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# Biology

ENGLISH MEDIUM



**SAMPATH  
LANKADHEERA**

B.Sc. (Hons), M.Sc.

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# Biology

ENGLISH MEDIUM



**UNIT  
05**

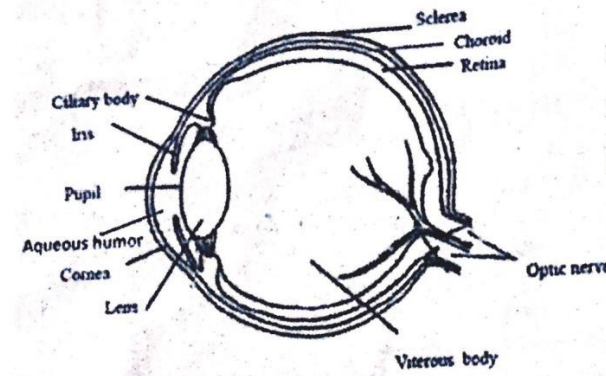
**Animal Form and Function**  
Peripheral Nervous System

**SAMPATH  
LANKADHEERA**

B.Sc. (Hons), M.Sc.



21 + 21 = 42  
Any 36x 4 = 144 marks  
Diagram = 6 Marks  
Total = 150



If fully labelled **06 marks**  
Partially labelled **03 marks**  
No marks if unlabelled

8-12 → fully  
1-7 → partially



- paired especially in relation to judgment of speed and distance
22. Seeing the visual field using two eyes with greater overlapping fields of view
  23. Enables three dimensional views/Very important in judging speed and distance of approaching objects/Gives more accurate assessment of one object relative to another in relation to distance, depth, height and width

### Essay Aid Answers

Essay 01

**(a) Briefly describe the basic structure of human eye**

1. Outer fibrous layer
2. Consist of sclera and cornea
3. Middle vascular layer
4. Consist of choroid ciliary body and iris
5. Inert nervous layer
6. Is the retina
7. Inside of the eyeball there is the lens aqueous fluid /aqueous humor and vitreous body/ with vitreous humor /vitreous fluid
8. Sclera is opaque /white
9. Cornea is clear /transparent
10. No blood vessels
11. Choroid is (thin) pigmented
12. Rich with blood vessels
13. Ciliary body consist of smooth muscle fibers/ ciliary muscles
14. Iris is colored contain pigmented cells and
15. Has two layers of smooth muscle fibers circular and radial bundles
16. Lens easy elastic
17. Biconvex and
18. Transparent
19. Aqueous humour /aqueous fluid is clear watery
20. Vitreous humor /vitreous fluid /vitreous body is colorless /transparent/ Jelly like structure (behind the lens)
21. Retina contain photoreceptors/ rods and cones.

**(b) Explain the role of human eye and brain in vision**

1. Light rays (coming from the object) are mostly refracted by lens
2. To focus a clear image on the retina of each eye
3. Which is upside down
4. Conjunctiva, cornea aqueous fluid/aqueous humour and vitreous fluid/vitreous humor / vitreous body also contribute to light refraction (any three should be written to get full marks)
5. For clear near vision eye make adjustment to increase the refraction
6. Under the control of autonomic nervous system
7. The muscles attached to the eyeball rotate the eye
8. To focus light rays on corresponding area of two retina/ convergence
9. For near vision (to focus near object on retina) curvature /convexity of the lens is increased
10. By ciliary muscle contraction /accommodation
11. For distant vision (to focus on distant objects on retina) curvature/ convexity of the lens is reduced
12. By relaxing the ciliary muscles
13. Photoreceptor cells /(in the retina) convert light energy to voltage change
14. Stimulation of rods lead to black and white vision and
15. Night vision
16. Stimulation of cones lead to color vision
17. Bipolar cells in the retina receive electrical signals from photoreceptor cells end
18. Pass to ganglion cells
19. Optic nerve (fiber) transmit that sensation/ action potential impulse
20. to occipital lobe of cerebrum /brain
21. Brain perceives the visual objects in the correct way /right way up

### Human sensory structures and functions

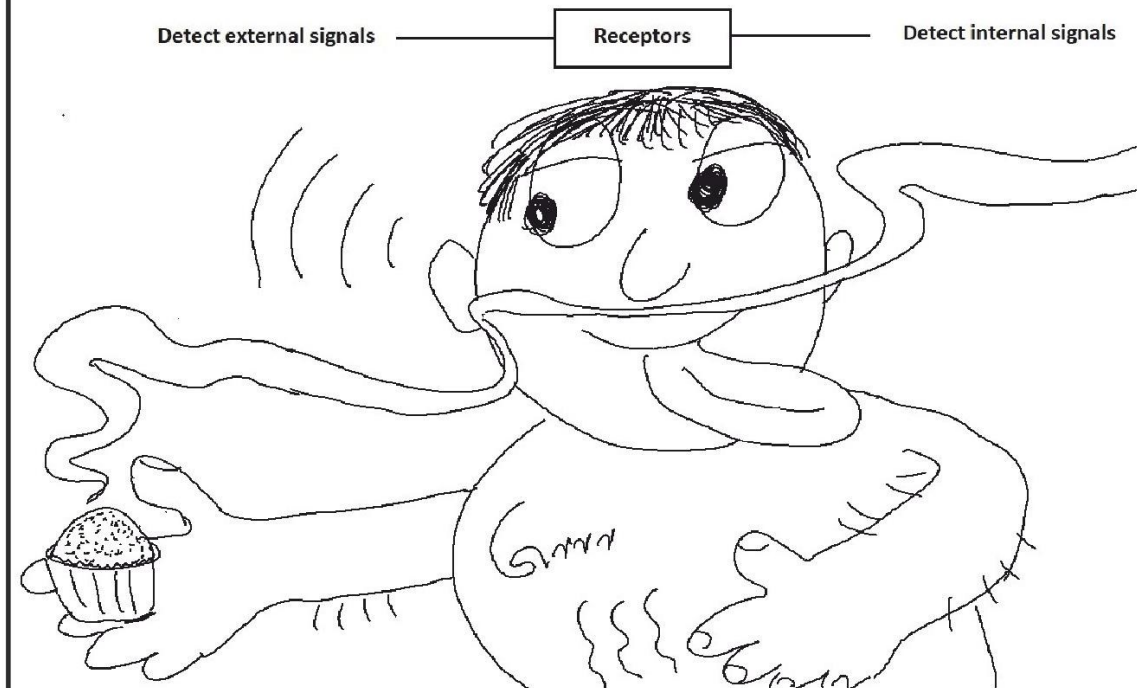
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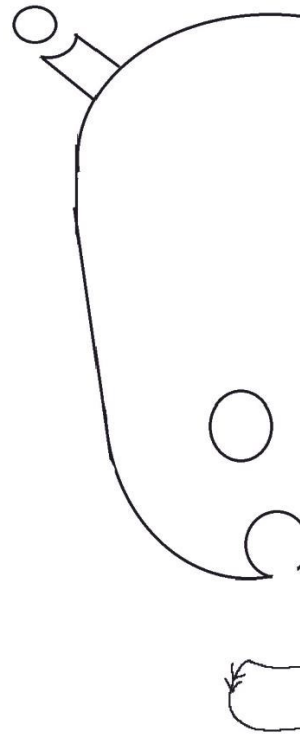
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Sensory receptor can be a specialized cell or an organ or a subcellular structure that could detect the stimuli. Some sensory cells are specialized neurons. Sensory receptors can inform the central nervous system about the conditions inside and outside the body in order to maintain homeostasis. Specific sensory receptors detect the stimuli that arise in the external environment Whereas internal receptors sense the stimuli that arise inside the body.





