UNIT 14 VISUAL PATHWAY, FIELDS AND VISUAL CORTEX

Structure

14.0 OBJECTIVES

After completing this unit, you should be able to understand:

- the visual nervous system;
- the visual pathway from the retina to the visual cortex; and
- how a visual field examination is done.

14.1 INTRODUCTION

The nervous tissues throughout the body, including the visual nervous system, are continuously active. Electrical reactions can only be induced if there is an active membrane that provides the source of electricity. In the retina an electrical stimulus is generated between the photoreceptors and the pigment epithelium to form this membrane. Through this the visual system functions as an information converter from the photoreceptor layer to simpler neurological images.

The visual pathway (Fig. 14.1) or the *retino calcarine* pathway includes:

1) Retina
2) Optic nerve
3) Optic chiasma
4) Optic tract

5) Lateral geniculate body
6) Optic radiation
7) Visual or calcarine cortex.

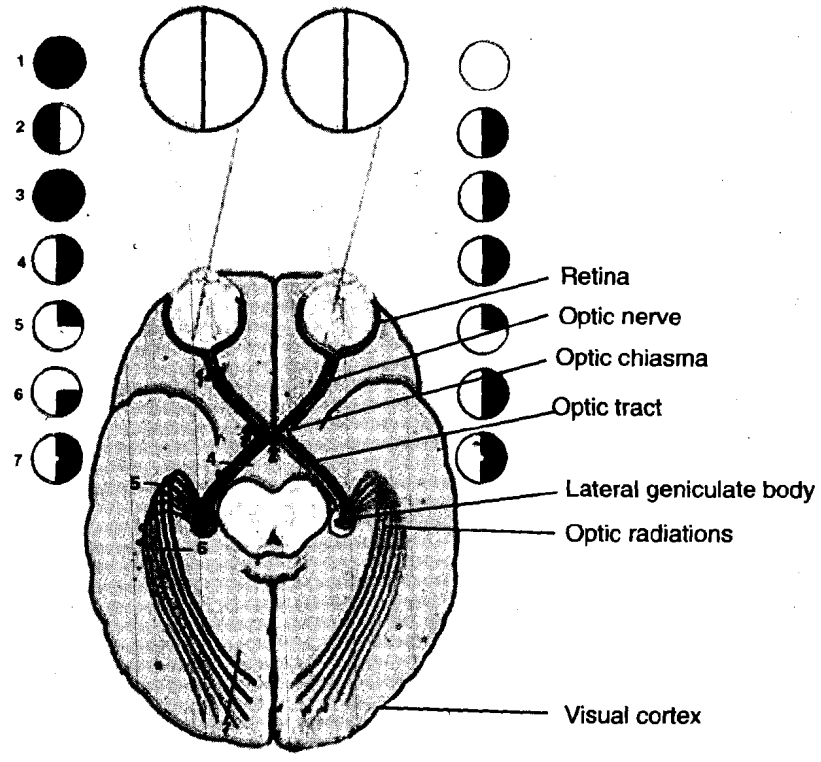

Fig.14.1: Visual pathway

Check Your Progress 1

What are the parts of the visual pathway?

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14.2 RETINA

The **retina** is a highly complex layer of nervous tissue. The photoreceptors are rods and cones for **scotopic** and **photopic** vision respectively. The retina is structured such that several rods are connected to a single bipolar cell and each cone is connected to an individual bipolar cell. Cones are connected to each other by horizontal cells. Upon ophthalmic examination, the fundus oculi (including the retina, its vessels and the optic disc) are visible. The macula, about 5-6 mm in diameter, contains the fovea, which is responsible for colour vision and has the highest visual acuity. The optic disc is also called a blind spot while the macula is referred to as the yellow spot. The ora serrata (the intersection between the retina and the pars plana) can be seen through indirect ophthalmoscopy. The red colour of the fundus is because of the transmission of light reflected from the posterior sclera through the capillary bed of the choroid.

Layers

The retina is composed of ten layers:

a) Pigmented epithelium (outermost layer),
b) Neuroepithelium, rods and cones (photoreceptors),
c) External limiting membrane,
d) Outer nuclear layer,
e) Outer plexiform layer,
f) Inner nuclear layer (bipolar neuronsj,
g) Inner plexiform layer,
h) Ganglion cell layer (ganglion cells),
i) Nerve fibre layer, and
j) Internal limiting membrane (innermost layer).

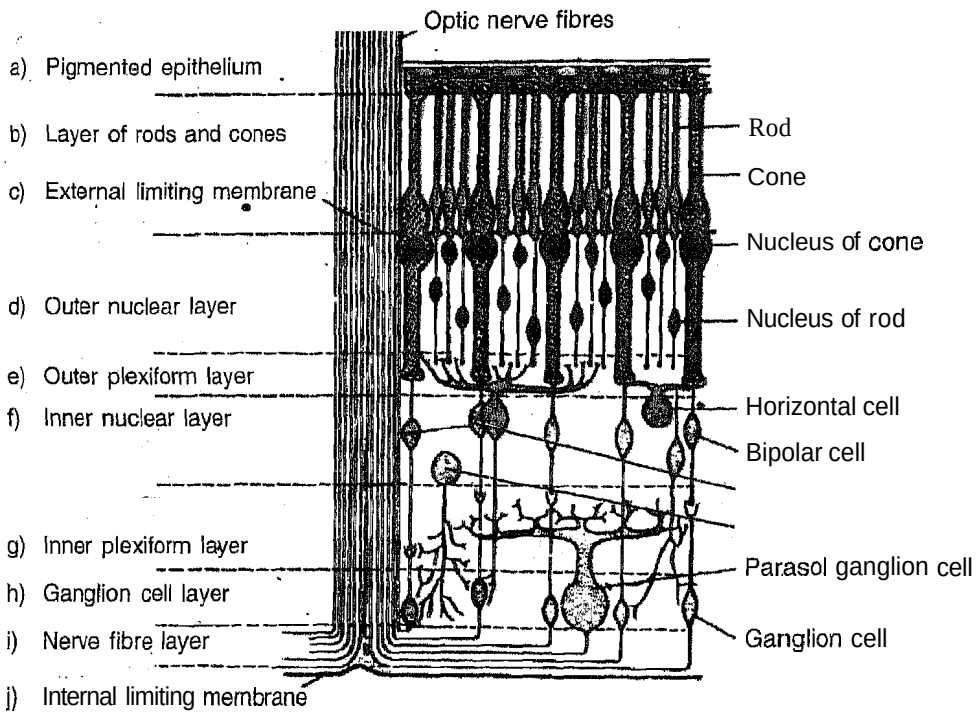


Fig. 14.2: Microscopic structure of the retina

14.3 OPTIC NERVE

The optic nerve contains more than one million axons that initiate in the ganglion cell layer of the retina. This structure originates at the back of the eye just above and medial to the posterior pole. It continues on from the retinal nerve fibre layer. The optic nerve consists of visual fibres and pupillomotor fibres (for pupillary reflex and ocular movements). Fibres from peripheral retina lie deeper in retina but occupy the most superficial part of optic nerve while those from central retina are superficial in retina but centrally placed in the optic nerve.

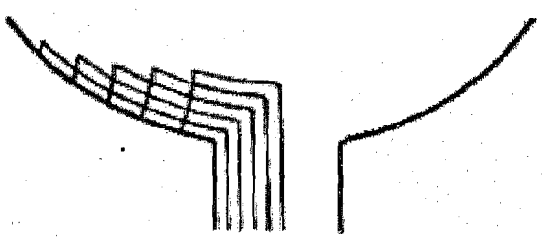


Fig. 14.3: Arrangement of nerve fibres at the optic nerve head

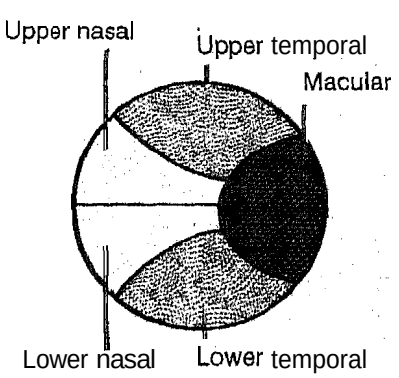
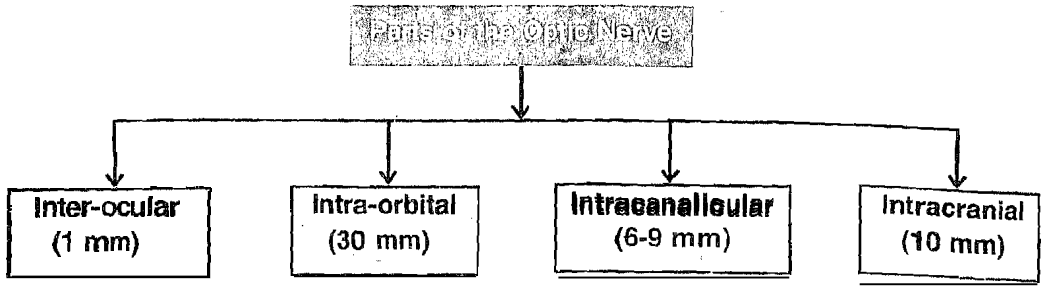


Fig. 14.4: Arrangement of fibres in the distal region (behind the eyeball) of optic nerve



Check Your **Progress** 2

Where does the optic nerve originate?

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14.4 OPTIC CHIASMA

This structure makes up a portion of the anterior inferior floor of the third ventricle. It is shaped like a flat oblong bridge and connects the optic nerves and optic tract. The optic chiasma is richly vascularized and is approximately 8 mm long, 12 mm wide and 4mm thick. In 80 per cent of cases the optic chiasma lies over the diaphragma sellae (centralchiasma). Macular projects are located centrally in tlic optic nerve and make up 80-90 per cent of the total volume of the optic nerve and the chiasmal fibres. Nasal macular fibres cross in the posterior portion of the chiasma.

14.5 OPTIC TRACT

The optic tracts arise from optic chitasma and end in tlic lateral geniculate body. Fibres from the upper retinal projections travel medially in the optic tract while lower projections tend to move laterally. The pupillary reflex fibres move to the superior colliculi and the lower visual reflex centres, which influence head, neck, and tnmk movements in response to visual, auditory, and somatic sensations.

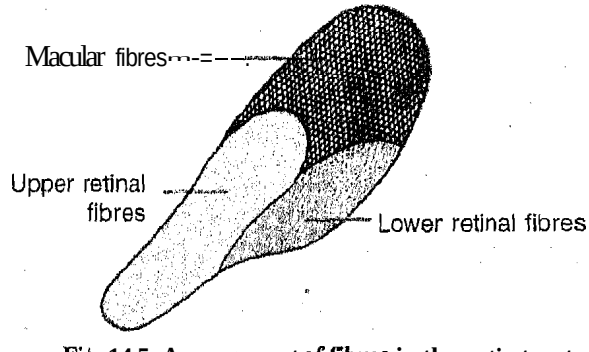

Fig. 14.5: Arrangement of fibres in the optic tract

14.6 LATERAL GENICULATE BODY

Also known as the nucleus, the lateral geniculate body is the synaptic zone for higher visual projections. It receives about 70 per cent of the optic tract fibres in its 6 layers of neurons (laminae 1-6). The six layers give rise to the optic radiations.

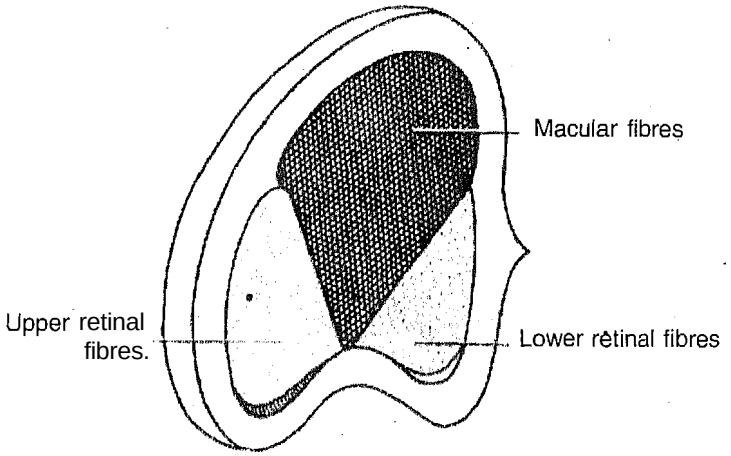

Fig. 14.6: Arrangement of fibres in the lateral geniculate body

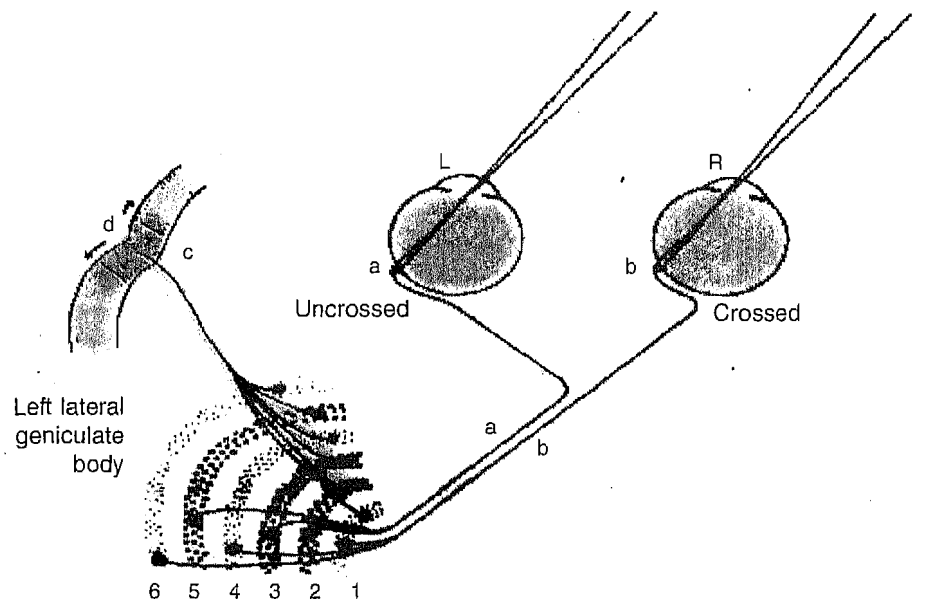

Fig. 14.7: Arrangement of termination of axons of ganglion cells (second order neurons of vision) of the two eyes in the lateral geniculate body

14.7 OPTIC RADIATIONS

Also called geniculocalcarine pathway. These are formed by neurons originating from the lateral geniculate body and extend up to the striate cortex. They are 3rd order neurons. The inferior fibres subserve the superior visual Fields and proceed to temporal lobe whereas the superior fibres subserve the inferior visual fields and proceed through the parietal lobe to the visual cortex.

14.8 VISUAL CORTEX

The visual cortex is the thinnest area of the cerebral cortex. Also known as the cortical retina (a true copy of the retinal image is formed here), it is located in the medial aspect of the occipital lobe around the calcarine fissure and may extend laterally. The cortex is divided into two sections—the visuosensory area (striate area 17) and the visuopsychic area (parastriate area 18 and 19). The visuosensory area is also called Brodman's area and it receives the fibres of the optic radiations. The parastriate area deals with visual association areas. Impulses that originate from the two corresponding points of the retina meet only in the visual cortex. The image that is formed in the visual cortex is what we can actually see,

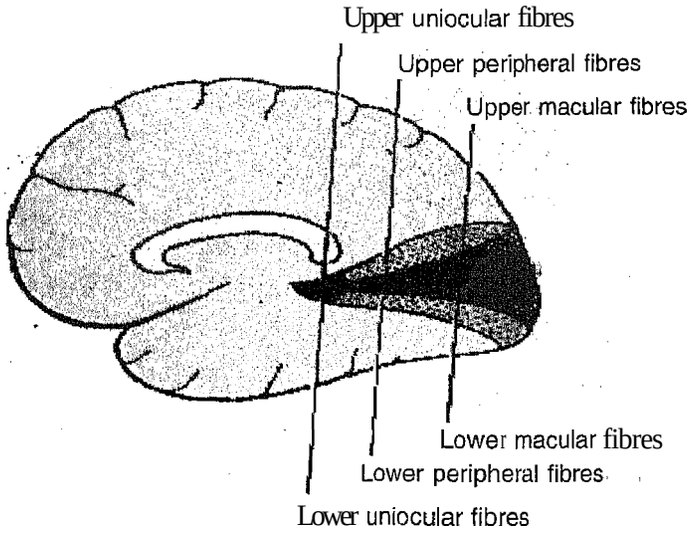

Fig. 14.8: The visual cortex

14.8.1 Physiological Aspects

The complete aspects of the visual cortex are unknown but can be discussed under the following general headings:

- Concepts of receptive field of striate cortex
- Columnar organization of striate cortex
- Serial versus parallel analysis of visual image
- Role of extra-striate cortex in visual function
- Psycho-physiological aspects of visual function

Concepts of Receptive Field of Striate Cortex

Cortical cells are named as three receptive field types—simple, complex, and hyper complex. Simple cells are found in the 4th layer of the visual cortex. Their function is to detect lines and borders and retinal images. Complex cells are found in the cortical layer above and below the 4th layer. These cells help in detection of lines, bass, and edges when they are moving. Hypercomplex cells are found in the 2nd and 3rd cortical layer. They help in detection of lines of specific length, angle or other shapes.

Columnar Organizatioiiof Striate Cortex

The visual cortex is an organized structure of several million veitical columns of neuronal cells. It helps in depth perception and in localization of points in three dimensions.

Serial versus Parallel Analysis of Visual Image

The parallel processing system organizes different types of visual information into different brain locations. There is a coinbination of serial and parallel analysis to give one full interpretation of the visual scene.

Role of Extra-striate Cortex in Visual Function

The extra-striate cortex sends information from the striate neurons to neurons of area 18, colour processing area (V4), motion processing area (MT), stereoscopic depth perception area (V2 &V3) and pulvinar. These regions arc specialized for processing particular aspects of visual information.

The visual cortex connects by way of its associated cortex with tactile sense, motor, auditory, olfactory and speech centses. These interconnections allow us to perceive several qualities simultaneously and to synthesize a united picture for our mind's eye.

Check Your Progress 3

What is another name for the visual cortex?

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14.9 VISUAL FIELDS

The visual field is commonly referred to as an "island of vision in the sea of blindness". It includes superiorly 60°, nasally 60°, inferiorly 75°, and temporally 100". A scotorna is a non-seeing area in the visual field. There are two categories: relative and absolute. Relative scotoma means scotoma that will be present only when tested with a small or less intense target. Absolute scotoma is present Io all targets. A visual field can be examined through a confrontation test, an arc perimetry for peripheral fields, a campimeter (Bjerrum's screen) for central fields, or an automated field analyzer like Humphrey's, Octopus or Oculus centerfield.

14.9.1 Perimetry

Perimetry is a quantitative analysis or mapping of the visual field defects using a perimeter. It is used to determine the topography of vision and to recognize any variation from the normal field. The general method of analysis is to adapt the eye to a background luminance and then present a brighter stimulus (target). The ability to distinguish the stimulus is tested either kinetically or statically. In the kinetic test the stimulus is presented in the periphery of the visual field and it is slowly brought towards fixation. It is brought from a non-seeing to a seeing area. This process is repeated in other ineridia. In the static test the stimulus size remains constant. Each point in the Geld is tested by varying the stimulus intensity until the visual threshold at that point is determined. This process is repeated until all the desired positions in the retina are tested and their threshold is defined.

14.9.2 Methods of Visual Field Examination

1) **Confrontation Test: A** rapid qualitative screening technique used to locale gross defects in the peripheral field.

2) **Tangent Screen: A** useful central field examination method to test the visual field by kinetic perimetry.

3) **Goldman Perimetry:** Consists of a bowl perimeter that provides standardized background and stimulus intensity; test performed through kinetic perimetry.

4) **Automated Perimetry:** Used to make analysis easier by comparison of an individual examination with a stored database of predicted normal values. It can perform both static and kinetic perimetry.

Check Your Progress 4

What is perimetry?

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14.10 LET US SUM UP

In this unit you have learnt the visual system functions as an information converter from the photoreceptor layer to simpler neurological images. The visual pathway begins at the retina and goes to the visual cortex through the optic nerve, optic chiasma, optic tract, and lateral geniculate body. The visual cortex is the thinnest area of the cerebral cortex. It is also known as the cortical retina **(a** true copy of the retinal image is formed here). The visual field is commonly referred to as an "island of vision in the sea of blindness". It includes superiorly 60°, nasally 60°, inferiorly 75°, and ternporally 100°. A scotoma is a non-seeing area in the visual field. The methods of visual field examination include: confrontation test, tangent screen, goldman perimetry, and automated perimetry. In next unit you will learn about visual acuity, uni-ocular and binocular vision.

14.11 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

The visual pathway consists of

i) Retina

ii) Optic nerve

iii) Optic chiasma

iv) Optic tract

v) Lateral geniculate body

vi) Optic radiation

vii) Visual or calcarine cortex

Check Your Progress 2

The optic nerve which consits of visual and pupillation fibres originate from the back of the eye just above and medial to the posterior pole.

Check Your Progress 3

Visual cortex is also known as the cortical retina.

Check Your Progress 4

Perimetry is a quantitative analysis or mapping of the visual field defects using a perimeter. It is used to determine the topography of vision and to recognise any variation from the normal field.