

**Zoology Assignment**

***“Invertebrate Sensory Receptors”***

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➤ **Last date of submission:**

15-8-2012

**BS-Zoology 4-Years**

**4<sup>th</sup> semester**

To understand the invertebrate sensory receptors, first we must have information about the basics of sensory receptions.

By **definition**, the senses of an animal limit and define its impression of environment. Sense organs are specialized receptors designed for detecting environmental status and change. An animal's sense organs are its first level of environmental perception; they are channels for bringing information to the brain.

The sensory receptors work on stimulus to nerve impulse rule, which means that they receive the stimulus and convert it into nerve impulses. **Stimulus** is any form of energy an animal can detect with its receptors. As we have said that the receptors change the stimulus into impulse, so all the receptors are transducers (to change over).

### **Classification of receptors:**

Receptors, sometimes, classified according to their position i.e. outside or inside the body.

- **Exteroceptors** are those receptors which are present outside the body such as those receptors which sense pressure or heat.
- **Interoceptors** are those receptors which present and response internally and receive the response for internal organs.

Receptors, for easiness, are also classified according to their type of reception i.e. chemoreceptors, thermoreceptors, photoreceptors etc. here we will also classify the receptors according to same method.

### **Basic features of sensory receptors:**

There are following four basic features of all sensory receptors.

1. They contain sensitive receptor cells or finely branched peripheral endings of sensory neurons that respond to a stimulus by creating a generator potential.
2. Their structure is designed to receive a specific stimulus.
3. Their receptor cells synapse with afferent nerve fibers that travel to the central nervous system along specific neural pathways.
4. In the central nervous system, the nerve impulse is translated into a recognizable sensation, such as sound.

**Sensory receptors in invertebrates:**

There are nine different types of sensory receptors present in invertebrates.

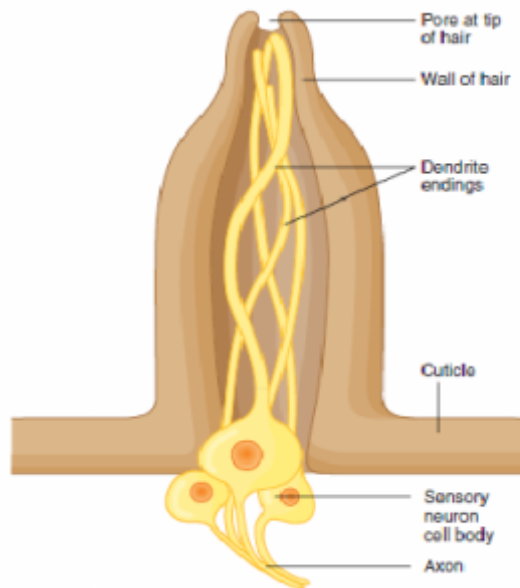
- ✓ Baroreceptors
- ✓ Chemoreceptors
- ✓ Georeceptors
- ✓ Hygroreceptors
- ✓ Phonoreceptors
- ✓ Photoreceptors
- ✓ Proprioceptors
- ✓ Tactilereceptors
- ✓ Thermoreceptors

**Baroreceptors:**

Baroreceptors (baros, weight + receptor) sense changes in pressure. Nevertheless, responses to pressure changes have been identified in ocean dwelling copepod crustaceans, ctenophores, jellyfish medusa, and squids. Some intertidal crustaceans coordinate migratory activity with daily tidal movements, possibly in response to pressure changes accompanying water depth changes.

**Chemoreceptors:**

Chemoreceptors (chemeia, pertaining to chemistry) respond to chemicals. Chemoreception is a direct sense in that molecules act specifically to stimulate a response. Chemoreception is the oldest and most universal sense in the animal kingdom. For example, protozoa have a chemical sense; they respond with avoidance behavior to acid, alkali, and salt stimuli. Specific chemicals attract predatory ciliates to their prey. The chemoreceptors of many aquatic invertebrates are located in pits or



**Fig. 1. Chemoreceptor of invertebrates**

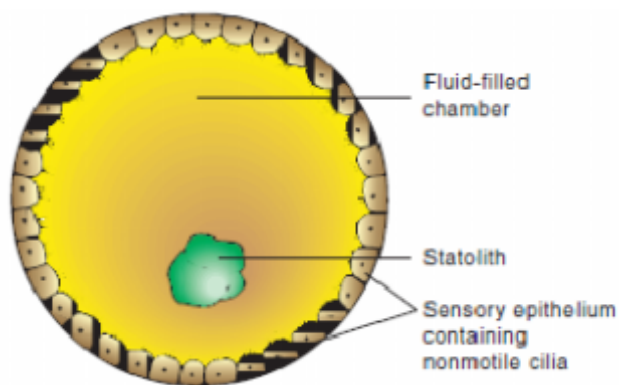
depressions, through which water carrying the specific chemicals may be circulated.