### Structured Essay Aid Answers

1. (1) Taste buds (2) Serous glands (3) Taste cells (4) Supporting cells (5) Nerve fibers
2. (1) Olfactory bulb (2) Bone (3) Epithelial cells (4) Olfactory receptor cells (5) Cilia
3. Body surface (skin)/ Internal environment (hypothalamus - detects blood temperature)
4. Krause end bulbs (detect cold)/Ruffini corpuscles (detect warmth) /Free nerve endings (detect both cold and warmth)
5. Skin thermoreceptors: detect body surface temperature/Hypothalamus thermoreceptors: detect temperature of blood circulating through internal organs (core temperature)
6. Rods: More sensitive to light/ Don't distinguish colors/ Enable night vision in black and white/ More numerous  
Cones: Provide color vision/Less light-sensitive/ Three types with different sensitivity to red, green, or blue light/Fewer in number
7. Pressure/Touch/Stretch/Motion/ Sound
8. Touch receptors: Close to skin surface (Meissner corpuscles, Merkel discs)/Pressure receptors: Deep skin (Pacinian corpuscles)/ Vibration receptors: Most touch receptors and hair cells in inner ear
9. Extreme pressure/Extreme temperature/Tissue-damaging chemicals
10. Chemoreceptors ↔ Olfactory receptors/taste receptors  
Free nerve ending ↔ Pain receptors  
Thermoreceptors ↔ Krause bulbs/Organ of Ruffini/Free nerve endings  
Merkel's disc ↔ Touch receptors of epidermis  
Pressure and stretch receptors ↔ sensitive to change of tension of muscles  
Free nerve endings ↔ Extreme temperature, pressure, chemicals
11. Fine transparent membrane that lines the iris and front of the eye ball
12. Outer fibrous layer (sclera and cornea)/Middle vascular layer (choroid, ciliary body and iris)/ Inner nervous layer (Retina)
13. Sclera: Maintains the shape of the eye and gives attachment of the extrinsic muscles of the eye  
Cornea: Passage through which light rays reach the retina; devoid of blood vessels; involved in refracting light rays to focus on the retina  
Choroid: Located just beneath the sclera; thin pigmented layer and rich with blood vessels  
Ciliary body: Acts as sphincter; holds lens in place; controls lens thickness through contraction and relaxation of muscle fibers  
Suspensory ligaments: Hold the lens in place  
Lens: Refracts light rays reflected by objects and focuses them on retina; can vary its refractive power by changing thickness  
Aqueous humor: Supplies nutrients and removes wastes from cornea, lens and lens capsule which have no blood supply  
Iris: Circular colored body; controls amount of light entering pupil by changing size; prevents penetration of excessive light  
Pupil: Hole in center of iris; controls amount of light entering by changing size  
Vitreous humor: Maintains intraocular pressure; supports retina against choroid; prevents eye ball from collapsing  
Retina: Contains photoreceptor cells (rods and cones) which contain photosensory pigments that convert light rays into membrane potential change  
Fovea: Contains only cones  
Blind spot: Lacks photoreceptors; where optic nerve leaves eye
14. Check note
15. Supplies nutrients to cornea, lens and lens capsule/Removes wastes from these structures/ These structures have no blood supply
16. Maintains intraocular pressure/Supports retina against choroid/Prevents eye ball from collapsing  
Based solely on the information provided in the textbook images:
17. Rods are more sensitive to light and function in dim light conditions
18. Cones function in bright light
19. Rhodopsin (visual purple) is the visual pigment in rods
20. There are three types of cones, each with different sensitivity across the visible spectrum providing optimal response to red, green, or blue light
21. Seeing the visual field using only one eye. When one eye is used, three dimensional vision is im-



.....  
.....  
17. Which cells are more sensitive to light and function at dim light condition.

.....  
18. What is the cell type stimulated under high light intensity.

.....  
19. What is visual purple/rhodopsin?

.....  
20. What are the cone cells sensitive to red, green and blue light?

.....  
21. What is meant by monocular vision?

.....  
22. What is meant by binocular vision?

.....  
23. What are advantages of binocular vision over monocular vision.  
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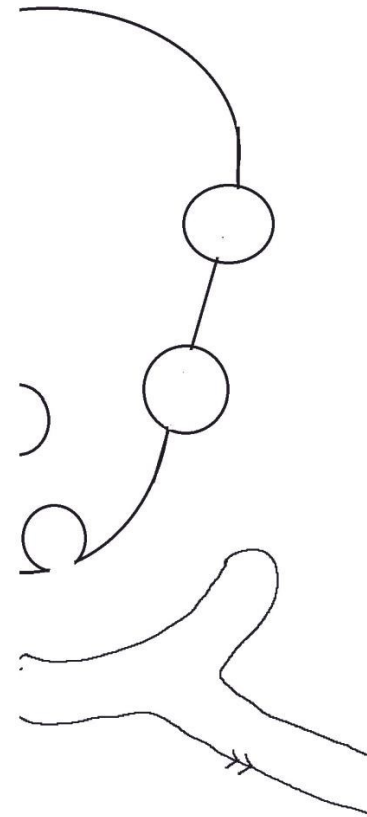
**Essay Aid**

**Essay 01**

- (a) Briefly describe the basic structure of human eye
- (b) Explain the role of human eye and brain in vision

**MCQ Aid Answers**

(1) ABD	(2) 5	(3) 3	(4) 2	(5) 2	(6) 2	(7) 2	(8) 3	(9) 4	(10) 3
(11) 2	(12) 2	(13) 2	(14) 2	(15) 2	(16) 2	(17) 2	(18) 3	(19) 3	(20) 5
(21) 3	(22) 3	(23) 3	(24) 2	(25) 3	(26) 1	(27) 3	(28) 2	(29) 2	(30) 1



### Basic characteristic of sensory receptors

- A specialized structure (...../ ...../ .....  
.....) designed to receive a specific stimuli.
- Detect the stimulus if the stimulus is ..... or ..... threshold level.
- Convert the ..... of the ..... (e.g. light energy, sound energy) into a ..... membrane potential to be later ..... as an ..... potential.
- Always connected with the nervous system.
- During the conversion of stimulus energy into the action potential, sensory ..... can be ..... which is called .....
- If the stimulation is ....., many receptors show ..... in responsiveness which is called sensory ..... (For example upon continuous exposure to a strong smell, perception of that smell gradually ..... and ..... within few minutes).

