Sense organs
The sensory organs are primarily responsible for the reception of stimuli and pass them on to the neuro-muscular system, resulting in the varied behavior patterns of insects.

Classification of insect sense organs
According to the various stimuli perceived, they are classified into the following:
1. Mechanoreceptors
2. Chemoreceptors
3. Temperature and humidity receptor
4. Photoreceptors or visual organ

1. Mechanoreceptor
Mechanoreceptors are the sense organs of insect, which respond to the sense of touch due to contact with external solid objects, current of air and water or even because of internal body pressure. The principal mechanoreceptors are:
   i. The tactile organs or trichoid sensilla
   ii. The campaniform organs
   iii. The chordotonal organs

i. The tactile organs or trichoid sensilla
The trichoid sensilla are the simple articulated sensory hairs and distributed on the entire body surface and commonly called as the sensilla.

Construction of tactile organ: They are made up of cuticle and articulated within the socket with the body wall. The trichoid sensillum is formed by two cells; the hair by the trichogen cell and the socket by the tormogen cell. Both the cells are modified epidermal cells. Each sensillum is innervated by a bipolar sensory neuron. The dendrite of the neuron is enclosed at the base of the hair by a cuticular tubular sheath, called the scolopale. It is, in some case, provided with a distal cap, called the scolopale cap.

Location of tactile organs: Trichoid sensilla present on the antennae, tarsi, tibia and cerci. These organs of the insects sub-serving the sense of touch.

Functions of tactile organs
   a. There are some trichoid hair plates at the joints of various appendages and function as proprioceptors during sliding of the segments over each other.
   b. There are tactile hair- beds on the facial region of the head of locusts and Lepidoptera, on the neck of dragonflies, on the wing margins of Lepidoptera which are responding to the air movements during flight.
   c. The tactile hairs of the antennae and lower segments of legs perceive earth-born-vibrations in terrestrial insects and water surface vibrations in aquatic insects.
ii. The campaniform sensilla:
The campaniform sensilla cannot be seen externally but recognized from the dome-shaped cuticular areas. They elevated above or depressed below the general body surface. Cell structure and arrangement is similar to that of trichoid sensilla.

**Location:** They occur in various parts of the body, wing-base, halteres, cerci, palps and on the base of trochanter, femora, tibia and tarsal segments.

**Mechanism of campaniform sensilla:** The cuticular stretches and the forces exerted on the cuticle by muscles and gravitational forces stimulate the campaniform sensilla. The campaniform sensilla function as the proprioceptors. They respond to the mechanical stimuli, in terrestrial insects, water pressure in aquatic insects and air pressure in flying insects.

![Campaniform sensillum](image)

**Fig.:** Campaniform sensillum (left), and section through campaniform sensillum to show stiffening rod of cuticle running along cuticular plate present in some species.

iii. Chordotonal organ

Chordotonal organ consists of single unit or group of similar unit is called scolopidia. They are sub-cuticular and are attached to the cuticle at one or both end often no sign of their presence. Each scolopidia consists of three cells:

a. Neuron
b. Scolopale cell or enveloping cell
c. Cap cell

**Location:** The chordotonal organs occur in legs at femoral, distal tibial and tibio-tarsal regions, in abdomen and wing base.

**Mechanism of Chordotonal organ:** They are stimulated by passive movement of segments, tension of muscles, internal pressure changed due to blood and tracheae.
Specialized chordotonal organ

a. Johnstone's organ
b. Auditory or tympanal organ

a. Johnstone's organ
Johnstone's organ is a specialized chordotonal organ in the 2nd antennal segment, occurs in all adult insect except Collembola and Diplura. It consists of single mass or several groups of scolopidia and is highly developed in Culicidae, where the pedicel is enlarged. Axon of sense cells run back and enter the antennal nerve. It perceives movement of antennal flagellum and flight speed indicator.

b. Auditory or tympanal organ:
Tympanal organs are present in the adult of many insect species. Tympanal organ consists of a thin layer of cuticular structure, called tympanic membrane, air sac and a group of chordotonal organ. Tympanic membrane and air sac form drum, sound waves that strike the drum cause it to vibrate and therefore the sensilla to be stimulated.
Chemoreceptor

Chemoreceptor is sensitive to chemicals, stimulation by chemicals can occur in the following different ways:

1. **Olfactory or smell chemoreceptor:** They provide sense of smell. Mechanism of perception of chemicals in gaseous state at high concentration is known as olfaction.

