Practical Lectures

of

Insect Physiology 1

(Post – Graduate)

Part of Prof. Dr.

Gamal Elsayed

Elbramony

NERVOUS SYSTEM

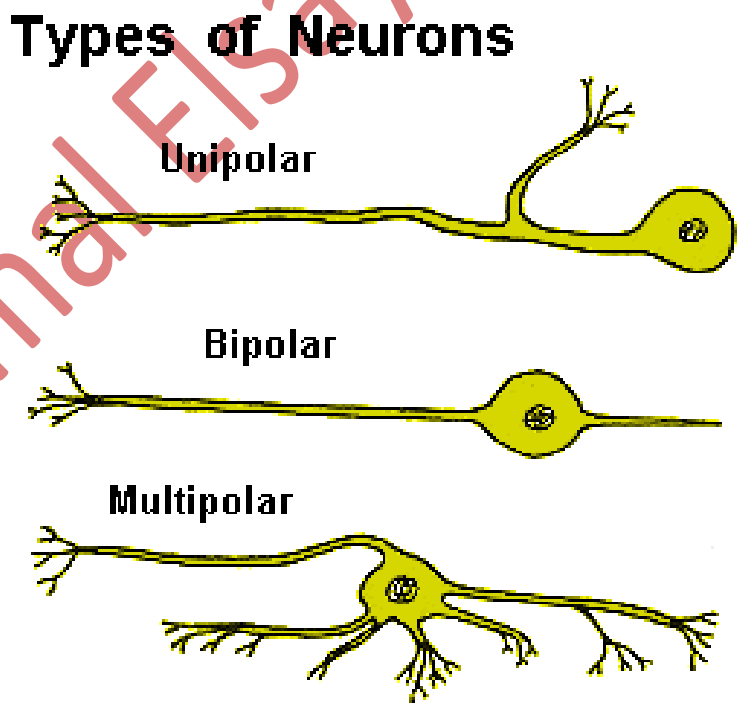
(NERVE CELL) NEURONS

NEURONS ARE DIVIDED BY STRUCTURE OR COMPOSITION:

1- **Unipolar:** Has a nerve axis that spans the nervous system

2- **Bipolar:** Has two axes, one that connects to the sensor neural organs and the other that connects to the nervous system

3- **Multipolar:** Has multi axes, spread below the Body wall to form the Peripheral sensory nervous system

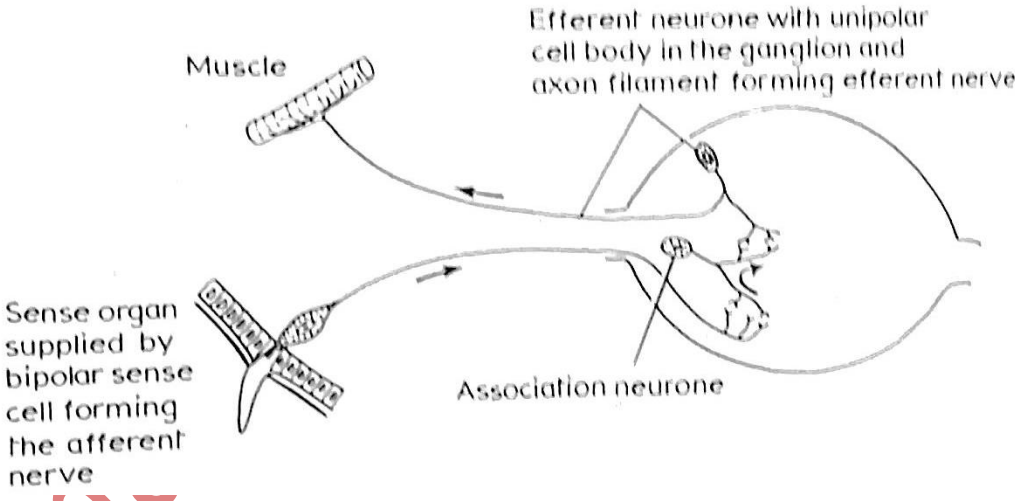


Neurons are divided by function:

1- **Sensory neurons:** Bipolar or Multipolar; its function is to transfer effects from sensory organs to Ganglia.

2- **Motor neurons:** Unipolar; It is found in the brain's nerve ganglia and the axes of these cells are grouped into a known motor axon which extends to response organs.

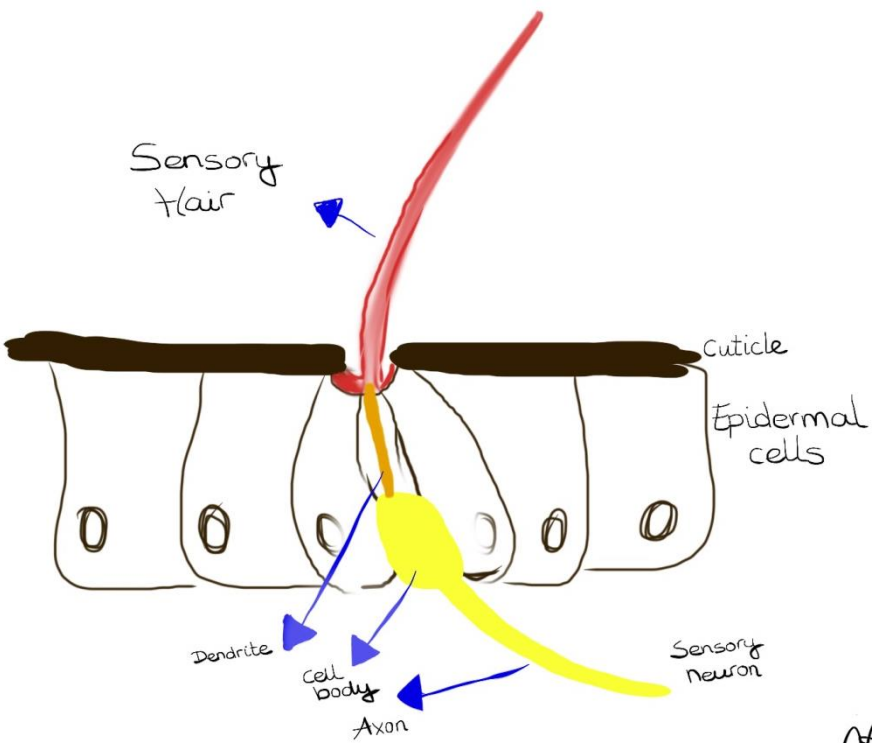
3- **Associated neurons :**Small cells are located in the brain's nerve ganglia; It exacts neurons axons that link motor neurons to sensory neurons