### Types of sensory receptors

Sensory receptors can be categorized based on the nature of the ..... they detect. Several types of sensory receptors are found in the human body. They are ....., ....., ....., ..... and ..... receptors.

#### • Chemoreceptors

These are sensory receptors that respond to chemical stimuli. Chemical substances should always be dissolved in Water to stimulate sensory cells. Chemoreceptors include taste receptors and olfactory receptors. These receptors mediate the senses of taste and smell. Some chemoreceptors can detect specific chemicals such as CO<sub>2</sub> in the circulating blood.

- **Taste receptors:** Five basic sensations of taste have been described: ....., ....., ....., ..... and ..... (savory taste). Receptor cells for taste are modified epithelial cells organized into taste buds. Taste buds are found in ..... which are small ..... of the tongue. A taste bud consists of ....., ..... cells and ..... Substances to be tasted should be ..... in the fluid ..... the sensory cells and .....to receptor cells.

Aqueous humor

Iris

Pupil

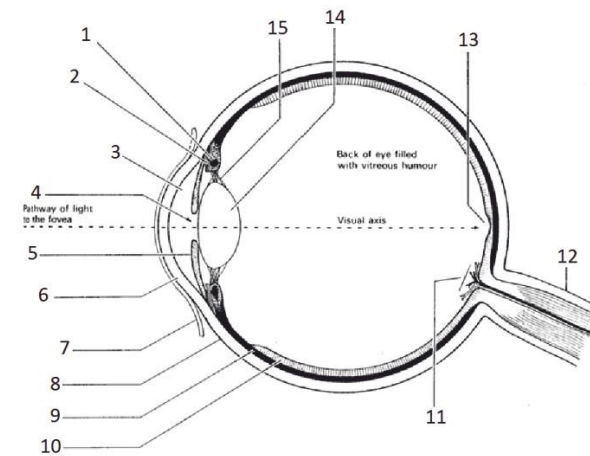
Vitreous humor

Retina

Fovea

Blind spot

14. Label the diagram.



15. What is the function of aqueous humor.

16. What is the function of vitreous humor.



9. What stimuli activate pain receptors.

.....  
.....

10. Find the relation between followings?

Chemoreceptors	Touch receptors of epidermis
Thermoreceptors	sensitive to change of tension of muscles
Merkel's disc	Krause bulbs/Organ of Ruffini/Free nerve endings
Pressure and stretch receptors	Olfactory receptors/taste receptors
Free nerve endings	Extremes of temperature, pressure, chemicals

11. What is conjunctiva

.....  
.....

12. What are layers of wall of the eye and what are structures include in to them.

.....  
.....

13. State the main function of following parts of human eye.

Sclera

.....  
.....

Cornea

.....  
.....

Conjunctiva

.....  
.....

Choroid

.....  
.....

Ciliary muscles

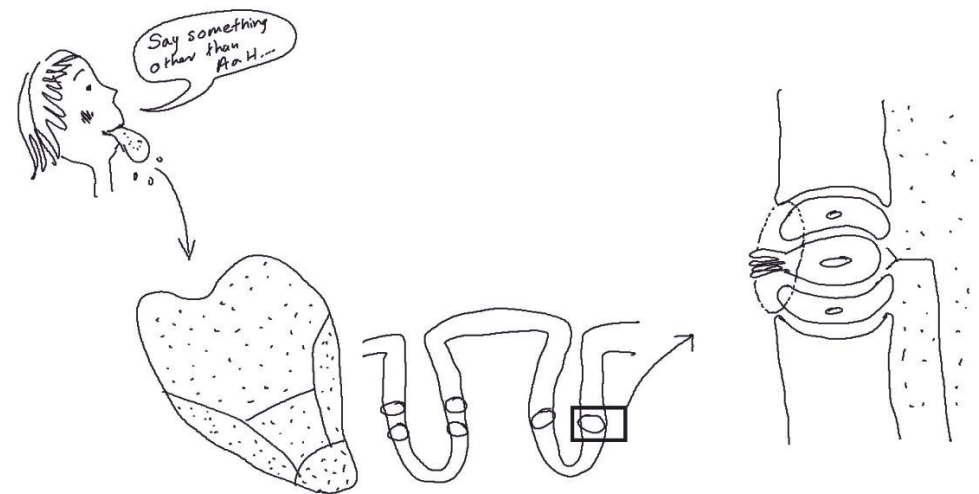
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Suspensory ligaments

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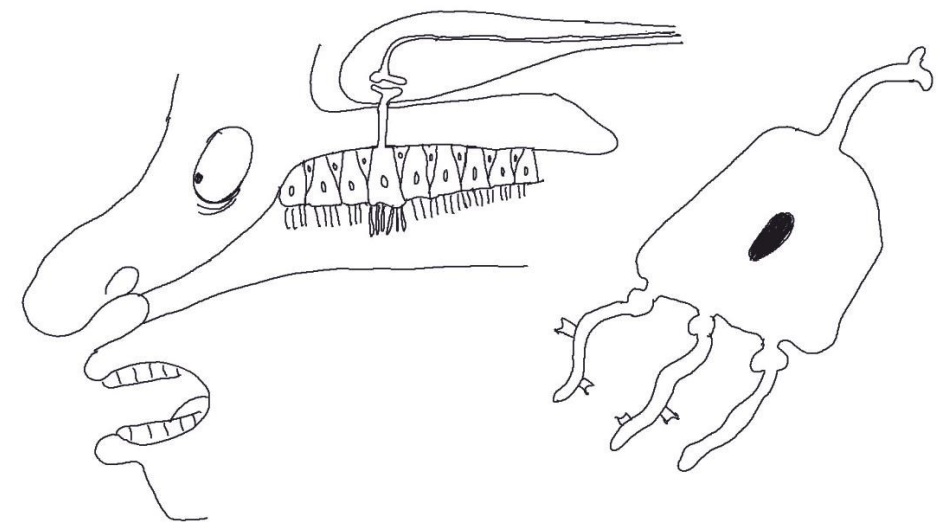
Lens

.....  
.....



• **Olfactory receptors:** .....

Olfactory receptor cells are located within the ..... of the upper portion of the ..... cavity. Receptive ends of the cells extend into the mucus layer of the nasal cavity. When ..... diffuse into this region, ..... cells are stimulated and the nerve impulse is ..... along their axons to the olfactory ..... in the brain.



