**\*Extra notes about last lecture**:

\*The two pathways take the whole frequencies; both the mono-oral pathway & the bi-oral pathway contain the whole frequencies from (20 Hz-20 KHz).

\*the cochlear nucleus receives all frequencies (which is the first step) that will be converted to the second order neuron and continue in the hearing pathway.

*Cochlear nucleus consists of 4 parts, but just 2 are important for us to know:*

1-anterior cochlear nucleus which is the biggest; it is the source of the bi-oral pathway.

2- Posterior cochlear nucleus it is the source of the mono-oral pathway.

**\*\*Visual system\*\***

\*anatomy of the eye:

The eye consists of 3 layers:

- Choroid ((الطبقة الوعائية🡪the layer that contains nerves &blood supply.

-Retina (الشبكية)

-Sclera (الصلبة) 🡪the hard part that gives the shape of the eye.

\*physiologically the most important one is “retina” because it is the site of sensation & photo receptors (conversion from photo power to nerve power).

\*from outside there is cornea “القرنية”, it has 2 functions:

-give the round shape.

-allow refraction of light.

\*At front; we have muscles that move the eye from inside then we have🡪Pupil: the place where the light enters the eye🡪 And around it there is the iris that gives the color of the eye and its function is to determine the quantity of light that enters the eye by sphincter&dilator muscles inside it to make the pupil be dilated or constricted.

\*\*the eye is composed of 2 parts: external compartment &internal compartment &each contain fluid 🡪if the fluid increase inside any of them 🡪pressure inside the eye increase 🡪glaucoma.

\*\***glaucoma”المياه البيضاء”**: increase in the pressure inside the eye because of:

1. Increase in the production of the fluid.
2. Blockage in the filtration of fluid.

Cataract = المياة الزرقاء

\*treatments:

- Drugs to minimize the quantity of fluids.

-Surgery, if there is blockage.

\*\*the real problem in glaucoma is the pressure; because the eye is surrounded by hard shell which prevents the expansion of the eye, so the extra pressure will affect the nerves and the blood vessels and this will lead to loss of vision or to damage of the eye.

**\*Retina\***

-The most important layer.

-found all through the inner part of the eye except “blind spot”.

-the most important area in the retina is the “macula” which contains the “fovea centralis”🡪 the vision is more here.

-if I want to focus on something or a person I need to put their image at fovea centralis &all surrounding things are on the rest of the retina .

-in this case I will see this person clearly &in details and see the other objects but the clarity will be less as you go far from the fovea centralis.

-when you move your eye, the purpose is to make the light focused on the fovea centralis.

\*\***Optic disc/blind spot:** the area at which the entrance and the exit of blood vessels&the nerves of the eye take place.

-retina is the part that is responsible about the sensation of vision.

And because there is no retina in the optic disc🡪no vision there🡪that’s why it's called blind spot.

##in this case when you look to a person there must be:

- A person’s image inthe fovea centralis.

- Images of other objects in the room in the rest of the retina.

- A point image that will be in theblind spot. 🡪

🡪But that's not the case; we can’t see this point because of 3 reasons:

1. Every eye will see the blind spot of the other 🡪they canceled each other.
2. The eye is always in a motion; even if you close one eye you still did not see the blind spot.
3. The brain will fill the space of blind spot with similar figure as the surrounding area. **”we see by our brain not by our eyes; the function of the eye is to analyze and conduct the sensation to the brain”**

\*\*how to determine the blind spot??

We need to cancel the 3 factors above.

Take a White paper and draw 2 points between them 20-30 cm, cover one eye, fix your vision at one point of them and move the paper at some point you will see just one point and the rest of the paper white, in this case the second point is at the blind spot .

So the brain will see what's around it 🡪white in color and logically the brain assume that it is like the surrounding and fill the space accordingly.

\*\*Retina converts the light power to neuronal signal.

It consists of the following layers:

1. Pigmented cell layer (last layer) 🡪epithelial cells contain pigment (melanin) making them dark, its function is to absorb light, why do we need to absorb light in the eye? So as not to see double vision, more explanation: the light will enter the eye and the photoreceptor will absorb the light and process it and the remaining unabsorbed light will reach pigmented layer if it didn't absorb the light then the light would be reflected and the photoreceptors will again see light forming double vision.
2. Photoreceptor layer 🡪cells that receive light and convert it to neuronal signals then transferred to bipolar cells
3. Bipolar cells will transfer signals to ganglion cells
4. Ganglion cells 🡪 cells that conduct signals to the brain; axons of ganglion cells will form optic nerve!
5. Horizontal cells🡪between photoreceptor &bipolar cells.
6. Amacrine cells🡪between bipolar cells & Ganglion cells.

