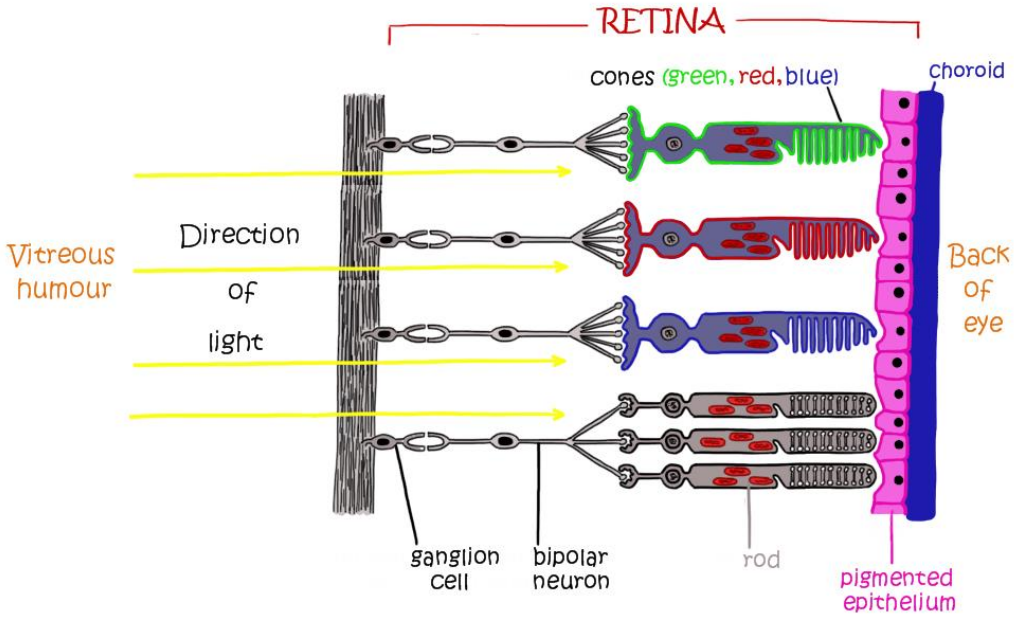
4. Be able to label a diagram of the structure of the human eye.
- These are the ones you have to know. Some are familiar, some may be new.



Our vision is best when the light is focused on the fovea. One could think that this is the opposite of blind spot. Fovea is our clear spot. Just to add, suspensory ligaments and ciliary muscles control the lens concavity, while circular and radial muscles control pupil.

5. Be able to annotate a diagram of the retina to show the cell types and the direction in which light moves.

- Be able to know every structure that is shown here.



RETINA = pigmented epithelium + rods + cones + bipolar neurons + ganglion cells

6. Be able to label a diagram of the structure of the human ear.

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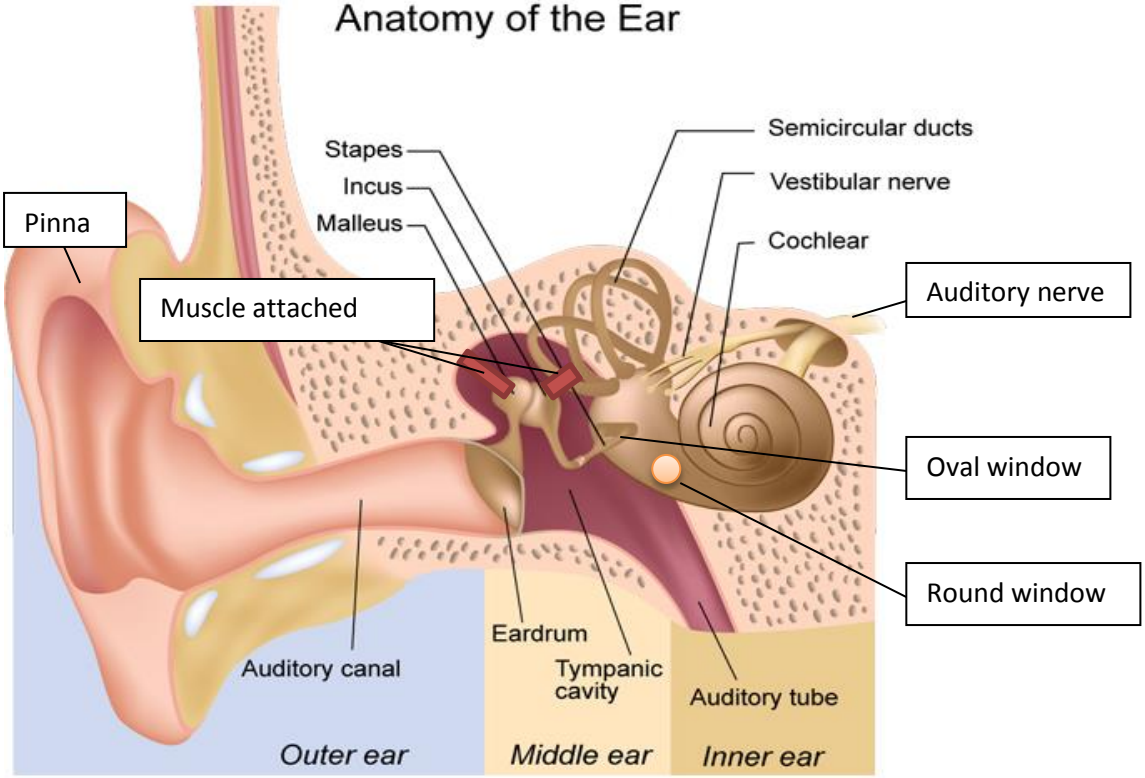

Structures we should know are: pinna, ear drum, muscle, malleus, incus, stapes, semicircular canals, round window, oval window, cochlea, auditory nerve.

TOK:

1. Other organisms can detect stimuli that humans cannot. For example, some pollinators can detect electromagnetic radiation in the non-visible range. As a consequence, they might perceive a flower as patterned when we perceive it as plain. To what extent, therefore, is what we perceive merely an individual construction of reality?