**Thermoreceptors**

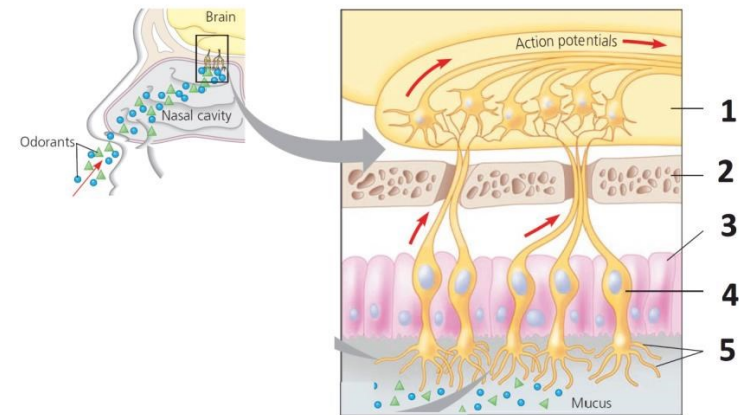
Thermoreceptors are ..... temperature sensitive receptors which detect ..... and ..... on the body ..... and in the ..... environment of the body. Thermoreceptors located in the ..... detect the body surface temperature whereas thermoreceptors found in ..... detects the temperature of the ..... circulating through the ..... organs (core temperature). Thermoreceptors found in the ..... are: ..... end bulbs (detect cold), ..... corpuscles (detect warmth) and ..... nerve endings (detect both ..... and .....). Thermoreceptors found in the ..... are specialized .....

• **Photoreceptors**

Photoreceptors are sensitive for light. Humans have two main types of photoreceptor cells called rods and cones.

- **Rods:** They are more sensitive to light but do not distinguish colours, they enable us to see at night but only in black and white.
- **Cones:** They provide colour vision. But they contribute very little to night vision as they are not much sensitive. There are three types of cones. Each has a different sensitivity across the visible spectrum providing an optimal response to red, green, or blue light

2. Label following diagram.



3. What are locations of thermoreceptors of the body.

.....

4. State different thermoreceptors of skin.

.....  
 .....

5. What is the different between thermoreceptors of skin and hypothalamus.

.....  
 .....

6. State differences between rods and cones.

Rods	Cones

7. What are different sensations captured by mechanoreceptors.

.....  
 .....

8. Explain the location of following mechanoreceptors.

- Touch receptor
- Pressure receptor
- Vibration receptor



23. Which of the following is the correct pathway of light and nerve impulses for vision?

- (1) Cornea→aqueous humour→lens→vitreous humour→photoreceptors→ganglion cells→bipolar cells→optic nerve→occipital lobe
- (2) Cornea→aqueous humour→lens→vitreous humour→photoreceptors→ganglion cells→bipolar cells→optic nerve→temporal lobe
- (3) Cornea→aqueous humour→lens→vitreous humour→photoreceptors→bipolar cells→ganglion cells→optic nerve→occipital lobe
- (4) Cornea→vitreous humour→lens→aqueous humour→photoreceptors→bipolar cells→ganglion cells→optic nerve→occipital lobe
- (5) Cornea→vitreous humour→lens→aqueous humour→photoreceptors→bipolar cells→ganglion cells→optic nerve→temporal lobe

24. Monocular vision affects primarily:

- (1) Color perception (2) Depth perception (3) Light perception (4) Motion perception (5) Contrast perception

25. Binocular vision is important for:

- (1) Color perception (2) Night vision (3) Depth perception (4) Peripheral vision (5) Light sensitivity

26. A person developed a tumour between pons varoli and thalamus affecting that region. Which function would be most affected?

- (1) Movement of eyes (2) Maintenance of balance (3) Memory (4) Control of respiration (5) Speech

27. The three bones in the middle ear are:

- (1) Malleus, incus, and stapes only (2) Hammer, anvil, and stirrup only (3) Both 1 and 2 are correct (4) None of these (5) Only two of these bones exist

28. Sensory adaptation is best exemplified by:

- (1) Adjusting to bright light (2) Getting used to a strong smell (3) Hearing loud sounds (4) Feeling temperature changes (5) Tasting strong flavors

29. In bright light, the pupil:

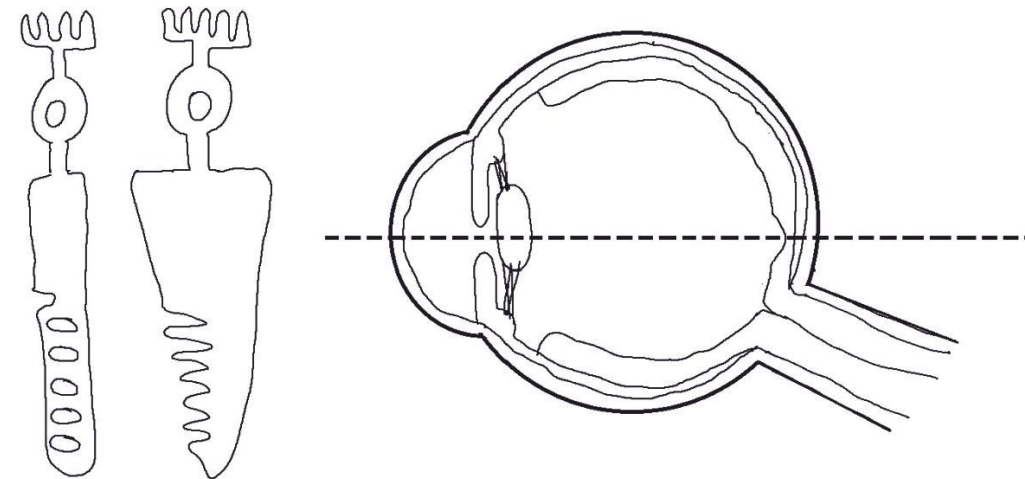
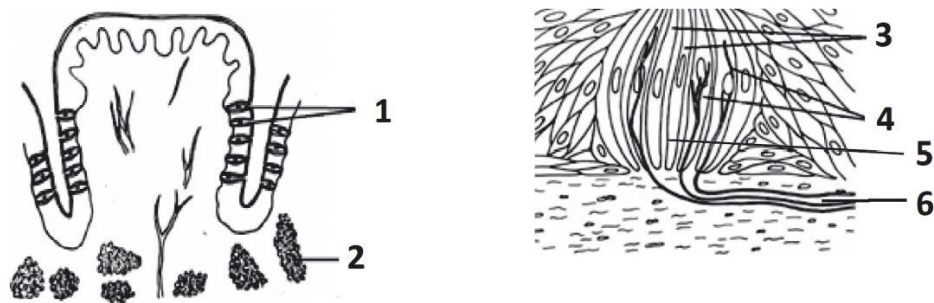
- (1) Dilates (2) Constricts (3) Remains unchanged (4) Disappears (5) Fluctuates rapidly

30. Olfactory receptors are located in:

- (1) Nasal cavity (2) Pharynx (3) Larynx (4) Trachea (5) Bronchi

### Structured Essay Aid

1. Label following diagram.

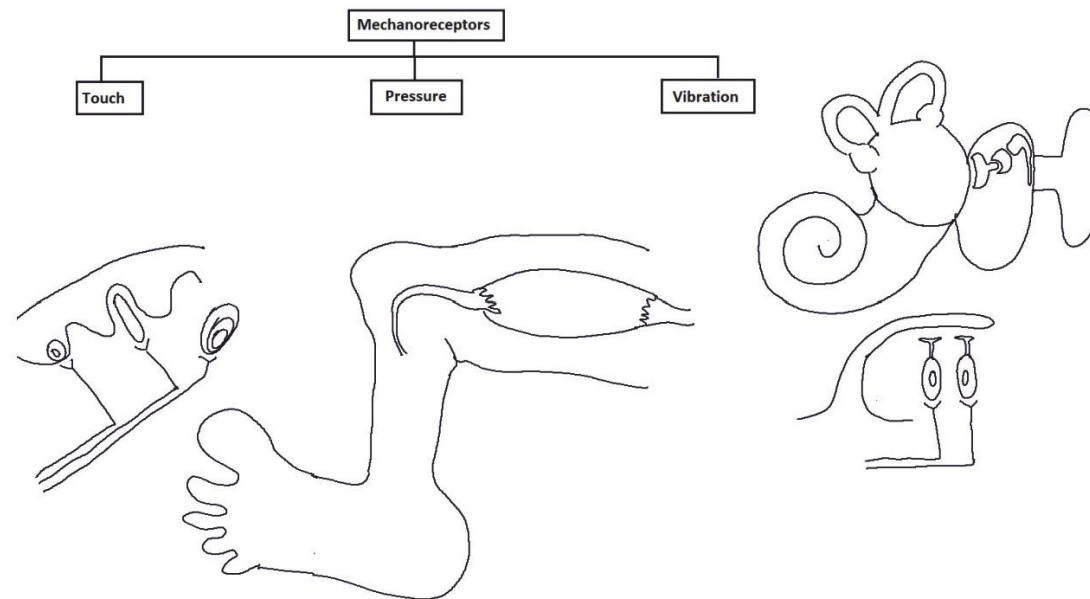


### • Mechanoreceptors

Mechanoreceptors respond to stimuli arising from mechanical energy deformation such as pressure, touch, stretch, motion and sound. Mechanoreceptors in the human body include the following ,

- **Touch receptors:** They are mostly present close to the surface of the skin. Examples for touch receptors are Meissner corpuscles (sensitive to light pressure), Merkel discs (sensitive to light touch) and free nerve endings
- **Pressure receptors:** Example for pressure receptors are Pacinian corpuscles which are present in the deep skin. They are sensitive to deep pressure.
- **Vibration receptors:** Most of the touch receptors can also detect vibrations (Eg: Meissner corpuscles, Pacinian corpuscles). Specific hair cells in the organ of Corti in the inner ear detect sound vibrations. Hair cells of the vestibule of the inner ear detect the gravity whereas hair cells of the semicircular canals detect the motion.





- **Pain receptors**

Pain receptors detect stimuli that reflect harmful conditions that could arise from extreme pressure or temperature and certain chemicals that could damage the tissues. Special nerve endings in different parts of the body can detect the tissue damage. Ultimately the pain is perceived by the brain.

- The middle layer of the eye is:  
(1) Sclera (2) Choroid (3) Retina (4) Cornea (5) Iris
- The aqueous humor is present:  
(1) Between lens and retina (2) In front of the lens (3) Within the lens (4) Behind the retina (5) Within the cornea
- The pigmented layer of the eye that gives color is:  
(1) Cornea (2) Iris (3) Lens (4) Sclera (5) Choroid
- Which of the following is responsible for black and white vision?  
(1) Cones (2) Rods (3) Bipolar cells (4) Ganglion cells (5) Horizontal cells
- The visual pigment in rods is:  
(1) Photopsin (2) Rhodopsin (3) Melanin (4) Iodopsin (5) Carotene
- In the human eye, rods:  
(1) Are found in the fovea centralis (2) Are highly sensitive to light (3) Have high visual acuity (4) Are associated with colour vision (5) Are fewer in number than cones
- Which of the following contains only cones?  
(1) Blind spot (2) Fovea centralis (3) Optic nerve (4) Iris (5) Macula lutea
- The blind spot in the retina is also known as:  
(1) Fovea (2) Macula lutea (3) Optic disk (4) Yellow spot (5) Retinal spot
- Select the correct statement regarding human eye:  
(1) The wall of the eyeball consists of two layers of tissue (2) Fovea is the cone free area of the retina (3) Rods are very light sensitive (4) Vitamin D is connected with night blindness (5) Cones have visual purple
- In the human eye:  
(1) Reflex movements are controlled by mid brain (2) Choroid lines about the 3/4 of the inner surface of sclera (3) Ciliary body is the anterior continuation of retina (4) Vitreous humour is found between the lens and cornea (5) The number of rods is about ten times as that of cones
- The refractory power of the eye can be changed by:  
(1) Cornea (2) Iris (3) Lens (4) Retina (5) Sclera
- Select the correct statement regarding human vision:  
(1) Changing refractory power of cornea facilitates binocular vision (2) Convergence occurs during distant vision (3) Accommodation is important for near vision (4) Photopsin in rods provides night vision (5) Correct perception of visual objects occurs in the frontal lobe of the cerebrum



## Materials and Equipment

- Chart/models of entire human eye and sagittal sections
- Chart showing the retina and retinal cells
- Chart /model of the human ear; external, middle and inner ear

## Instructions

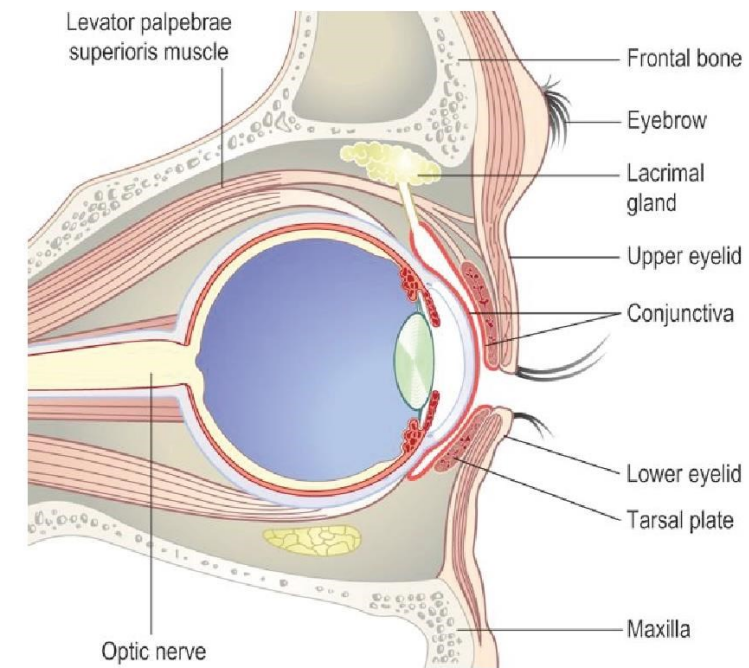
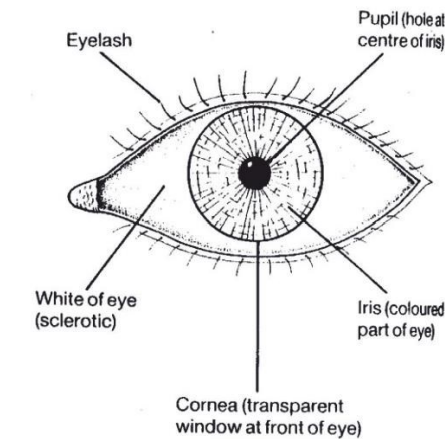
- Allow students to observe the location and structure of the human eye.
- Direct the students to relate the main parts of the human eye to their functions.
- Instruct students to study the various parts and functions in balance and in hearing of the human ear.