**\*\*Notes\*\***

* “3” of these layers are neuronal layers; Photoreceptor, Bipolar cells, Ganglion cells, while horizontal cells & amacrine cells are laid horizontally &they are important for initial processing of visual signal through retina.
* Light pathway:

Light go in one direction and doesn't comeback.

Light enter the eye and reach the retina, pass these layers without being affected: ganglion, amacrine, bipolar &horizontal because they don’t have photoreceptors.

When reaching the photoreceptor cells it will be converted to neural signal.

-Neuronal signal

Begins in the photoreceptors 🡪 bipolar🡪 ganglion cells 🡪optic nerve🡪 CNS.

\*light and action potential go on opposite directions.

\*\***Types of photo receptors:**

1-Cones.

2- Rods.

Both contain:

* Nucleus.
* Outer segment (which contain photoreceptor protein “rhodopsin”).
* Inner segment (which contain synaptic axons at its end).

They differ from each other by: color, sensitivity, distribute through the spectrum & distribution in the retina.

|  |  |  |
| --- | --- | --- |
|  | Cones | Rods |
| Color | 3 types of proteins distribute through the spectrum 🡪(low, mid &high). | One type of protein absorbs light at approximately the whale spectrum (400-700 wave length). |
| Combination between them allows the vision of colors. | One type 🡪either on or off🡪black, white or grey. |
| Sensitivity | Low🡪 need strong light to be able to work. | High 🡪work in darkness |

|  |  |  |
| --- | --- | --- |
| Distribution in the retina. | Mainly in the fovea centralis (we need to see the focused point in colors.) | All over the retina. |

\*as we move away from the fovea centralis, cones ↓& rods ↑.

\*\* Retina covers all the surface of the eye 🡪 the most concentrated part of the retina is in the fovea centralis containing high no. of photoreceptors per surface area (high number of cones and they are so small almost as small as the rods)🡪 to have a better resolution 🡪 fovea centralis is small in size (1 mm).

So it’s **not true** to distinguish between cones and rods by size, mostly cones are bigger than rods but at fovea centralis (high conc. & small area) 🡪 cones will be similar in size to rods.

\*As we said in page 4 light must pass through many layers then reach the photo receptors but in fovea centralis we must not have anything to interfere with the light coming, so here all other layers are displaced (however, they are still present) and this displacement results in a depression in the retina in the area of fovea centralis.

**\*light detection\***

How is light signal converted to neuronal signal?

In normal case, photoreceptors especially the outer segment contain Na channels which open when they are attached to cGMP.

**At dark:**

-cGMP attach to Na channels 🡪 Na channels open 🡪Na enters the cells 🡪membrane potential 🡪voltage gated Ca channels 🡪release of neurotransmitter (just like hair cells).

**\***so there is a graded potential in the photoreceptors which help:

1- To know the intensity of light.

2-To reserve energy because photoreceptors are working throughout the whole day so in case of graded potential we don’t need action potential for every light we see (action potential needs ions 🡪consuming more energy).

**At light:**

* In the outer segment of the **rod** there is a protein called “rhodopsin”.
* Rhodopsin consists of 2 proteins: opsin &retinal.
* At dark, opsin and retinal attach to each other.
* At light, power of light will transfer **cis** retinal to **trans** retinal.
* Opsin & retinal become separated from each other.
* Free opsin degrades cGMP.
* Na channels close.
* No Na leakage.( memebrane potential reaches -70)
* Voltage gated Ca channels close.
* No neurotransmitter release.
* Now you would probably ask at light there is no release of neurotransmitter thus there is no signal then how do we see light? The reflex of the neurotransmitter released is not always excitatory🡪 depends on the receptors at the other side (bipolar cells).

-There are inhibitory receptors on the bipolar cell by glutamate:

\*at dark: there is release of glutamate 🡪inhibition of the bipolar cells 🡪 no action potential or frequency of action potential is low (any cell contains base line).

\*at light: no neurotransmitter release 🡪 no inhibition of the bipolar cells 🡪potential is high.

\*\*Actually we have **2 types of bipolar cells**; one has activatory receptors &the other has inhibitory receptors.

Bipolar cells have a base line, when there is neurotransmitter release:

-cells that have inhibitory receptors will be activated.

-cells that have activatory receptors will be inhibited.

**\*\* In cones**:

-There are 3 proteins act by the same concept of cis retinal, opsin

-The only difference is that each one of them distinguishes certain wave length.

**Note** that absorption of light depends on retinal, and the presence ofretinal especially in cis formation determine the sensitivity to the light because it is the one that absorbs the light.

If I have just 100 retinal protein in the cell, then the sensitivity will be low.

\*retinal protein is formed from vitamin A.

\*if there is depletion of vitamin A 🡪 weakness in vision especially in darkness🡪 night blindness.

النجاح سلالم لن تستطيع أن ترتقيها ويداك في جيبك..

بالتوفيق جميعا