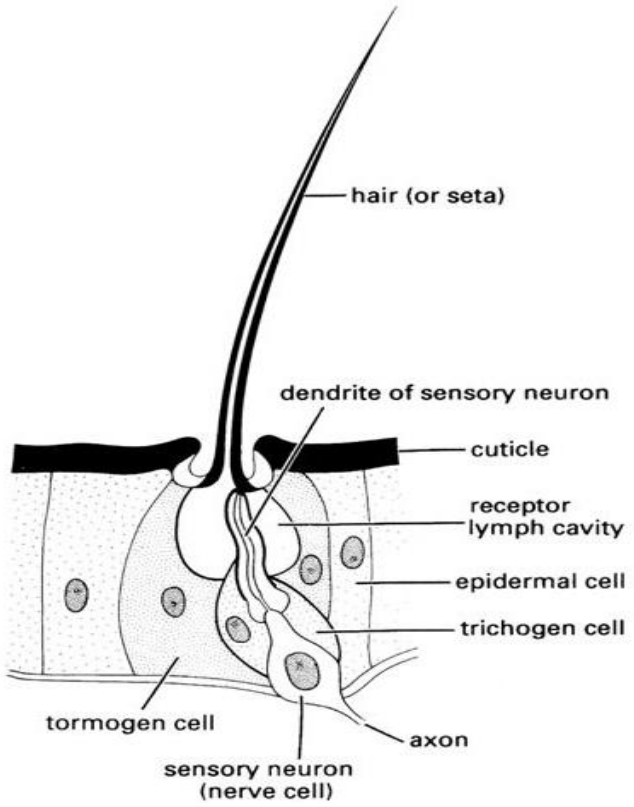


Sense receptors

1- Mechanoreceptors

A- **Sensillate trichoid:** They are tactile sensory like: Sensory bristles on antennae or tarsus or end of tibia or cerci .This organ sensory translate the neural signal forward where the neural ganglia assigned to respond to this alarm.

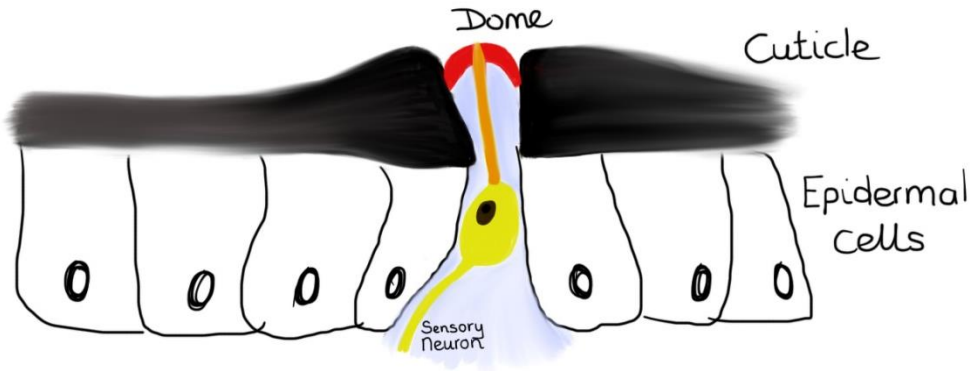




2- Companiform sensillae.

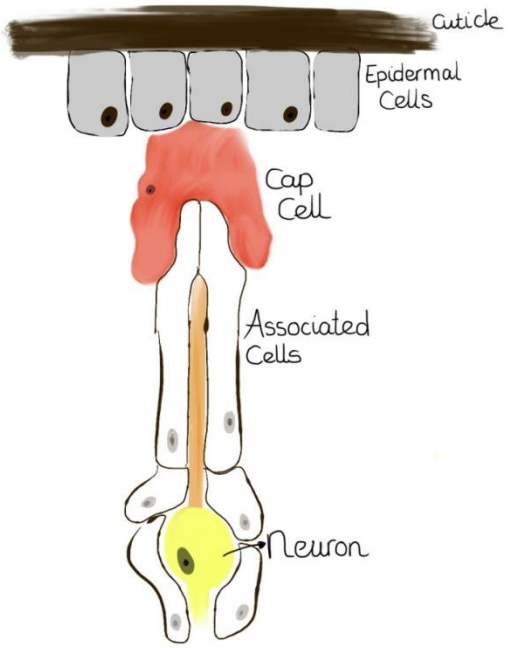
This organ sensory is found on cerci or wings or haltere.

This organ sensory is sensitive to mechanical changes resulting from pressure on the body wall surrounding the organ causing it to extend or curve, such as air pressure.



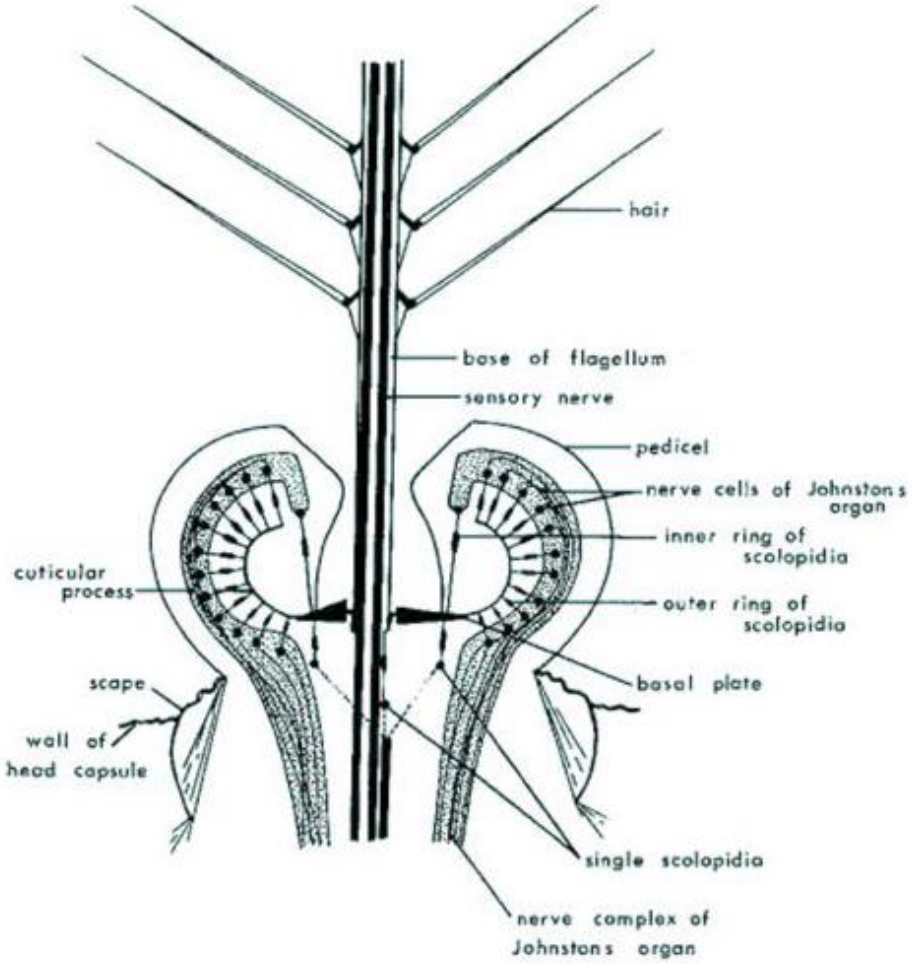
3- Chordotonal sensillae.

This organ sensory is found on abdominal appendages; the bases of the wings and legs. The chordotonal organ is stretch receptor that senses to what degree the cuticle is being deformed. This deformation can then give information about movement of body parts, gravity (proprioception) and vibration of the surrounding air (hearing).



4- Proprioceptive organs.

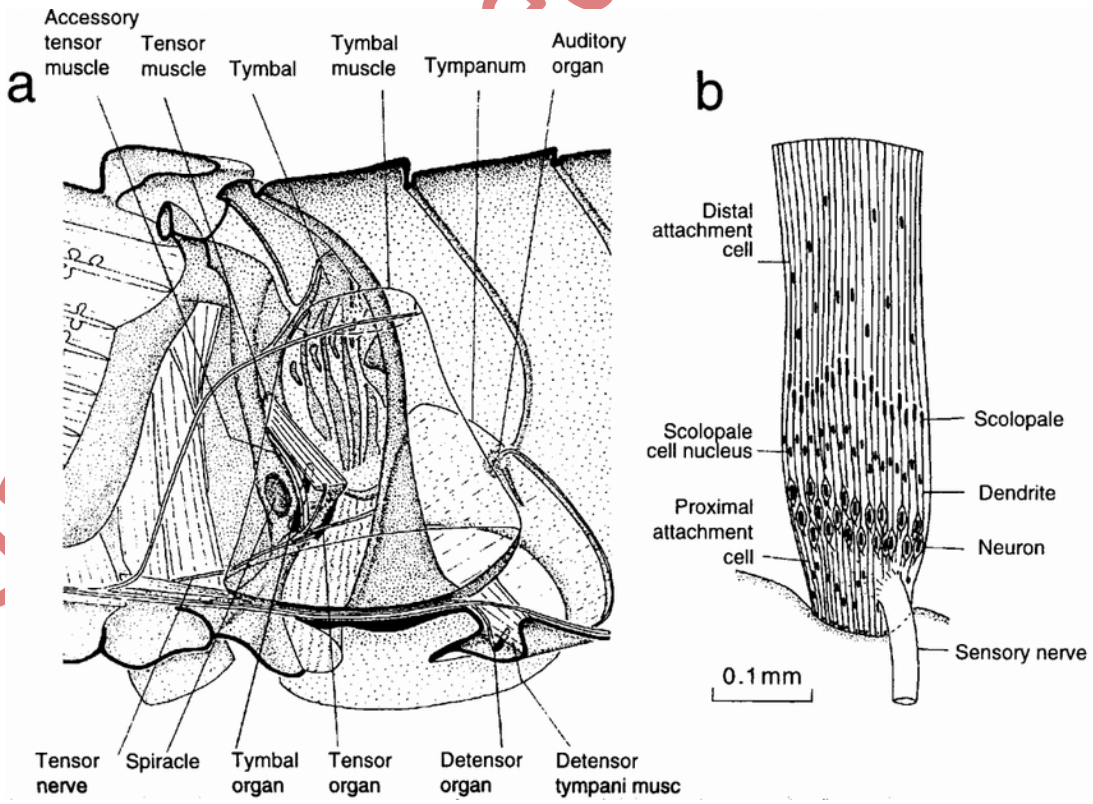
They are receptors affected by the movement of the body itself or by stretching the muscles, including the Johnsons organ which is located inside the pedicel segment in the antennae of the most winged insects like as mosquitoes. The function of this organ is to recognize the insect to perceive the intensity of the air currents and the contact of solid bodies and vibrations arising from the surface of the water as in some water beetles and It acts as a sound receiver like a home mosquito.



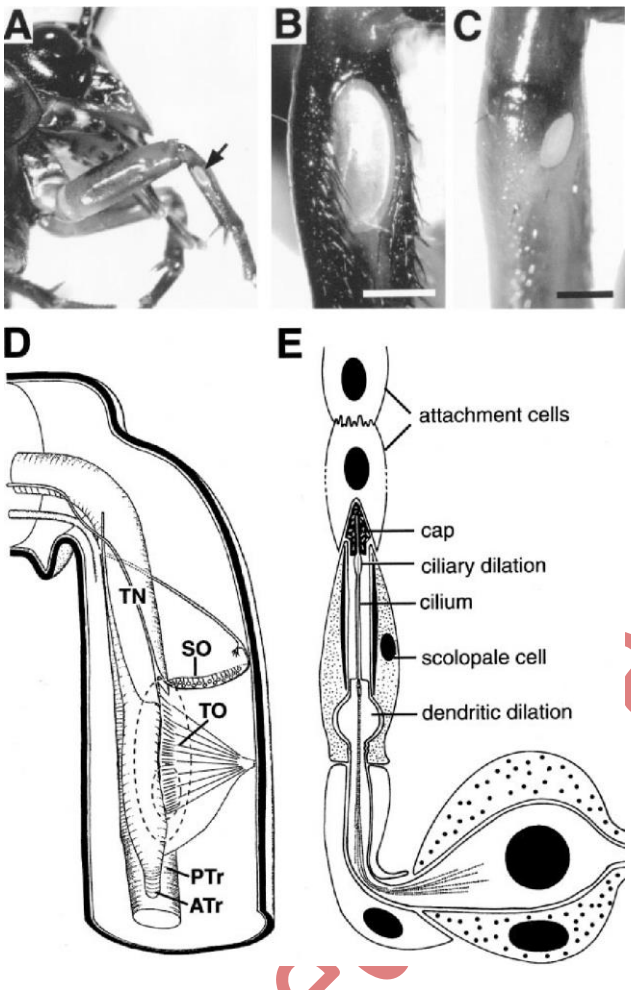
5- Auditory organs.

They are mechanical sense organs that respond to local variations of and from less intense air components.

A- **Drumming sense organs**: They are contact organs and consist of a thin layer of cuticle that you know tympanic membrane; behind it is an air bag that acts as a sound repeater when waves come on and makes the membrane free to move in the vibration; these vibrations cause movements that affect the tendon sensory organs, causing hearing. These organs are found in Orthoptera insects where they are located on either side of the first abdominal segment (locusts) or on the front leg (grasshoppers and mole cricket).



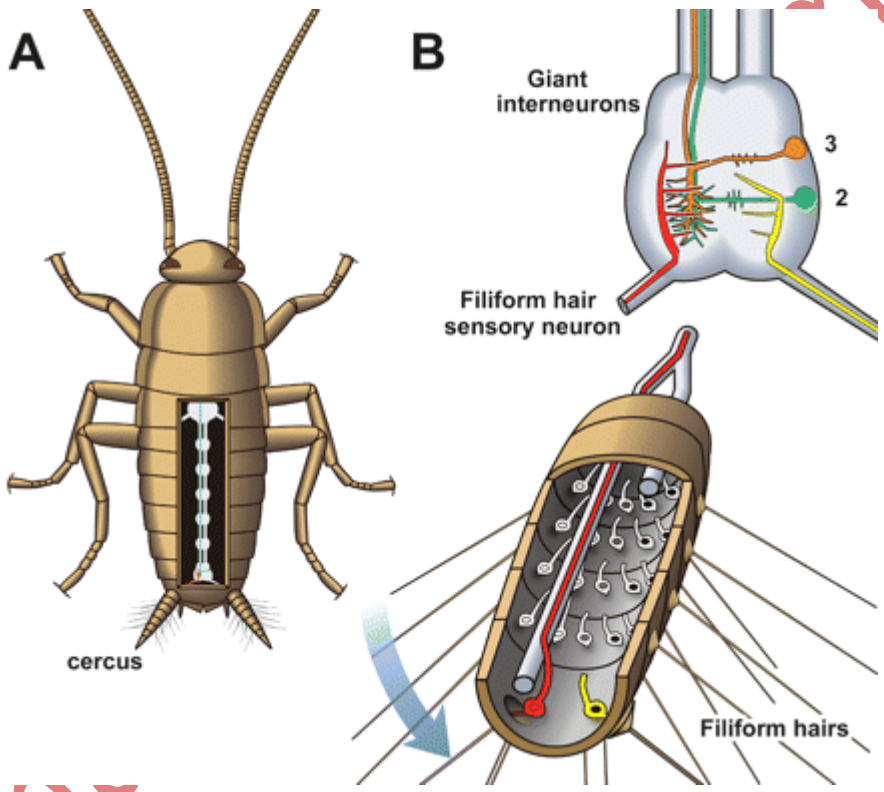
Abdominal segment

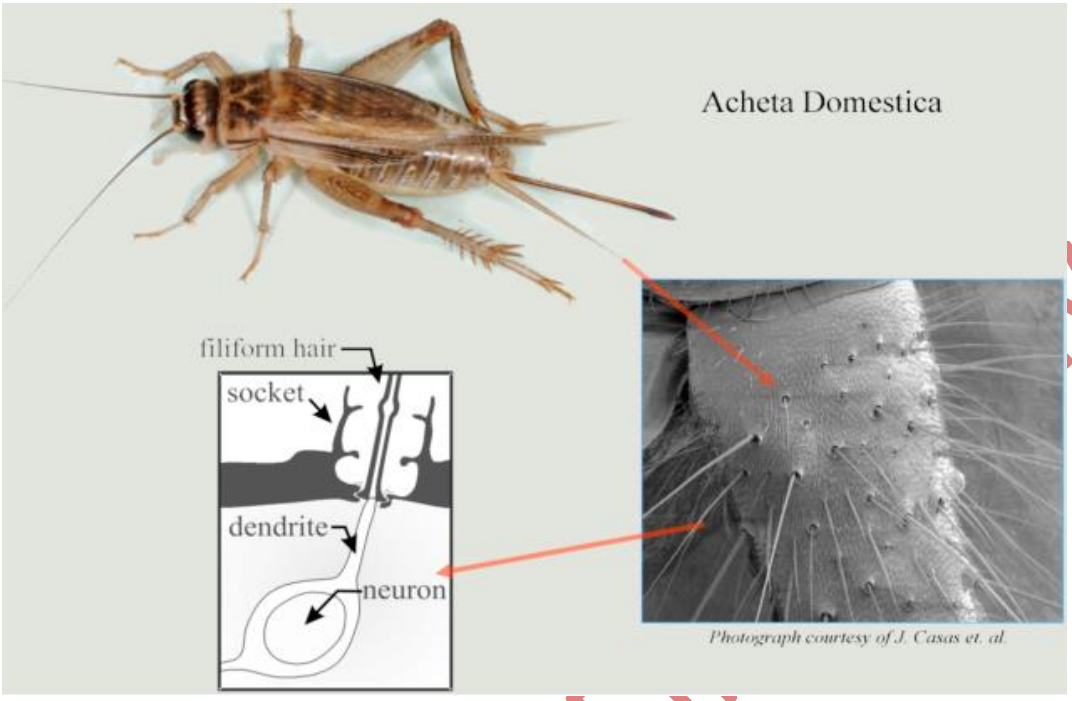


Tympanal hearing organ of Gryllus bimaculatus (Gryllidae: Ensifera). A: Right lateral view of an adult male. An arrow points to the posterior tympanal membrane on the tibia of the foreleg. B,C: The posterior and anterior tympanal membranes, respectively. Scale bars 0.5 and 0.4 mm. D: Schematic drawing of the of the complex tibial organ, including the tympanal organ (TO) and the subgenual .

B- Auditory sensillum.

They are sensitive hair located on the **Cercus** acting as receivers for sound waves that are less than 3000 vibrations per second and they usually exist in Orthoptera and Lipodoptera.

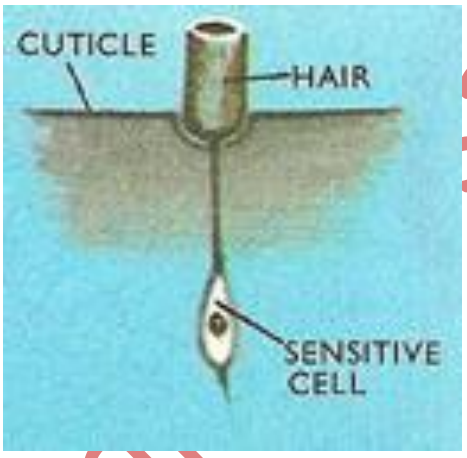


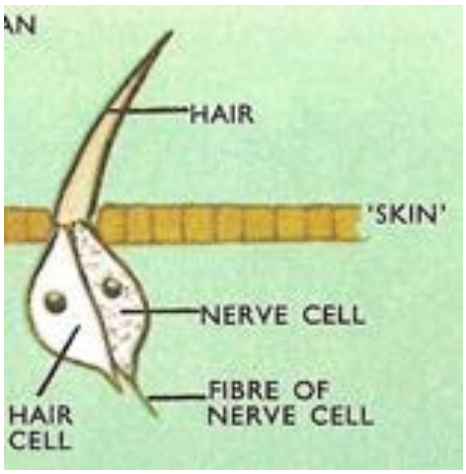


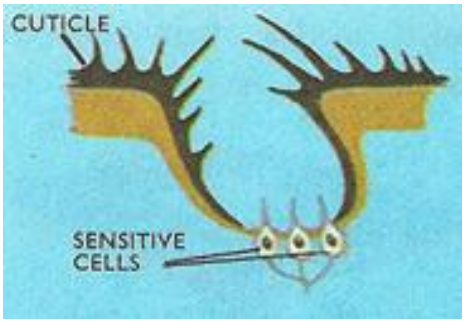
6- Heat and humidity receptors.

Heat receptors spread on the surface of the body wall, antennae, maxillary palp and tarsus of legs and this sensory organs respond to changes in temperature and this response is a vital factor in the life of insects that are infested with the blood of mammals such as mosquitoes that are attracted to a family based on the temperature of the body.

Humidity receptors are found on the sensor century as in human lice and it is also located on the maxillary palp or on the lower sides of the posterior body segments in the drosophila.





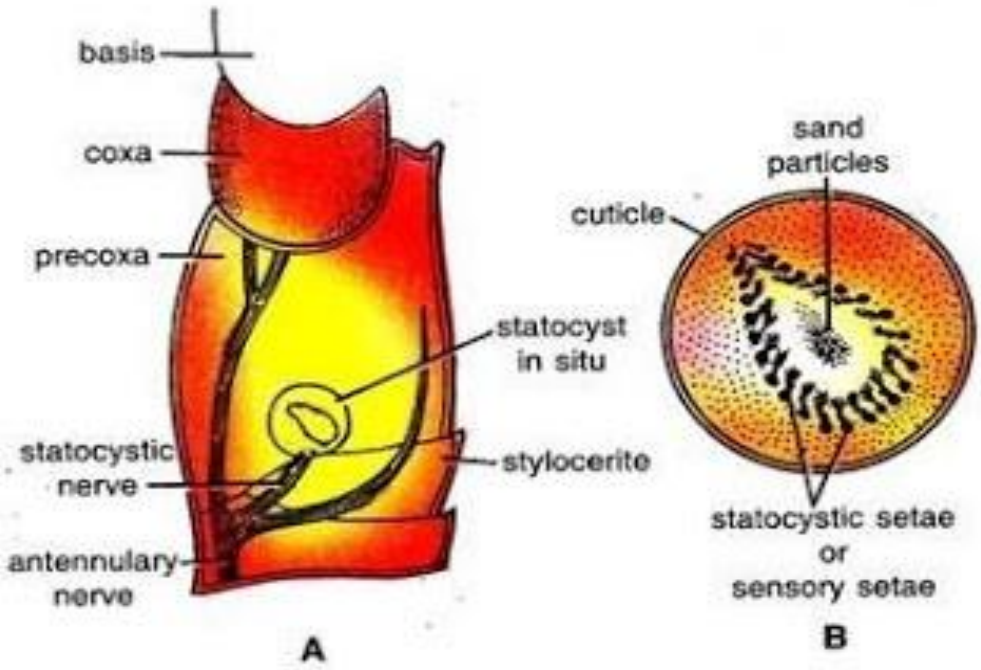


7- Statocysts.

The vesicles of balance in Hymenoptera are located directly on the posterior thorax just behind the coxa of third leg, and they are formed by a constriction of cuticle, determined by sensory bristles.

Palmen's organ acts as a statocyst balance conductive in the head of both Ephemeroptera larvae and adult insects.

The vesicles are characterized by being free-moving although they are not able to move much, and if the insect changes its direction as a result of changing the direction, it presses on some of the bristles (Hairs), and it warns the different bristles by changing the direction, and on this the organs act as gravity receptors.



Palaemon organ: A- Statocyst in situ;B- T.S of Statocyst

2- Chemoreceptors

They are found in the form of chemical sensory organs spread over the antennae; mouthparts and legs and they are characterized by accurate nerve endings found in cuticle gaps and are susceptible to irritation with chemicals that give the two types of sensation of smell and taste. The sense of smell (tarsus- antennae) is alerted to the low concentrations of the vapor of volatile substances and the sense of taste (mouth) is only measured by the relatively high concentrations of stimulant in a water solution.

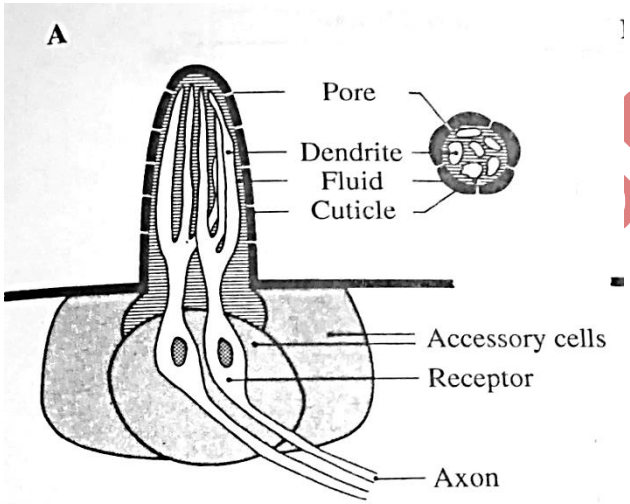
A- Olfaction

Smell receptors are mostly located on the antennae (grasshoppers); maxillae (*Apis mellifera*); labium palpi (Lepidoptera) and tarsus (Diptera).

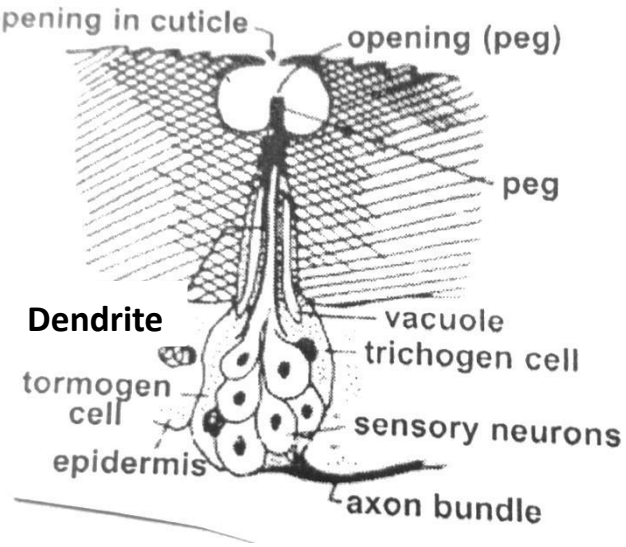
They can detect odours chiefly by sensilla on the antennae but to a lesser degree by the palps. The antennae is a odor-screen for containing the olfactory receptors (olfactory Pits) that exist in a way that allows them to experience as much air currents as possible with volatile substances.

The olfactory receptors are a basiconic pegs or Coeloconic pegs ; this pegs have a many pores which the ends of nerve cells (dendrites) are extended inside to

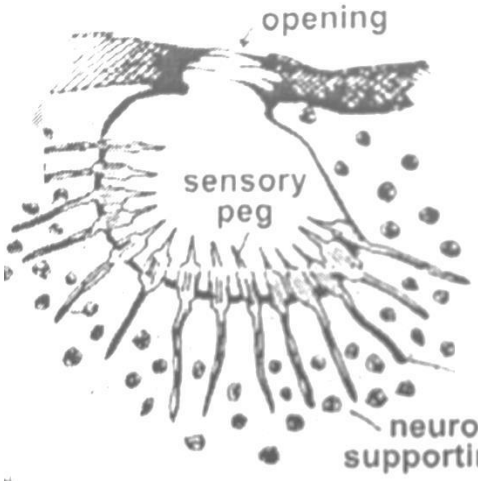
catch the volatile chemical particles that interact with them to produce a neural signal (nerve impulse)) stimulating to the nervous system.



Basiconic pegs in maxillary palps of females culicidae (Mosquitoes)



Coeloconic pegs in antennae of grasshoppers



Multi pegs in *antennae of Apis*

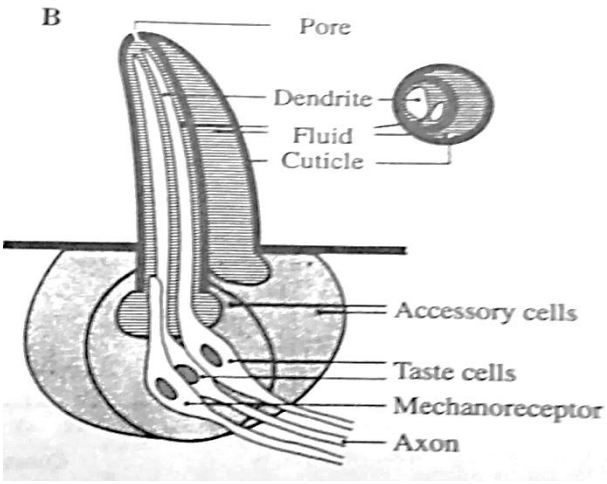
B- Tasting.

Taste receptors are found in the form of taste buds. Tasting receptors are mostly located on the mouthparts (*Apis* ; hypopharynx (tongue) ; antennae (Hymenoptera) and tarsus (Diptera). Insects can recognize the tastes of the salt; sweet and acid. The sensitivity of the organs of taste in insects may be very high under conditions of starvation.

Insects may differ in respect to concentration of chemicals not only between themselves, but even when the organs of taste on the tarsi are compared with those on the mouthparts.

Taste buds related to dendrites of neurons (taste sensory cells) and fill the bud cavity with chemical excretions from gland cells, these chemical secretions interact with the chemical substances that make up food when tasting food, resulting in a nervous signal sent to the central nervous system for food sensor.

Mouthparts receptor in flies is more sensitive than tarsus receptor for light-concentrations solution.



Taste sensillum showing only one chemoreceptor neuron and the mechanoreceptor neuron surrounded by accessory cells.

3- Light receptors (The eyes and vision).

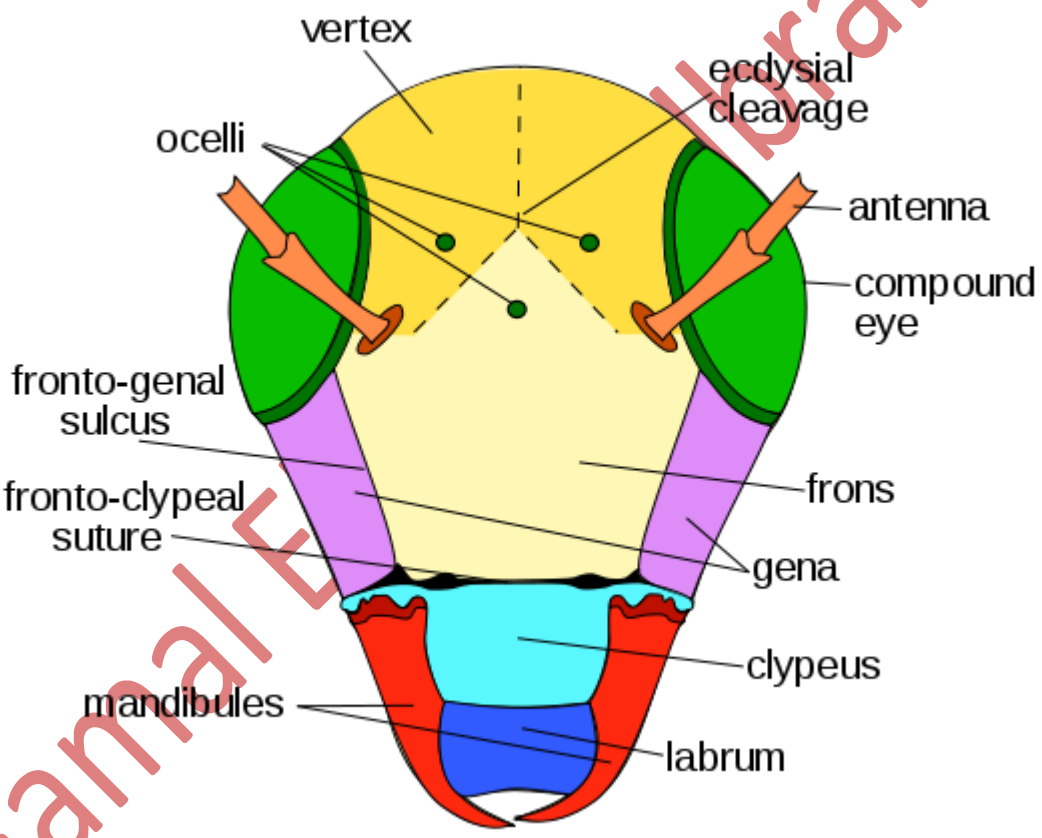
A- Simple eyes (Ocelli).

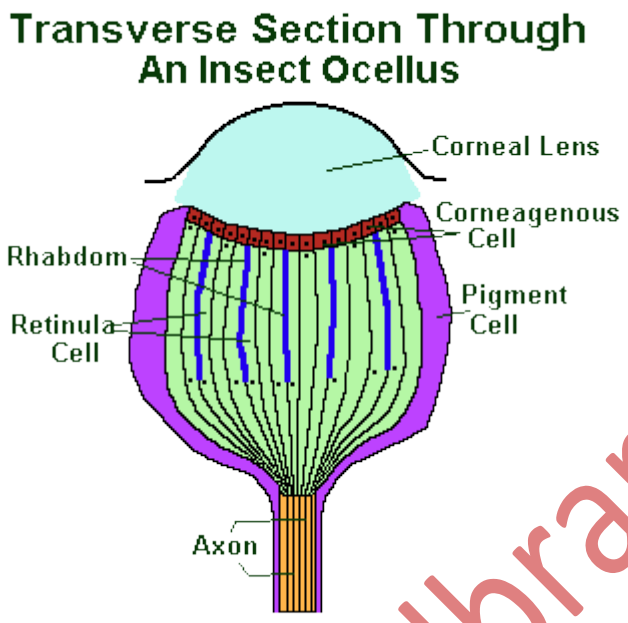
Generally they consist of five separate parts the 'cornea', the 'corneagen layer', the 'retina', the 'pigment cells', and the 'central nervous connections'.

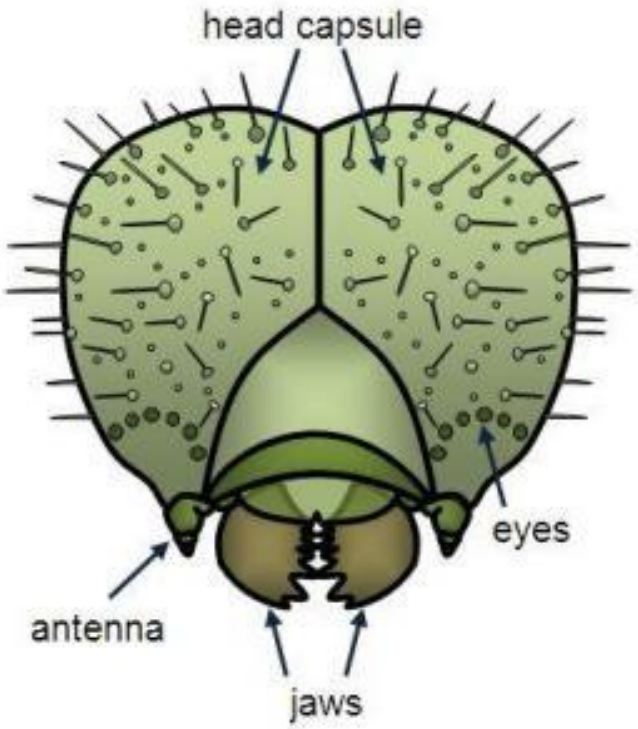
Dorsal ocelli occur mostly in adult insects and are situated on the front of the insects face in the area of the 'frons' and or the vertex and they consist of three eyes, which connect with the first brain. The function of the corneal lens is obscure, although it does project an image into the ocellus this image forms below the level of the light-sensitive cells, or rhabdom. Therefore the ocellus can generate no image information; however it is very sensitive to low levels of light and to changes in light intensity and scientists believes that the ocelli are useful in allowing the insect to detect the horizon, to respond quickly to changes in light intensity. This action helps the insect for responding quickly to external stimuli and speed of movement.

Lateral ocelli generally occur on the sides of the insect head and are the form of eye most common in larval forms; and the number of simple side eyes ranges from one eye, as in wheat stem saw fly larvae to six eyes, as in Lepidoptera larvae. Lateral ocelli enable the larvae to be

seen because of their ability to form an image centered on their optical axis.







Lateral ocelli in larvae

B- Compound eyes.

Compound eyes are so named because the cornea is composed of a number of individual facets or lenses (called ommatidia), rather than a single lens as in ocelli (or our own eyes). The number of separate visual elements or ommatidia varies greatly between species as well as between the larger taxa, so that while worker ants of different species may have between 1 (*Ponera punctatissima*) and 600 ommatidia per single eye, adult male Odonata may have more than 28,000 per single eye.

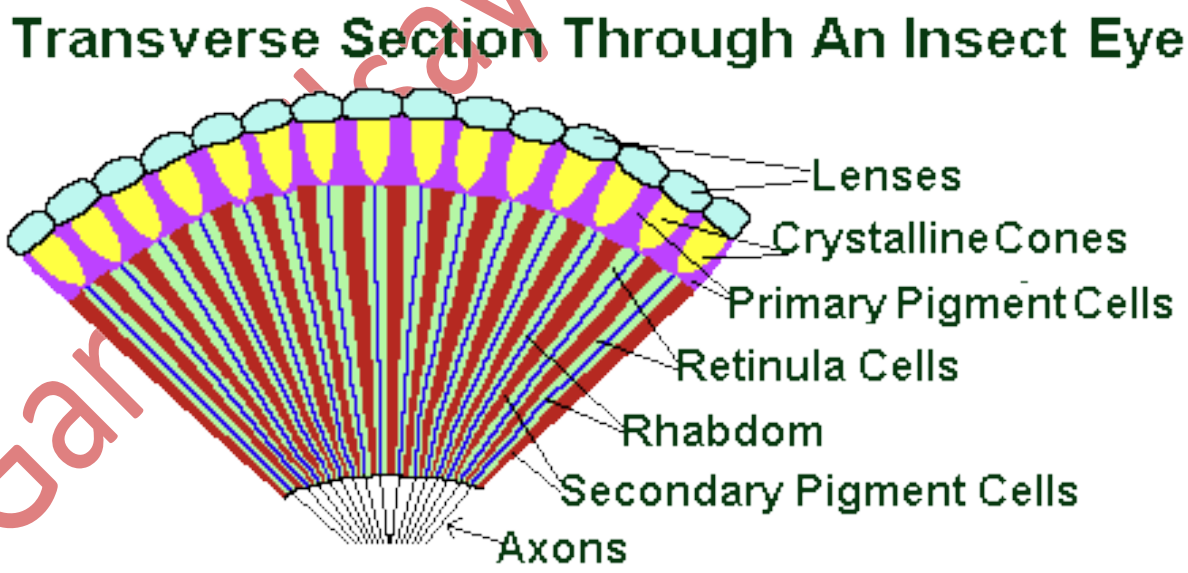
Compounds eyes of insects, can be divided into four basic parts: the supportative material that keeps all the parts together; a light gathering part (the lens and the auxiliary lens called a 'crystalline cone'); a light receptor that converts the received light into electrical energy; and the nerves that carry the electrical impulses to the brain for analysis. In the compound eyes of insects these parts are repeated numerous times side by side in a space saving hexagonal pattern.

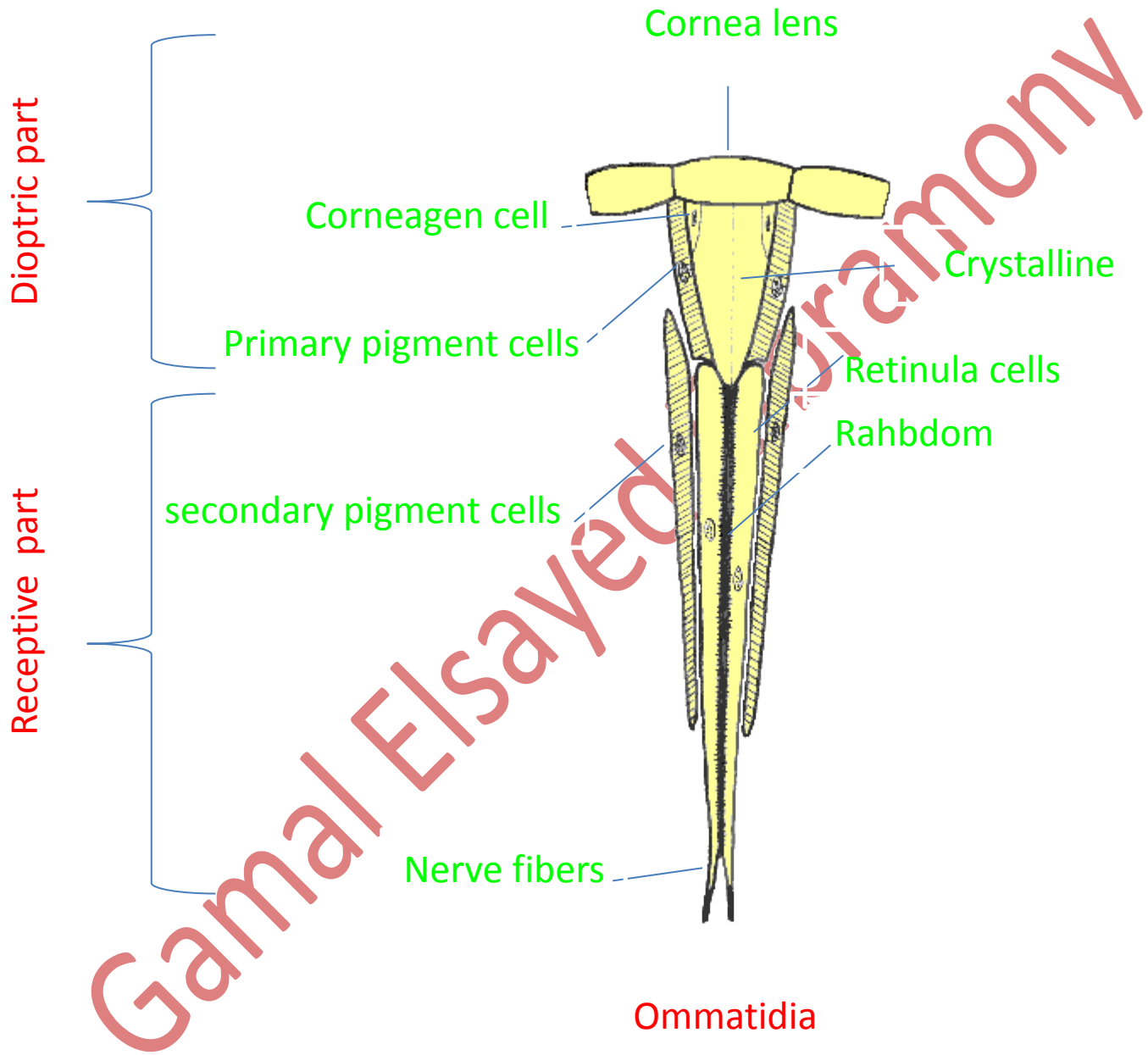
The lens is formed by a transparent and colorless cuticle and it is usually biconvex. Beneath this is the crystalline cone. Normally this functions as a secondary lens.

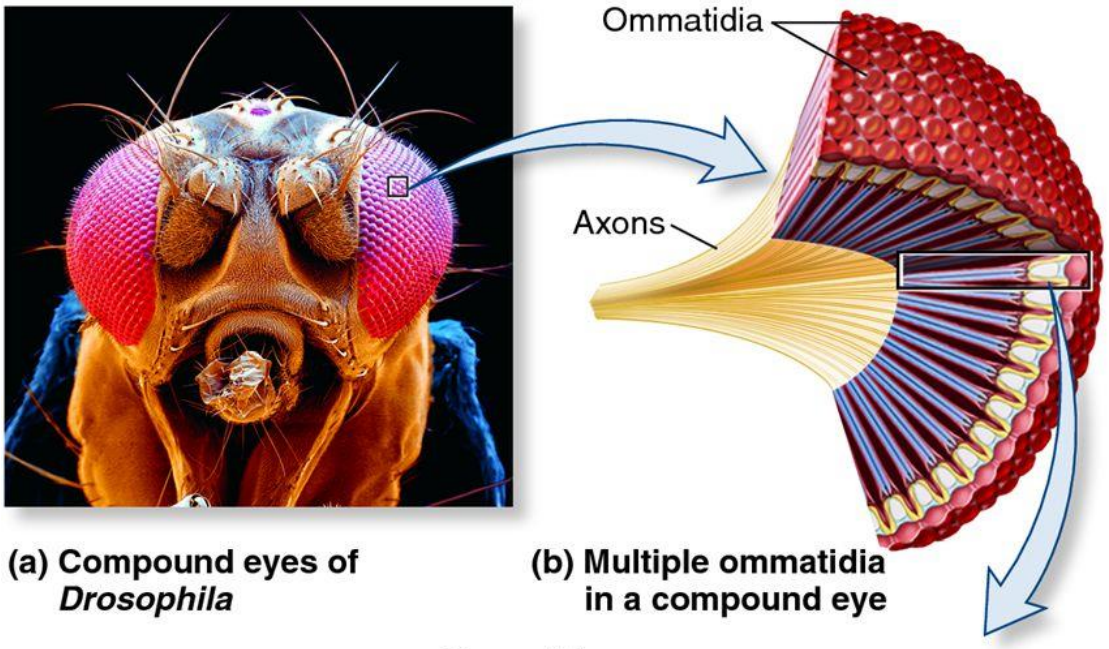
The receptive parts of an insect's eye are the 'retinula cells'. Each ommatidium normally has eight retinula cells arranged to leave a central core space in the centre of the

ommatidium, into which each retinula cell projects a series of microvilli. These microvilli are the actual light detecting part of the cells and are collectively referred to as the rhabdomere (think cornea). The eight (or occasionally 7 or 9) rhabdomeres (sets of microvilli) form a rhabdom.

The corneal lens is supported by 'primary pigment cells' and the retinula cells and associated rhabdoms are supported by 'secondary pigment cells'. The retinula cells are connected to axons at the base of the eye, it is these which carry the information collected by the lenses and converted into electrical impulses by the rhabdom to the brain, thus allowing the insect to see.

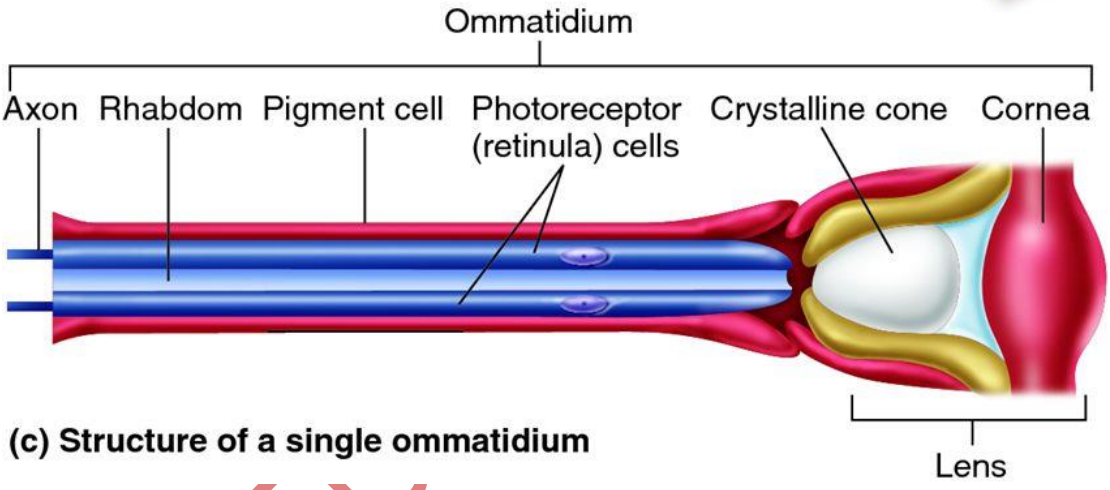






(a) Compound eyes of *Drosophila*

(b) Multiple ommatidia in a compound eye



(c) Structure of a single ommatidium