Course: Animal form and function

COMMUNICATION II: Senses

SENSORY RECEPTION

Sensory receptors have the following basic features:

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.

Receptors of different kinds:

- BARORECEPTORS
- CHEMORECEPTORS
- GEORECEPTORS
- HYGRORECEPTORS
- PHOTORECEPTORS
- TACTILE RECEPTORS
- THERMORECEPTORS

❑ BARORECEPTORS

Baroreceptors (Gr. baros, weight receptor) sense changes in pressure.

- ✓ Zoologists have not identified any specific structures for baroreception in invertebrates.
- ✓ Nevertheless, responses to pressure changes have been identified in ocean dwelling copepod crustaceans, ctenophores, jellyfish medusae, and squids.
- ✓ Some intertidal crustaceans coordinate migratory activity with daily tidal movements, possibly in response to pressure changes accompanying water depth changes.

❑ Chemoreceptors

Chemoreceptors respond to chemicals

For example:

- ✓ protozoa have a chemical sense; they respond with avoidance behavior to acid, alkali, and salt stimuli.
- ✓ The chemoreceptors of many aquatic invertebrates are located in pits or depressions.
- ✓ In arthropods, the chemoreceptors are usually on the antennae, mouthparts, and legs in the form of hollow hairs (sensilla; sing., sensillum) containing chemosensory neurons.

Chemoreceptors that provide information that the animal uses to perform tasks such as:

- ✓ humidity detection,
- ✓ pH assessment,
- ✓ prey tracking,
- ✓ food recognition, and
- ✓ mate location. For example in male silkworm moths (Bombyx mori).

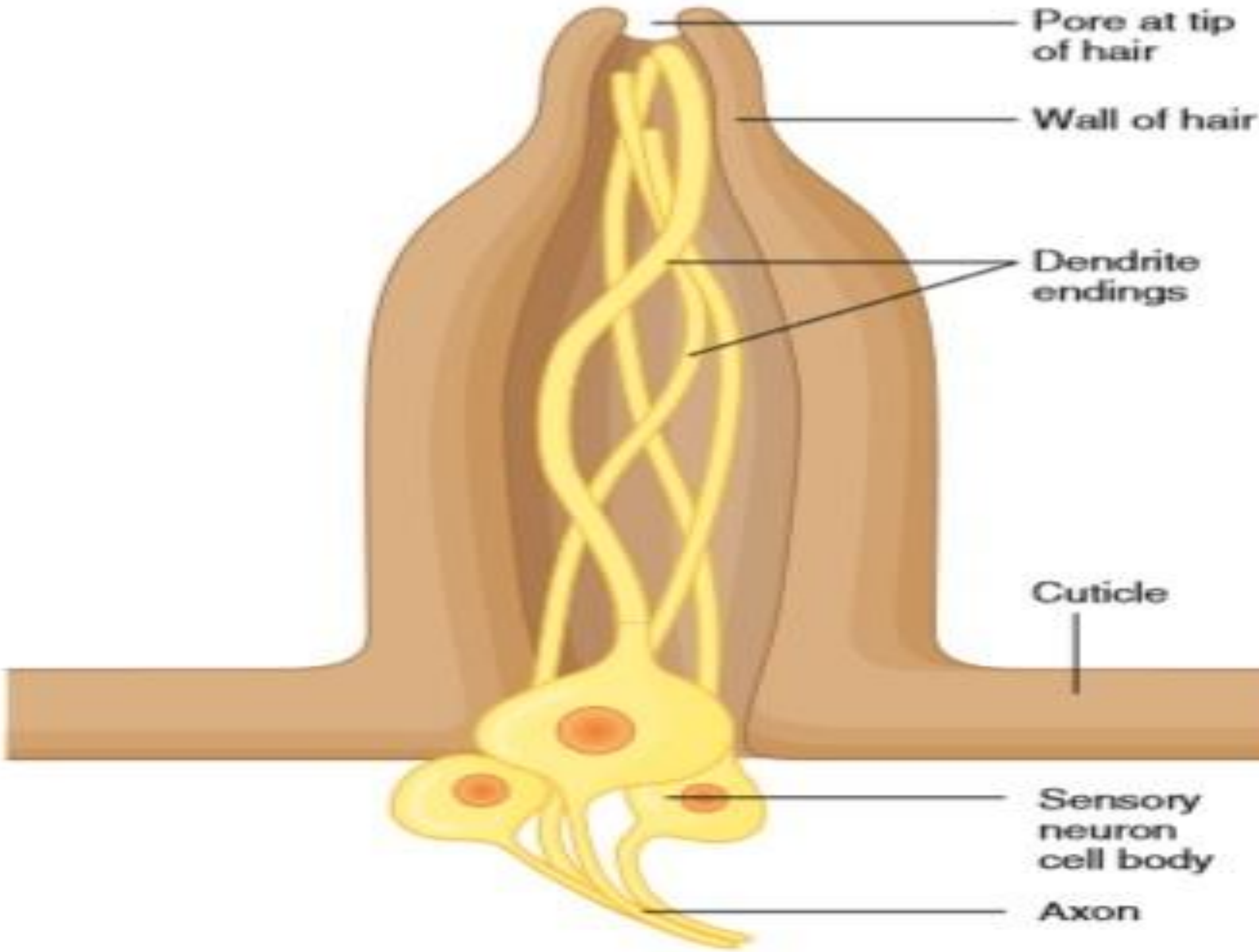


Fig: Invertebrate Chemoreceptor. Cross section through an insect sensillum. The receptor is a projection of the cuticle with a pore at the tip. Each chemoreceptor generally contains four to five dendrites, which lead to sensory neuron cell bodies underneath the cuticle. Each sensory cell has its own spectrum of chemical responses. Thus, a single sensillum with four or five dendrites and cell bodies may be capable of discriminating many different chemicals.