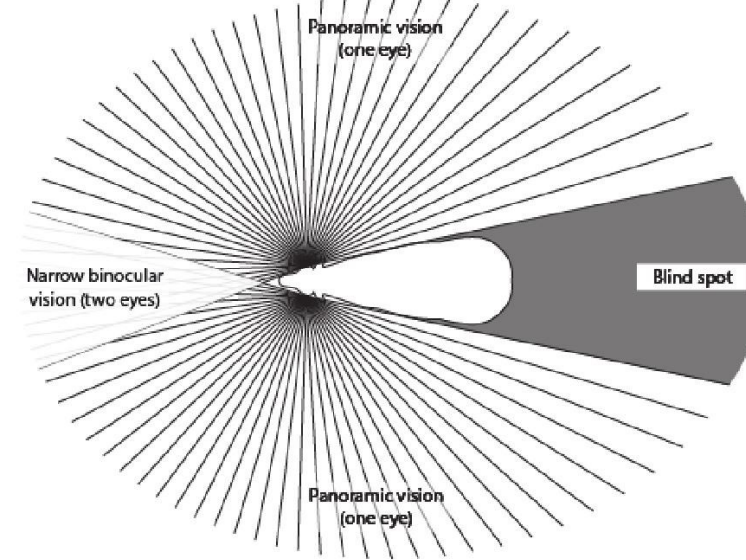
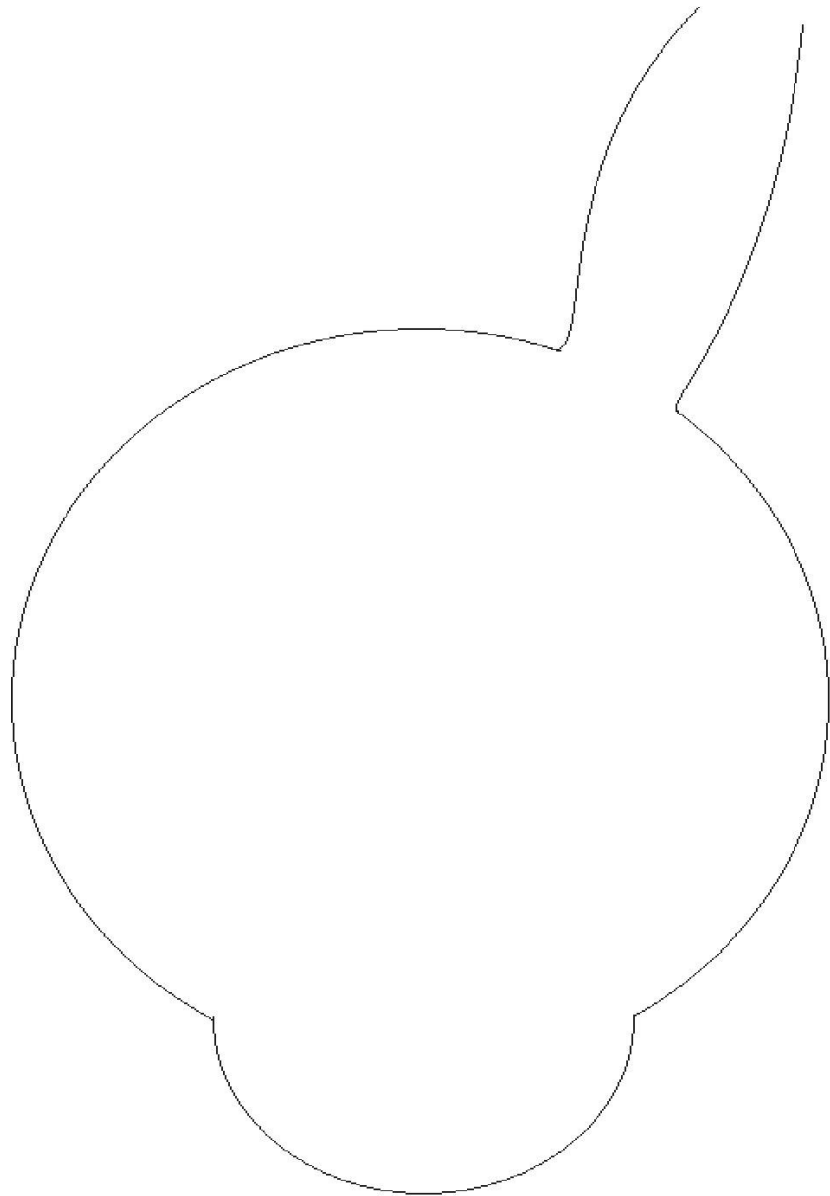
## MCQ Aid

1. Sensory receptors  
(A) Are connected with the nervous system  
(B) Include specialized glands designed to receive specific stimuli  
(C) Show sensory adaptation (D) Can amplify the sensory signal  
(E) Detect the stimuli that arise only in the external environment
2. Which of the following is incorrect about sensory receptors?  
(1) They transform one form of energy to nerve impulses  
(2) Activity of some receptors diminishes with continuous stimulation  
(3) Pacinian corpuscles are mechanoreceptors  
(4) Organ of Corti contains vibration receptors  
(5) Krause's bulbs are sensitive to high temperatures
4. The basic taste sensations include all EXCEPT:  
(1) Sweet (2) Sour (3) Spicy (4) Umami (5) Bitter
5. Chemoreceptors in blood primarily detect:  
(1) O<sub>2</sub> (2) CO<sub>2</sub> (3) N<sub>2</sub> (4) H<sub>2</sub> (5) He
6. Select the correct statement regarding sensory receptors of man:  
(1) Receptors for taste are modified neurons  
(2) Olfactory receptors show sensory adaptation  
(3) Ruffini corpuscles detect cold  
(4) Cones are more sensitive to light than rods  
(5) Hair cells of the vestibule of the ear detect angular movements
7. Thermoreceptors that detect cold in the skin are called:  
(1) Ruffini corpuscles (2) Krause end bulbs (3) Free nerve endings (4) Pacinian corpuscles  
(5) Meissner corpuscles
8. Which type of receptor detects pressure in deep skin?  
(1) Meissner corpuscles (2) Merkel discs (3) Pacinian corpuscles (4) Free nerve endings  
(5) Ruffini corpuscles
9. The iris of the eye is formed from:  
(1) Retina (2) Sclera (3) Choroid (4) Ciliary body (5) Lens
10. The inner layer of the eye is:  
(1) Sclera (2) Choroid (3) Retina (4) Cornea (5) Iris

## Basic Structure and Function of Human Eye

The eye is the organ responsible for sight. There is a fine ..... membrane that lines the ..... and front of the eye ball; this is called ..... The walls of the eye are made up of ..... layers of tissue: The outer ..... layer (sclera and cornea), the middle ..... layer (choroid, ciliary body and iris) and the inner ..... layer (Retina). Inside the eyeball contains the ....., aqueous ..... and ..... body





.....  
 .....  
 The left eye views more on the left of the visual fields. The right eye views more on the right of the visual fields. ....  
 .....

