Introduction

Arthropods possess various kinds of sensory structures which are sensitive to different kinds of stimuli. Arthropods possess simple as well as compound eyes; the latter evolved in Arthropods and are found in no other group of animals. Insects that possess both types of eyes: simple and compound.

Photoreceptors: sensitive to light

Photoreceptor in Arthropoda

1. Simple Eyes

2. Compound Eyes

1. Simple Eyes in Arthropods - Ocelli

The word ocelli are derived from the Latin word ocellus which means little eye. Ocelli are simple eyes which comprise of single lens for collecting and focusing light. Arthropods possess two kinds of ocelli

a) Dorsal Ocelli

b) Lateral Ocelli (Stemmata)

Dorsal Ocellus - Dorsal ocelli are found on the dorsal or front surface of the head of nymphs and adults of several hemimetabolous insects. These are bounded by compound eyes on lateral sides. Dorsal ocelli are not present in those arthropods which lack compound eyes.

- Dorsal ocellus has single corneal lens which covers a number of sensory rod-like structures, rhabdome.
- The ocellar lens may be curved, for example in bees, locusts and dragonflies; or flat as in cockroaches.
- It is sensitive to a wide range of wavelengths and shows quick response to changes in light intensity.
- It cannot form an image and is unable to recognize the object.

Lateral Ocellus - Stemmata Lateral ocelli,

It is also known as **stemmata.** They are the only eyes in the larvae of holometabolous and certain adult insects such as spring tails, silver fish, fleas and stylops. These are called lateral eyes because they are always present in the lateral region of the head.

The number of lateral ocelli varies from one to six on each side.

- They are structurally similar to dorsal ocelli except that they have a biconvex lens and a crystalline cone beneath the cornea with a smaller number of rhabdomes.

- These ocelli are sensitive to light intensity and thus capable of detecting outlines and movement of nearby objects and organisms.

Compound Eyes in Arthropods

A number of arthropods possess eyes which are made up of hundreds/thousands of long, cylindrical photoreceptor units. Such eyes are termed as **compound eyes**. Each unit is called an **ommatidium** (pl; ommatidia) and is capable of forming a separate image, independent of other ommatidium. Thus, image formed is a combination of inputs from a number of ommatidia.

a) Cornea:

- The outer surface of each ommatidium is convex and is covered by the transparent cuticle. It forms the cornea and functions as a biconvex lens.
- The external surface of cornea is generally hexagonal but sometimes square in shape and is called a corneal facet. Large number of facets gives an interesting appearance to the compound eyes, which often looks like a graph paper.
- Cornea, being cuticular in nature, sheds during each moult. New cornea is secreted by corneagen cells which are present beneath each facet.

b) Crystalline Cone:

- The corneagen cells are followed by a long, cylindrical or tapering, transparent **crystalline cone**.
- It is surrounded by 4-6 elongated cone cells, called **vitrellae,** with long and tapering ends.
- Crystalline cone functions as the **second lens** and helps to **focus light** upon the photoreceptors present in the ommatidium.

The region of each ommatidium, from cornea till the end of cone cells, is termed as **dioptrical region**.

c) Photoreceptor Unit:

- Basal end of cone cells of the ommatidium lie upon a translucent cylinder, called **rhabdome**.
- Rhabdome receives light and functions as a single photoreceptor unit forming an image.
- Rhabdome is surrounded by 7-8 light-sensitive photoreceptor cells, **retinular cells**. These are arranged in a radial pattern like the sections of an orange.
- Each retinula cell rests upon a **basement membrane** and extends into an **axon**.
- The bundle of 7-8 axons leaving each ommatidium is further connected to the neurons of **optic ganglion** which is connected to the brain through **optic nerve**.

Rhabdome and retinular cells collectively form the **receptor region** of the eye.

d) Pigment Cells:

- Each ommatidium is separated from its neighbouring ommatidia by certain **pigment cells**.
- The primary pigment, **iris**, is present in the proximal region of the ommatidium surrounding the tapering ends of the cone cells.
- The secondary pigment, **retinal pigment**, surrounds the rhabdome and retinal cells in the distal region of the ommatidium.
- These pigments are movable and can migrate centrally or distally depending upon the light intensity.