In arthropods, the chemoreceptors are usually on the antennae, mouthparts, and legs in the form of hollow hairs (sensilla; sing sensillum) containing chemosensory neurons (figure 1).

The types of chemicals to which invertebrates respond are closely associated with their lifestyles. Examples include chemoreceptors that provide information that the animal uses to perform tasks, such as humidity detection, pH assessment, prey tracking, food recognition, and mate location.

### **Georeceptors:**

Georeceptors (geo, earth+receptor) respond to the force of gravity. This gives an animal information about its orientation relative to “up” and “down.” Most georeceptors are **statocysts** (stato: standing , kystis: bladder) (figure: 2). Statocysts consist of a fluid-filled chamber lined with cilia-bearing sensory epithelium; within the chamber is a solid granule called a **statolith** (lithos, stone). Any movement of the animal changes the position of the statolith and moves the fluid, thus altering the intensity and pattern of information arising from the sensory epithelium. For example, when an animal moves, both the movement of the statolith and the flow of fluid over the sensory epithelium provide information about the animal’s linear and rotational acceleration relative to the environment. Statocysts are found in various gastropods, cephalopods,



**Fig.2: Georeceptors of invertebrates**

crustaceans, nemertines, polychaetes, and scyphozoans. These animals use information from statocysts in different ways. For example, burrowing invertebrates cannot rely on photoreceptors for orientation; instead, they rely on georeceptors for orientation within the substratum. Planktonic animals orient in their threedimensional aquatic environment using statocysts. This is especially important at night and in deep water where there is little light. In addition to having statocysts, a number of aquatic insects detect gravity from air bubbles trapped in certain passageways (e.g. tracheal tubes). Analogous to the air bubble in a carpenter’s level, these air bubbles move according to their orientation to gravity. The air bubbles stimulate sensory bristles that line the tubes.

**Hygroreceptors:**

Hygroreceptors (hygros, moist) detect the water content of air. For example, some insects have hygroreceptors that can detect small changes in the ambient relative humidity. This sense enables them to seek environments with a specific humidity or to modify their physiology or behavior with respect to the ambient humidity. Zoologists have identified a variety of hygrosensory structures on the antennae, palps, underside of the body, and near the spiracles of insects.

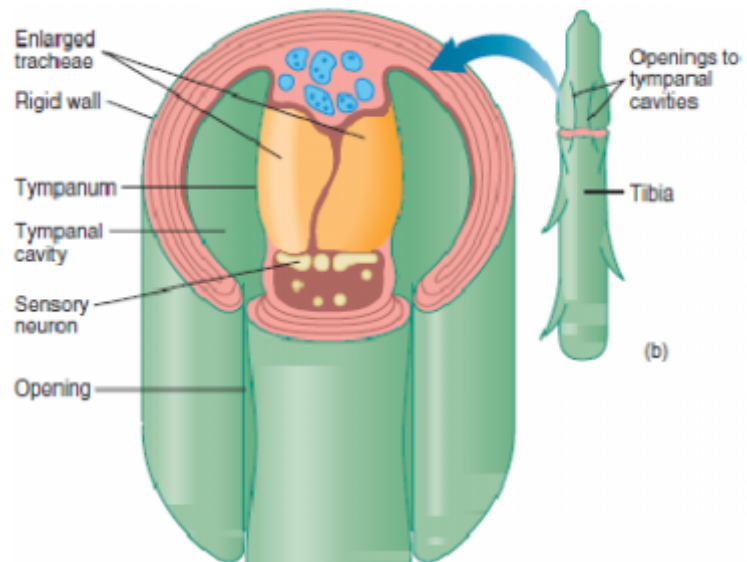
**Phonoreceptors:**

True phonoreceptors (phone, voice + receptor) that respond to sound have been demonstrated only in insects, arachnids, and centipedes, although other invertebrates seem to respond to sound-induced vibrations of the substratum. For example, crickets, grasshoppers, and cicadas possess

phonoreceptors called **tympanic** or **tympanal organs** (figure. 3). This organ consists of a tough, flexible tympanum that covers an internal sac that allows the tympanum to vibrate when sound waves strike it. Sensory neurons attached to the tympanum are stimulated and produce a generator potential.

Most arachnids possess phonoreceptors in their cuticle called slit sense organs that can sense sound-induced vibrations.

Centipedes have organs of Tomosvary, which some zoologists believe may be sensitive to sound. However, the physiology of both slit sense organs and organs of Tomosvary is poorly understood.