However only one image is perceived due to the fusion of left, middle and right of the visual field images from the two eyes in the occipital lobe of the cerebrum. Unlike monocular vision, ..... vision enables ..... views. So binocular vision is very important in judging the ..... and ..... of an ..... object such as a vehicle. It gives more ..... assessment of one object relative to another in relation to ....., ....., ..... and ..... In some individuals, binocular vision may be impaired. Such individuals face difficulties to judge the speed and distance of an approaching object.

**PRACTICAL NO. 25**

**Study the structure of the human eye and ear using diagrams /models /charts.**

**Expected Learning Outcomes**

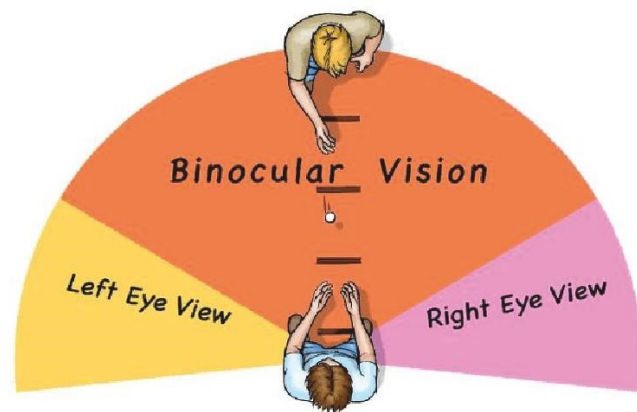
1. Makes appropriate sketches of the human eye and the ear.
2. Observes the location and the structure of the human eye and the ear.

- Choroid functions in absorption of light after the entered light stimulate sensory receptors in the retina.

### Monocular vision and binocular vision in human

In humans, both eyes are located in front of the face which facilitates coordinated vision from the two eyes. However it is possible to see Visual fields with one eye. ....

.....  
 .....  
 .....



### Sclera and cornea

- .....  
 ..... It connects anteriorly With the clear transparent epithelial membrane called ..... Sclera maintains the ..... of the eye and gives attachment of the ..... muscles of the eye.
- Cornea is the ..... through which light rays reach the retinal. It is ..... of ..... vessels. The cornea is convex ..... and is involved in refracting ..... rays to ..... on the retina.

### Choroid, ciliary body and iris

- Choroid is located just ..... the sclera. It is a thin ..... layer and ..... with blood vessels.
- Ciliary body is the ..... of the choroid layer consisting of ..... muscle fibers (ciliary muscle) and ..... epithelial cells. Most of these smooth muscle fibers are circular. Therefore ciliary muscles act as a sphincter. The ciliary body holds the ..... in place by ..... ligaments. The size and ..... of the lens can be controlled by ..... and ..... of the ciliary muscle fibers attached to these suspensory ligaments. Epithelial cells ..... aqueous humour.
- Iris is a ..... body composed of ..... cells. It is located at the front of the eye. It extends anteriorly from the ciliary body and present behind the cornea and in front of the lens. It contains ..... layers of smooth muscle fibers which are arranged as ..... and ..... bundles In the center of ..... is a hole called ..... Iris controls amount of light entering the pupil by changing size which is mediated by the autonomic nervous system. Pigments prevent penetration of excessive light.

### Lens

The lens is lying immediately behind the pupil. It is an ....., ..... transparent ..... made up of protein enclosed within a ..... capsule. It refracts light rays reflected by objects in front of the ..... and focuses them on the retina to form the image by changing the ....., the lens can vary its refractive power in order to focus rays on the retina.

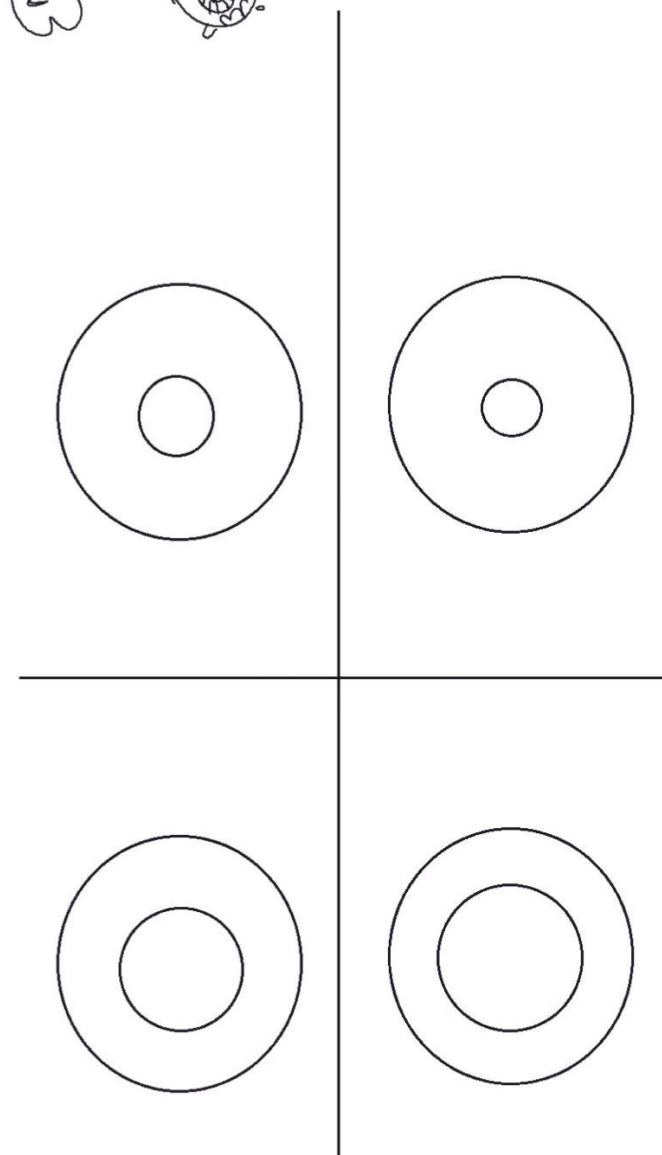
**Aqueous fluid (aqueous humour) and vitreous body (vitreous humour)**

.....  
.....  
.....