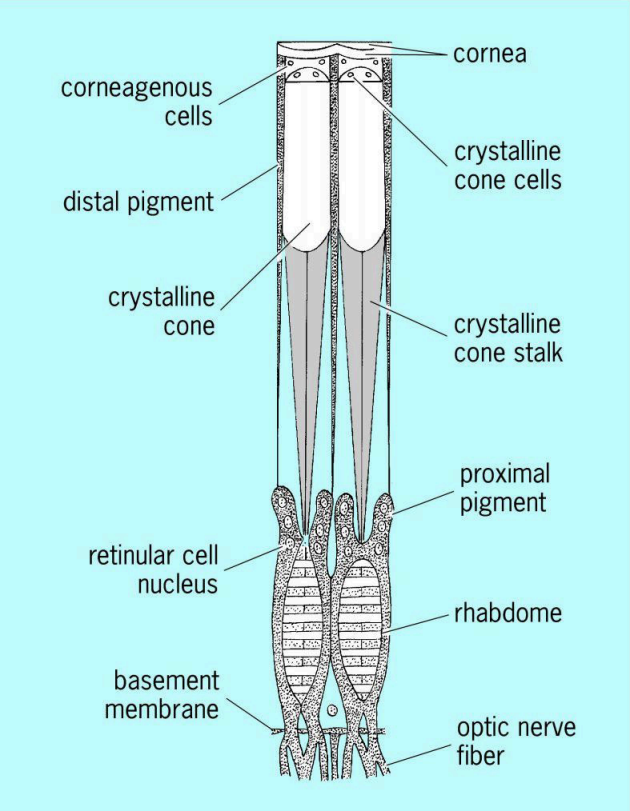

Fig. Structure of an Ommatidium

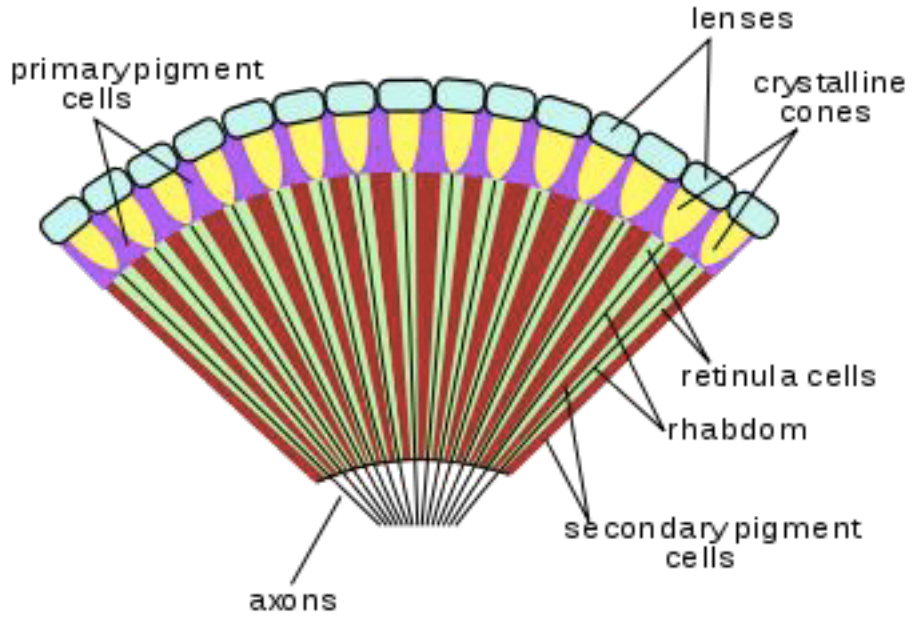

Fig. Compound eye showing ommatidia

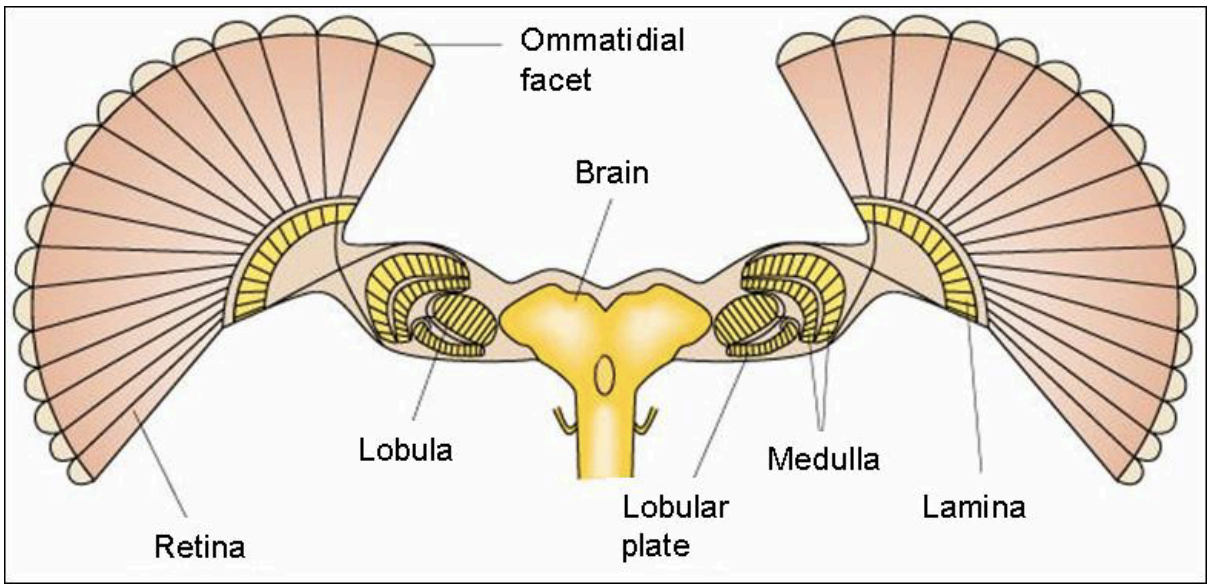

Fig . Compound eyes connected to the brain

Photochemistry of Insect vision

- Photons are caught on the rhabdome by retinal.

- Retinal is connected to opsin, forming rhodopsin.
- On absorption of photon, retinal changes its form from bent to straight.
- When retinal changes its form, it separates from the rhodopsin and the opsin triggers a nerve cell.
- The nerve cells conduct the signal to the brain.

Image Formation

Compound eyes form image with the help of inputs received from ommatidia. Each ommatidium forms a separate image of a small part of the object. Thus, the image formed consists of several pieces and is crude. This type of vision is called mosaic vision. Compound eyes of arthropods can form two kinds of image depending on the intensity of light:

a) Apposition image

b) Superposition image

Apposition Image

The compound eyes form apposition image in the bright light.

- In bright light, both proximal and distal pigments extend and act as a screen to prevent light rays from passing from one ommatidium to another.
- The light rays remain restricted to the axial region of the crystalline cone and rhabdomes.
- As a result, only those rays which fall perpendicularly on the cornea and pass through rhabdome form the point of an image. The rays which fall obliquely on the cornea are absorbed by the pigment and do not produce any visual effect.
- Thus, each ommatidium responds to a patch of light from the visual field and overlaps little with the neighbouring ommatidia forming a point of an image.
- The final image is formed by combining all these points formed by the stimulated ommatidia.
- This is, therefore, mosaic vision as it results from small pieces put together.

- Apposition eyes are the most common form of eye, and are presumably the ancestral form of compound eye. They are found in all arthropod groups.

Superposition Image

The superposition image is formed in the dim light.