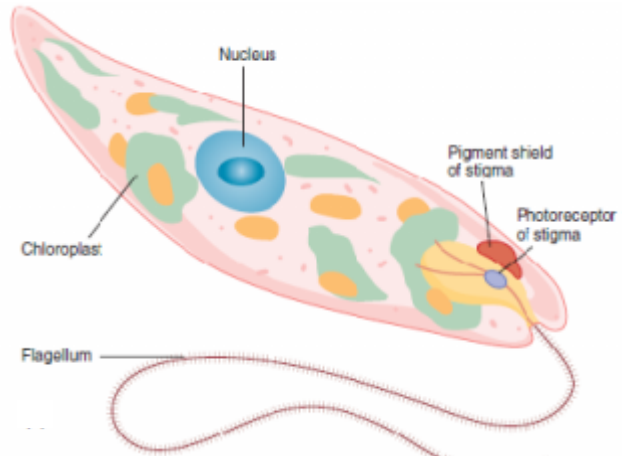


**Fig.3: invertebrate Phonoreceptor**

## Photoreceptors:

Photoreceptors (photos, light + receptor) are sensitive to light. All photoreceptors possess light-sensitive pigments (e.g. carotenoids, rhodopsin). These pigments absorb photons of light energy and then produce a generator potential. Beyond this basic commonality, the complexity and arrangement of photoreceptors within various animals vary incredibly.

Certain flagellated protozoa (Euglena) that contain chlorophyll possess a mass of bright red photoreceptor granules called the **stigma** (figure.4a). The granules are carotenoid pigments. The actual photoreceptor is the swelling at the base of the flagellum. The stigma probably serves as a shield, which is essential if the photoreceptor is to detect light coming from certain directions but not from others. Thus, the photoreceptor plus the stigma enable Euglena to orient itself so that its photoreceptor is exposed to light. This helps the protozoan maintain itself in the region of the water column where sufficient light is available for photosynthesis.

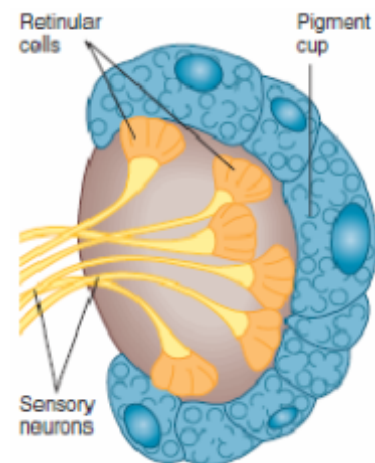


**Fig.4a: stigma in protozoa (Euglena)**

In other invertebrates, there are three main types of photoreceptors:

- ✓ Ocelli
- ✓ Compound eye
- ✓ Complex eye

An **ocellus** (dim of oculus, eye) is simply a small cup lined with light-sensitive receptors and backed by light absorbing pigment (figure. 4b). The light-sensitive cells are called reticular cells and contain a photosensitive pigment. Stimulation by light causes a chemical change in the pigment, leading to a generator potential, which causes an action potential that sensory neurons carry for interpretation elsewhere in the animal's body. This type of visual system gives an animal information about light direction and intensity, but not image formation. Ocelli are common in many phyla.



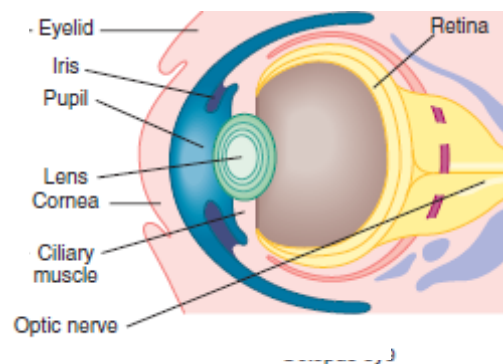
**Figure. 4b: Ocellus**

**Compound eyes** consist of a few to many distinct units called ommatidia (ommato, eye+ium, little) (figure. 4c). Although compound eyes occur in some annelids and bivalve molluscs, they are best developed and understood in arthropods. A compound eye may contain thousands of ommatidia, each oriented in a slightly different direction from the others as a result of the eye's overall convex shape. The visual field of a compound eye is very wide, as anyone who has tried to catch a fly knows. Each ommatidium has its own nerve tract leading to a large optic nerve. The visual fields of adjacent ommatidia overlap to some degree. Thus, if an object within the total visual field shifts position, the level of stimulation of several ommatidia changes. As a result of this physiology, as well as a sufficiently sophisticated central nervous system, compound eyes are very effective in detecting movements and are probably capable of forming an image. In addition, most compound eyes can adapt to changes in light intensities, and some provide for color vision. Color vision is particularly important in active, day-flying, nectar-drinking insects, such as honeybees. Honeybees learn to recognize particular flowers by color, scent, and shape.



**Figure. 4c:**  
**Compound eye**

The **complex eyes** of squids and octopuses are the best image-forming eyes among the invertebrates. In fact, the giant squid's eye is the largest of any animal's, exceeding 38 cm in diameter. Cephalopod eyes are often compared to those of vertebrates because they contain a thin, transparent cornea, and a lens that focuses light on the retina and is suspended by, and controlled by, ciliary muscles (figure 4d). However, the complex eyes of squids are different from the vertebrate eye in that the receptor sites on the retinal layer face in the direction of light entering the eye.

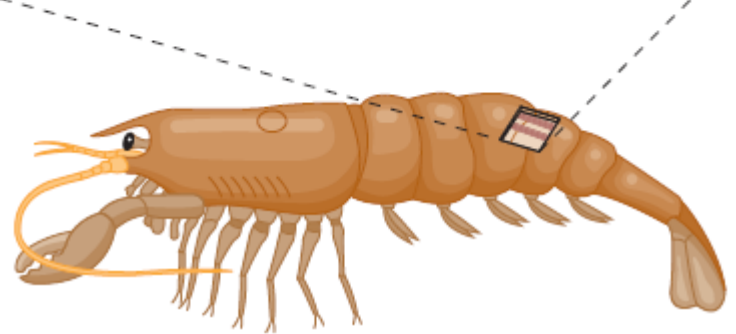
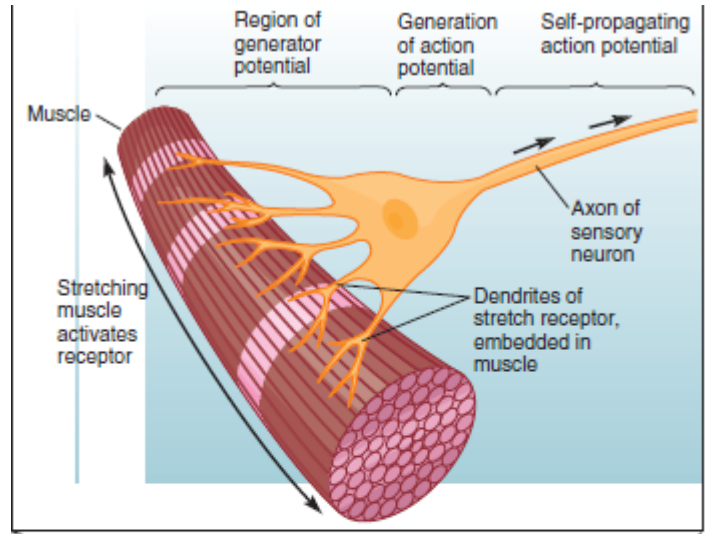


**Figure. 4d: complex eye**



**Proprioceptors:**

Proprioceptors (proprius, one’s self + receptor), commonly called “stretch receptors,” are internal sense organs that respond to mechanically induced changes caused by stretching, compression, bending, or tension. These receptors give an animal information about the movement of its body parts and their positions relative to each other. Proprioceptors have been most thoroughly studied in arthropods, where they are associated with appendage joints and body extensor muscles (figure. 5). In these animals, the sensory neurons involved in proprioception are associated with and attached to some part of the body that is stretched. These parts may be specialized muscle cells, elastic connective tissue fibers, or various membranes that span joints. As these structures change shape, sensory nerve endings of the attached nerves distort accordingly and initiate a generator potential.



**Figure. 5: proprioceptors of invertebrates**

**Tactilereceptors:**

Tactile (touch) receptors are generally derived from modifications of epithelial cells associated with sensory neurons. Most tactile receptors of animals involve projections from the body surface. Examples include various bristles, spines, setae, and tubercles. When an animal contacts an object in the environment, these receptors are mechanically deformed. These deformations activate the receptor, which, in turn, activates underlying sensory neurons, initiating a generator potential. Most tactile receptors are also sensitive to mechanically induced vibrations propagated through water or a solid substrate. For example, tube-dwelling polychaetes bear receptors that allow them to retract quickly into their tubes in response to movements in their surroundings. Web-building spiders have tactile receptors that can sense struggling prey in webs through vibrations of the web threads.



**Thermoreceptors:**

Thermoreceptors (therme, heat + receptors) respond to temperature changes. Some invertebrates can directly sense differences in environmental temperatures. For example, the protozoan Paramecium collects in areas where water temperature is moderate, and it avoids temperature extremes. Somehow, a heat-sensing mechanism draws leeches and ticks to warm-blooded hosts. Certain insects, some crustaceans, and the horseshoe crab (*Limulus*) can also sense thermal variations. In all of these cases, however, specific receptor structures have not been identified.

**References:**

1. Zoology Miller and Harley 4<sup>th</sup> edition
2. Integrated Principles of Zoology, Hickman 11<sup>th</sup> edition

**Diagrams:**

- ✓ <http://www.scribd.com/doc/7111705/Miller-the-Zoology-Book-2> Page 382-385