Aqueous fluid supplies nutrients and removes wastes from the cornea, lens and lens capsule which have no blood supply. Behind the lens a colourless and transparent jelly like vitreous humour is present. It maintains enough intra ocular pressure to support the retina against choroid and prevents the eye ball from collapsing

**Retina**

- Retina is the innermost lining of the eye. It consists of three layers: Outer pigmented epithelium, middle photoreceptive layer and inner layer with neurons. Photoreceptor layer consists of sensory cells (rods and cones) which contain photosensory pigments that can convert light rays into membrane potential change. Retina is thickest at the back. At the centre of the posterior part of the retina, macula lutea (yellow spot) is present In the centre of the yellow spot there is a little depression called the fovea centralis which contains only cones. Towards the anterior part of the retina there are fewer cones than rods. About 0.5 cm to the nasal side of the macula lutea all the nerve fibers of the retina converge to form the optic nerve. The small area of retina Where the optic nerve leaves eye is the blind spot (optic disk). It lacks photoreceptors.

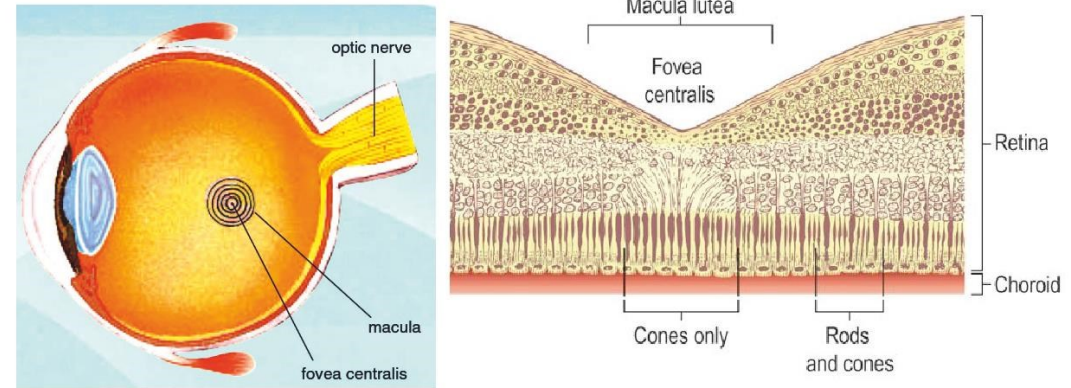


For clear vision, the amount of light entering the eye is controlled by changing the size of the pupil which is mediated by the autonomic nervous system.

- **Constriction of the pupil:** In bright light, pupils are constricted to avoid entering too much light into the eye and damage the sensitive retinal. In dim light, the pupils are dilated to allow entering sufficient light to activate photoreceptors which would eventually enable the vision. Light rays coming from the distant objects need least refraction but as the object comes closer, the amount of refraction needs to be increased to focus light rays on the retina. Hence for near vision the eye must make some adjustments
- **Movement of the eye ball (convergence):** As light rays from near objects enter the two eyes at different angles, for clear vision they must stimulate corresponding areas of two retina. Muscles attached to the eye ball rotate the eyes to achieve the convergence. This is under autonomic controls.
- **Changing the refractory power of the lens:** Parasympathetic nervous supply to the ciliary body controls the contraction of ciliary muscles and accommodation of eye. Accommodation is important in near vision for focusing on near objects. In near vision the ciliary muscles contract thereby moving the ciliary body inwards towards lens. As a result convexity of the lens is increased due to the reduction of the pull of the suspensory ligaments on the lens. Thus light waves from the near objects are focused on the retina. When seeing a distant object, ciliary muscles relax, then ciliary body moves away from the lens that increases the pull of the suspensory ligaments on the lens so convexity of the lens is reduced thus light rays from distant objects are focused on the retina.

#### **Focusing the image on the retina and converting the light energy to action potential to be transmitted to the brain**

- The light waves coming from the object are bent (refracted) and focused on the retina. This process produces an image on the retina which is upside down. Once light rays reach the retina, chemical changes happen in the photoreceptive cells (rods and cones).
- Bipolar cells receive information from photoreceptor cells and each ganglion cell gathers inputs from several bipolar cells. In addition, specific neurons in the retina can integrate information across the retinal. Ganglion cells form the optic nerve fibers that transmit sensation from the eyes as action potential to the brain. This change will generate a nerve impulse
- The optic nerve transmits this nerve impulse into occipital lobes (visual area) of the cerebrum. There the visual objects are perceived in the correct way (the right way up) by the brain.



- **Photoreceptor cells:** There are two types: rods and cones. Within the outer segment of these cells is a stack of membranous disks in which visual pigments are embedded. In the retina, more rods are present than cones. In the rods visual pigment is rhodopsin. They are sensitive to light but do not distinguish colours. They enable us to see at night but only in black and white. In the cones, visual pigment is photopsin. They provide colour vision. They contribute very little to night vision as they are less sensitive. There are three types of cones each of which has a different sensitivity across the visible spectrum providing an optimal response to red, green or blue light.
- **Neurons in the retina:** are present including bipolar cells and several types of neurons ganglion cells.

#### **Functioning of the human eyes**

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Cones are sensitive to light and colour therefore bright light is needed to activate them and



give sharp clear colour, vision. The different wavelengths of visible light activate light sensitive pigments in the cones Which result in perception of different colours.

• **Refraction of light rays**

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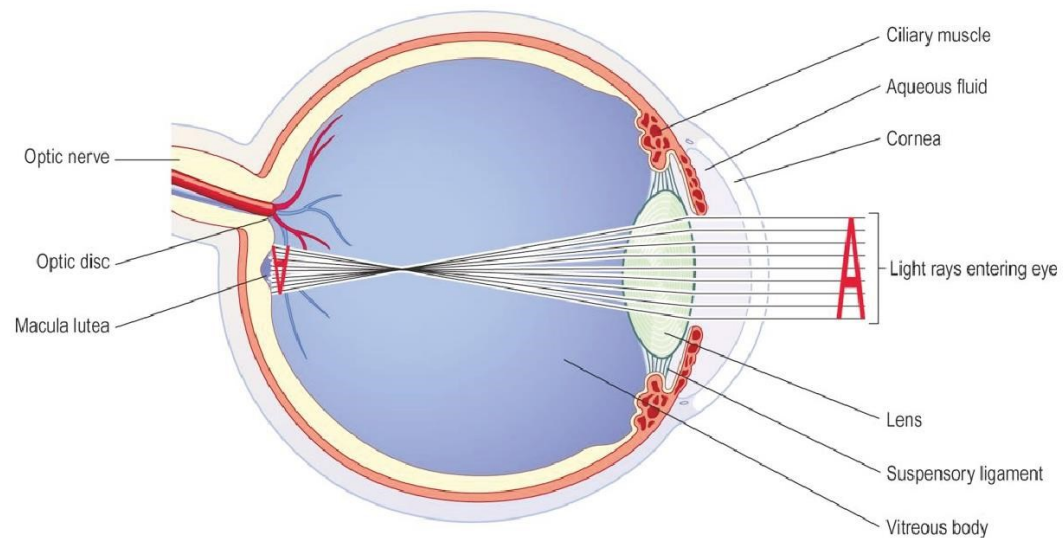
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• **Changing the size of the pupil, convergence and accommodation**