2. **Gustatory or contact chemoreceptor:** They provide sense of taste. Mechanism of perception of chemicals in liquid state at high concentration as known as contact chemoreceptor.

**Construction and form of Chemoreceptor**

Chemoreceptor consists of one or more neurons associated with cuticular structures having small pores through which molecules enter and stimulate dendrites. Cuticular structures have wide variety of forms.

- Trichoid sensilla: Sensory cells provided with hairs.
- Sensilla basiconica: Sensory cells provided with peg-like or cone-like structure.
- Sensilla coeloconica: Sensory cells provided with pits.
- Sensilla placodea: Sensory cells provided with plates.

**Functions of chemoreceptor**

Chemoreception, essentially taste (gustation) and smell (olfaction), is an extremely significant process in the Insecta, as it initiates some of their most important behavior patterns that is section of food, oviposition site, location of host or mate, and responses to commercial attractants and repellents.

**Location of chemoreceptor**

Organs of taste are common on

- The mouthparts, especially the palps,
- The antennae (Hymenoptera),
- Tarsi (many Lepidoptera, Diptera, and the honeybee),
- Ovipositor (parasitic Hymenoptera and some Diptera) and
- General body surface.

Organs of smell are located on the following sites:

- The antennae are the primary site of olfactory organs and often bear many thousands of these structures.
- The mouthparts also carry olfactory structures in many species.
Fig. Gustatory Chemosensillum

Fig. Olfactory Chemosensillum
Photoreceptors

Photoreceptors may be defined as the ability to perceive light in visible or near visible range of the electromagnetic spectrum. Organisms have to be a pigment capable of absorbing light of a given wavelength and a means of producing a nervous impulse as a result of this absorption.

Three types of photoreceptive structures found in insects:
1. Compound eyes
2. Dorsal ocelli
3. Lateral ocelli (stemmata)

Compound eyes
Most adult insects have a pair of compound eyes. The compound eyes are composed of a large number of alike structural units called ommatidia. The number of ommatidia varies from insect to insects.
The structural parts of an Ommatidium

The ommatidium consists of the followings structural parts:

i. **The cornea**: It is outmost part of the ommatidium. It is transparent, colorless and biconvex modified cuticular area often termed as a facet or lens.

ii. **The corneagen cells**: They are the epidermal or hypodermal cells lying behind the cornea. A group of two corneagen cells secretes a single lens.

iii. **The cone or semper cells**: Beneath the cornea, there are four distinct cells. Generally they secrete the crystalline and form a cone. In most cases, these cells are represented by the nuclei only, called the semper cells.

iv. **The retinula cells**: The crystalline cone is followed by a long retina forming a basal part of an ommatidium. It is firmed from a group of alike seven retinula cells as pigmented visual cells. Each retinula cell posteriorly terminates above the basement membrane and gives out a post retinal axonal fibre running towards the optical lobe. The inner margin of the retinula cell lying around the ommatidial axis is highly differentiated from rest of the cell body, and it is called the rhabdomere. These rhabdomere of all 7 retinula cells extend the whole length of the retina and form a rhabdom. The rhabdom is nothing but an internal optic rod having a fibrillar structures, and it becomes a central axis of retina.

v. **The pigment or iris cells**: There are two groups of iris cells, one around the crystalline cone cells and the other around the retinula, called the primary and secondary iris cells, respectively. Each group of iris cells is composed of six cells arrange in a short of circlet. The secondary iris cells separate one ommatidium from the neighbour one.

![Transverse Section Through An Insect Eye](image)
The mechanism of image formation:

i. **The apposition mechanism:** It is a mechanism of image formation in the bright day light by most of the diurnal insects. The pigment cells envelop the ommatidia completely and thus the rays of light can enter from the central point of the dioptic apparatus. Different ommatidia finally produced a single complete, erect image of an object.

ii. **The super position mechanism:** It is a mechanism of image formation in poor light generally during night, mostly the nocturnal insects. At night time the pigment cells become contracts so that the light from the wide visual field can enter to the rhabdom of retinula cells obliquely. So light can enter centrally and obliquely. Each rhabdom therefore receives the light from several cones of neighboring ommatidia. Hence there is an overlapping of points of light. The image thus formed from a group of rays refracted by neighboring cones, called the superposition image. It is erect in position and represents merely a part of an image. The compound image is formed after an amalgamation of all such images and it is the final form of a complete superposition image.
Dorsal and Lateral Ocelli: