Compound Eye

In case of Arthropods eyes are two types simple eye (in some Copepods) or Oceli and Compound eye. In case of Cockroach and Prawn compound eyes are found.
Compound eyes are usually two types Photopic and Scotopic.
Photopic: It forms the Aposition image and it is found in diurnal insects such as Cockroach, Butterfly etc.
Scotopic: It forms the Superposition image and it is found in nocturnal insects such as Prawn, firefly etc, which helps to form image in dim light.

Compound eye of Cockroach:

Here in case of Cockroach we can study the structure and mechanism of **Photopic compound eye.**

In cockroach, usually compound eyes are found. The compound eyes of cockroach are a pair of large, sessile, black, kidney-shaped structures situated at the dorsolateral sides of the head capsule. It is a complicated structure and covered externally by the cuticle which is transparent. The transparent cuticle covering the compound eyes is divided into a large number of hexagonal compartments (2000 in cockroach) called corneal facets.
These facets possess ectodermal structures beneath them arranged vertically and radially in the compound eyes. One facet and all the elements beneath it constitute an ommatidium which is in fact the visual unit. Thus, a compound eye consists of a large number of visual units or ommatidia and 2000 such visual units are found in a compound eye of cockroach.

Structure of an Ommatidium:

An ommatidium has a **bi-convex lens** or **cornea** which is formed by the cuticle becoming thickened and transparent, these form the facets. Below the lens the epidermis forms two clear **corneagen cells** or lenticular cells which secrete the lens. Below the corneagen cells is a transparent **crystalline cone** which functions as a second lens, it is surrounded by four vitrellae or **cone cells**.
The vitrellae secrete the crystalline cone, they taper downwards. All this forms the focusing or **dioptrical region**. Below the cone and in contact within is a spindle-shaped refractive body, the **rhabdome** surrounded by seven photoreceptor **retinular cells** or retinulae which are elongated cells.
The retinular cells secrete the rhabdome which is made up of seven **rhabdomeres**, one for each retinular cell. The rhabdome and retinulae constitute the receptor region, and below it is a basement membrane of the eye. Each retinular cell joins a nerve fibre at its base, and the fibres enter the optic nerve.

Surrounding each ommatidium and separating it from its neighbours in many insects there are heavily pigmented cells arranged in two groups, an iris pigment sheath around the cone, and a retinal pigment sheath around the rhabdome and retinular cells. The retinal pigment sheath is absent in some insects.

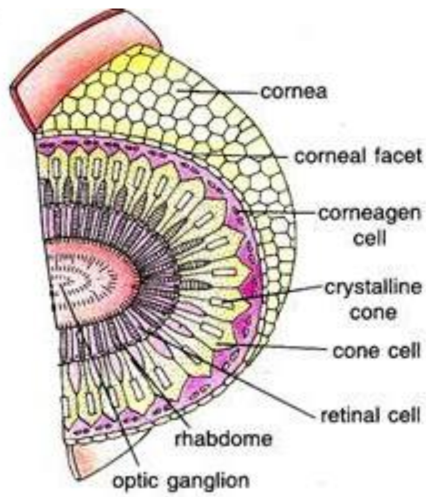

Fig. 73.29. *Periplaneta.* Gross V.S. of a compound eye.

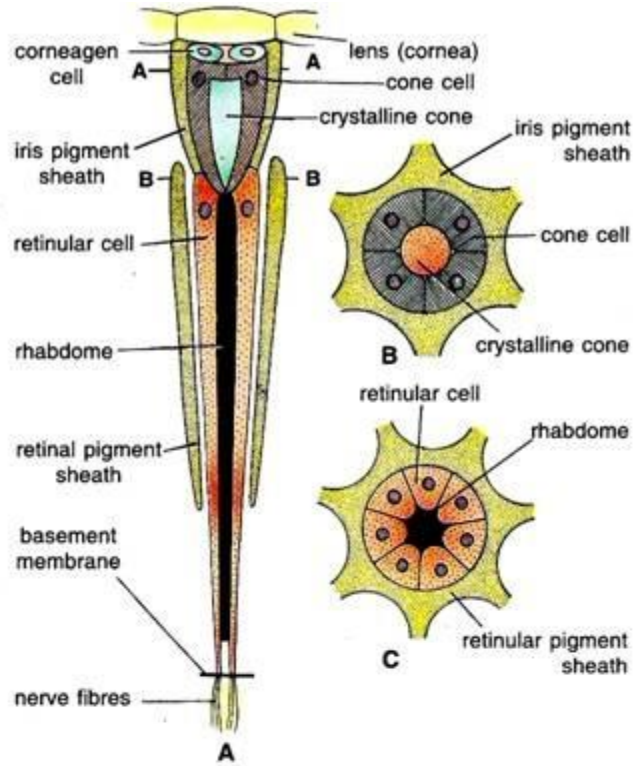

Fig. 73.30. *Periplaneta.* A—L.S. of an ommatidium ; B—T.S. through cone at A—A ; C—T.S. through rhabdome at B—B.

Working Mechanism of Photopic Compound eye:

The working of the compound eye is very complex. In the formation of an image, several adjacent ommatidia take part and light enters through them.

Each ommatidium is capable of producing a separate image of a small part of the object seen. Therefore, the whole image formed in a compound eye is actually made of several small pieces contributed by the several adjacent ommatidia. On this account the vision effected through a compound eye is called mosaic vision

In **diurnal arthropods** the compound eyes are adapted for **bright light** and it produces an **apposition** or mosaic image.

Formation of apposition or mosaic image:

In the bright light, during the day time, the pigment cells spread in such a way that they completely separate optically one ommatidium from the adjacent ommatidia.

In this condition, rays of light, which strike the cornea obliquely, are absorbed by the pigment cells, therefore, they cannot produce a visual effect. Only those rays of light, which pass directly through the centre of the cornea, can travel through the ommatidium and reach the rhabdome to from an image of a part of an object.

These small parts, placed together like the parts in a mosaic, form the image of the entire object. This is known as a mosaic vision in which the rays are received simultaneously by distinctly separate visual elements, i.e., ommatidiaand the image is made up of several components placed in juxtaposition. Such an image is called an apposition image.

The sharpness of the image depends upon the number of ommatidia involved and the degree of their isolation from one another ; the larger number of ommatidia and more complete their isolation from one another, the sharper the image.

However, an eye adapted for this type of image formation functions best at short distances only; it is, therefore, most of the arthropods are short-sighted. Such arthropods are usually night blind, e.g., Cockroach, Butterflies.

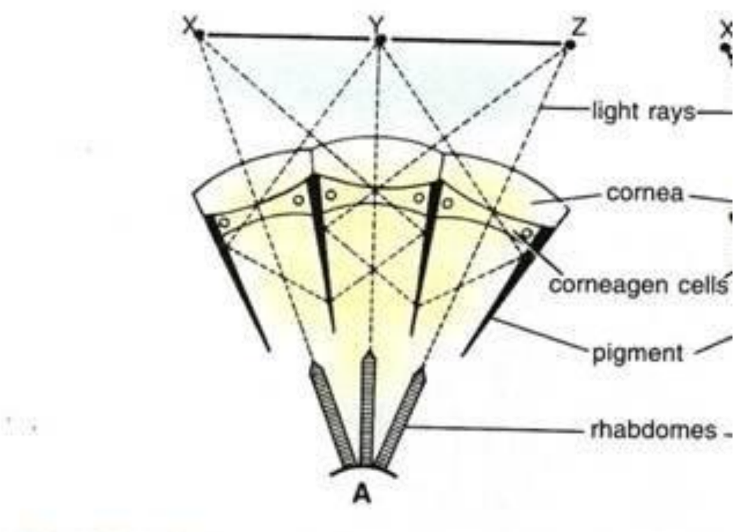

Fig: Formation of Apposition image

Compound eye in Prawn:

In case of Prawn we can study the structure and mechanism of **Scotopic** compound eye

Structure:

In *Palaemon*, there is a pair of black and hemispherical compound eyes. Each eye is borne on a short two-jointed movable stalk lying in an orbital notch.

Each eye is a composite structure made of a large number of structural and functional visual units called ommatidia lying radially. This type of eyes, made up of hundreds or thousands of ommatidia, are termed as the compound eyes and are found in majority of arthropods.

The eye is covered with a transparent chitinous covering of cuticle forming a cornea. The cornea is divided into a large number of square facets placed in juxtaposition like squares of a graph paper. Each facet corresponds to a single ommatidium and below each facet lies one ommatidium inside the eye. All ommatidia are simple and are arranged radially lying side by side and separated by dark pigment cells.

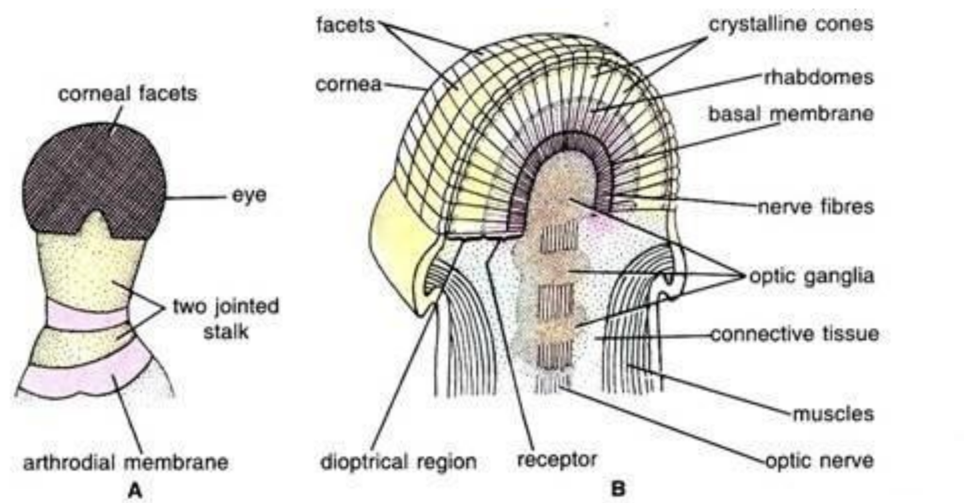

Fig. 71.31. *Palaemon.* A—Compound eye; B—A diagrammatic L.S. of compound eye showing arrangement of ommatidia.

Structure of ommatidium:

Each ommatidium is composed of a number of cells arranged end to end along a central axis.

However, it comprises the following structures:

(i) Cornea:

The outermost layer of an eye is the transparent cuticle forming cornea which is divided into a large number of square-like facets. These facets are thickened in the centre to give them the appearance of a biconvex lens. Thus, each corneal facet behaves like a lens and sheds off at the time of moulting, again secreted by the underlying cells.

(ii) Corneagen cells:
Each corneal facet is followed by a group of two cells; these cells are modified epidermal cells called corneagen cells. Their function is to secrete cornea when it is moulted off.

(iii) Cone cells or vitrellae:
These are a group of four much elongated cells situated beneath the corneagen cells. These cells secrete and enclose a transparent and refractile crystalline cone which works like a second lens. The inner end of cone cells is long and tapering. The cornea, corneagen cells and cone cells together constitute the dioptrical region, whose function is to focus the light rays on the inner sensitive region.

(iv) Retinal cells:
The cone cells are followed by a group of seven elongated cells forming the proximal part of the axis of an ommatidium. These cells are elongated and provided with distally placed dilations having nuclei.

(v) Rhabdome or optic rod:
It is an elongated, spindle-shaped and transversely striated body which is secreted and fully enclosed by the retinal cells.

(vi) Basement membrane:
It is the innermost layer of a thin fenestrated membrane that marks the internal boundary of the ommatidia in a compound eye. The ommatidia are innervated by optic nerve fibres, coming from optic ganglia, through the fenestrae in the basement membrane. The retinal cells and rhabdome up to the basement membrane constitute the receptor region; its function is to receive the light rays focused by the dioptrical region.

Pigment sheath:
Each ommatidium is cut off from its neighbouring ommatidia by a sheath of dark pigment formed by the surrounding amoeboid chromatophores which are arranged in two groups. The proximal group surrounding the rhabdome forms the retinal pigment and the distal group surrounding the crystalline cone forms the iris pigment. The amoeboid pigment cells take up different positions according to the changes in the intensity of light.

Working of the compound eye:
The working of the compound eye is very complex. In the formation of an image, several adjacent ommatidia take part and light enters through them.

Each ommatidium is capable of producing a separate image of a small part of the object seen. Therefore, the whole image formed in a compound eye is actually made of several small pieces contributed by the several adjacent ommatidia. On this account the vision effected through a compound eye is called mosaic vision.

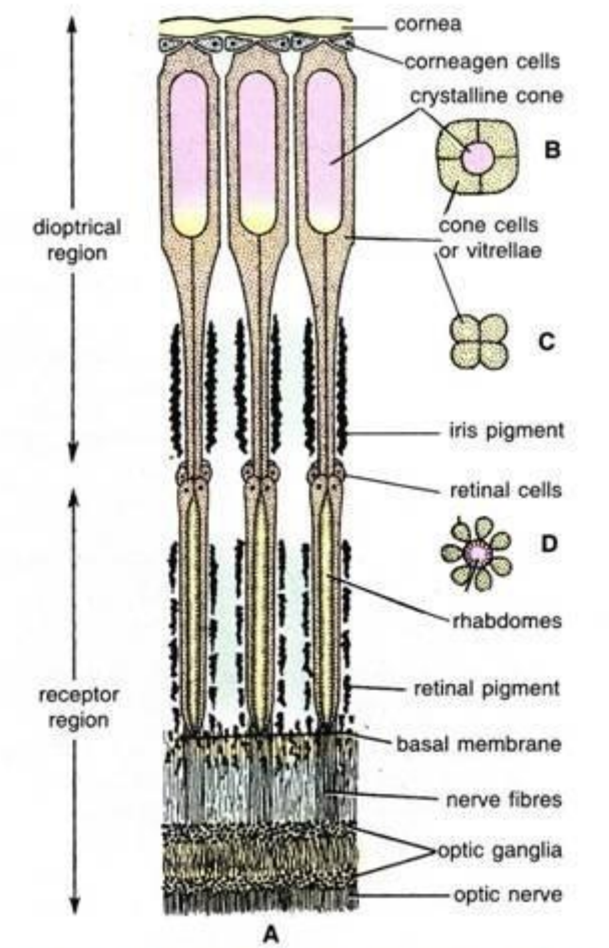

Fig. 71.32. *Palaemon.* A—Three ommatidia in L.S. (semi-diagrammatic); B—T.S. of an ommatidium through cone-cells; C—T.S. through basal ends of cone-cells; D—T.S. through retinal cells and rhabdome.

in nocturnal forms, like Palaemon, it is adapted for seeing in weak light and superpostion image is formed.

Formation of superposition image:

In the dim light, the pigment cells migrate towards the distal and basal parts of the ommatidia and the neighbouring ommatidia work in unison. In this condition, even the oblique rays of the light are capable of forming a point of image, after passing through a number of ommatidia.

As a result, an overlapping of the adjacent points of image takes place and, thus, a continuous image is formed. Such an image is called superposition image.

In this case, the vision is not distinct but the animal is able to have some sort of idea of its surrounding objects, specially of their movements.

In some insects, like fire-flies and some moths, the eyes are permanently set in the way that they are adapted for vision in the dim light, i.e., at night but they are day-blind, e.g., moths and fireflies. It is probable that the Palaemon Malcolmsonii like most of the arthropods can adjust its eyes so as to form both the types of images according to the intensity of light available.

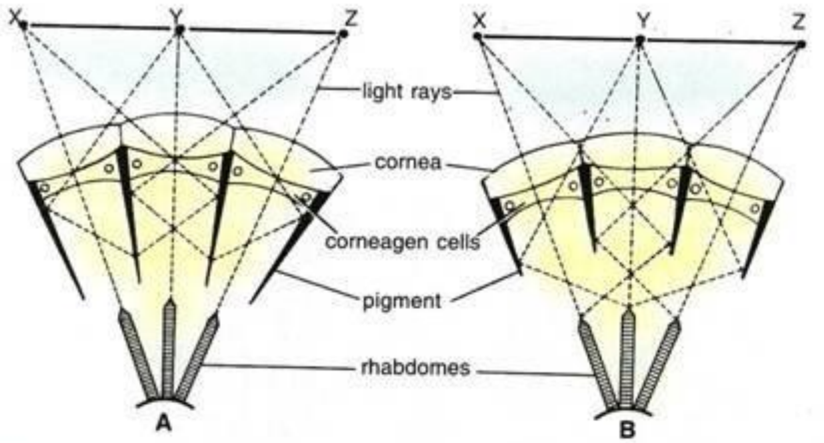

Fig. 71.33. *Palaemon.* Diagrammatic representation of image formation by a compound eye. A—Apposition or mosaic image; B—Superposition image.