- In weak light, both proximal and distal pigments retract. The ommatidia do not remain optically isolated and the light rays can pass from one ommatidium to another.
- As a result, the oblique rays as well those which fall perpendicularly on the cornea and pass through rhabdome form the point of an image.
- Thus, each ommatidium responds to the light rays which had entered through different corneal facets.
- The final image is continuous formed by overlapping of the adjacent points of images.

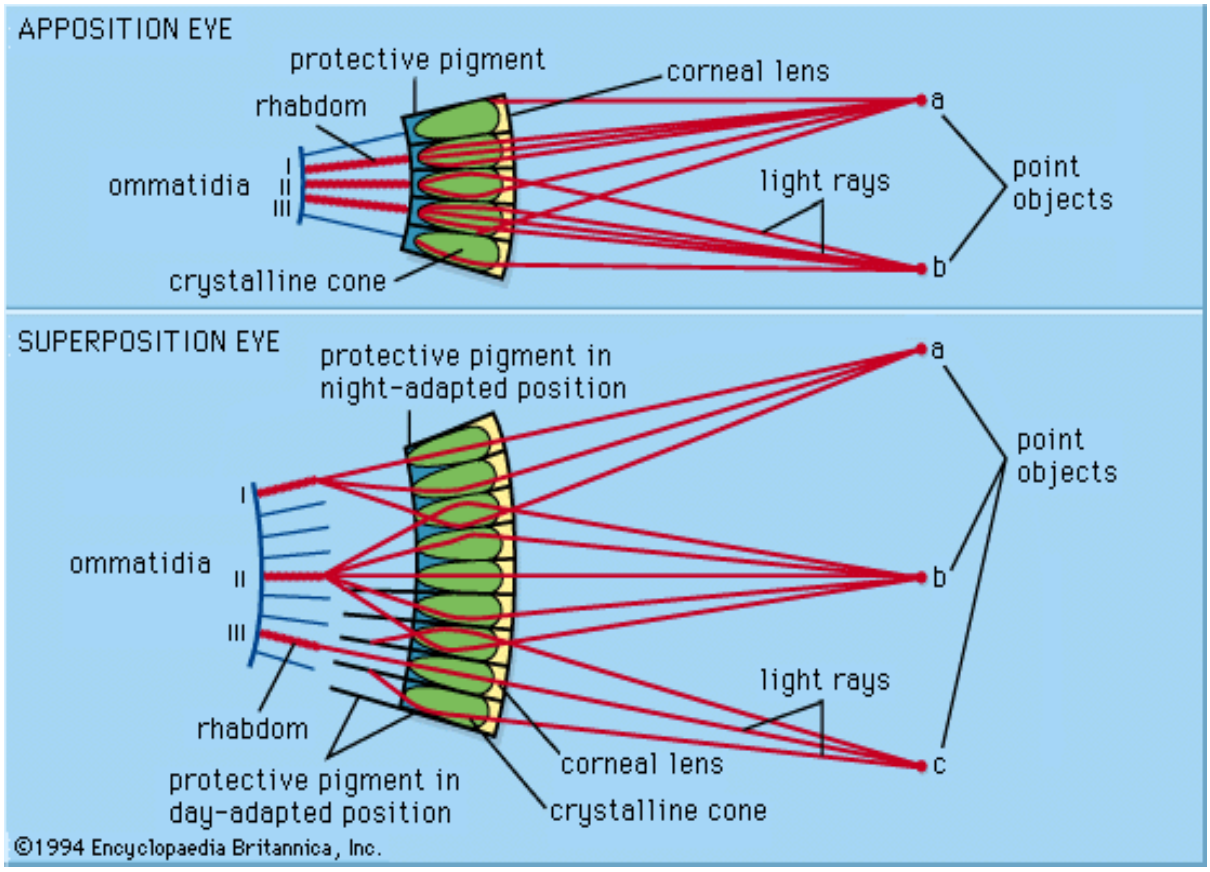

Fig. Apposition and Superposition Eyes