❑ GEORE(GEORECEPTORS)

Georeceptors (Gr. ge, earth receptor) respond to the force of gravity.

- ✓ Most georeceptors are **statocysts**. Statocysts consist of a fluid-filled chamber lined with cilia-bearing sensory epithelium; within the chamber is a solid granule called a **statolith**.
- ✓ 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.
- ✓ Statocysts are found in various gastropods, cephalopods, crustaceans, nemertines, polychaetes, and scyphozoans, burrowing invertebrates and Planktonic animals.
- ✓ In addition to having statocysts, a number of aquatic insects detect gravity from air bubbles trapped in certain passageways (e.g., **tracheal tubes**).

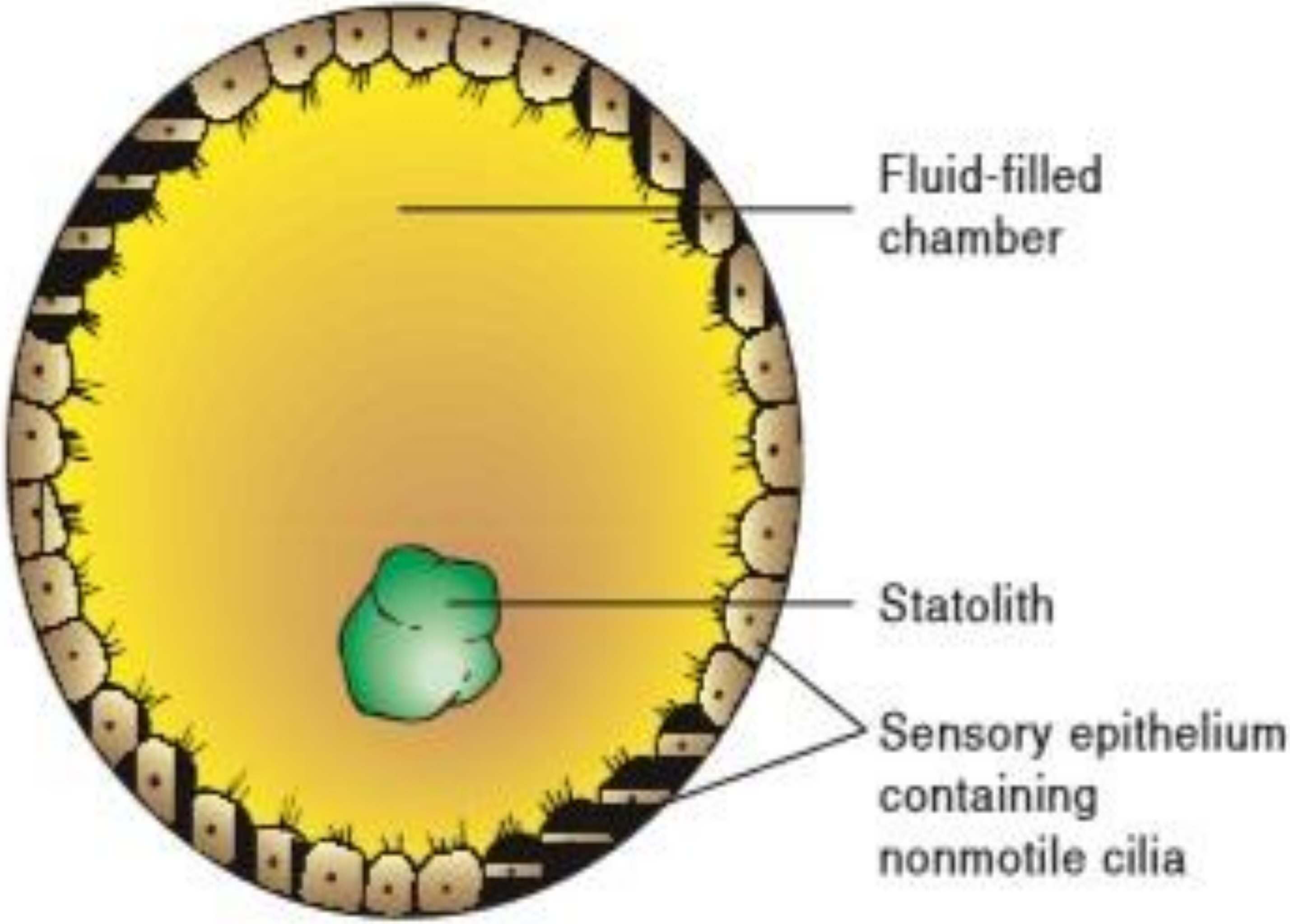


Fig: Invertebrate Georeceptor. A statocyst (cross section) consists of a fluid-filled chamber containing a solid granule called the statolith. The inner lining of the chamber contains tactile epithelium from which cilia associated with underlying neurons project.

❑ HYGRORECEPTORS

Hygroreceptors (Gr. hygros, moist) detect the water content of air.

For example:

- ✓ some insects have hygroreceptors that can detect small changes in the ambient relative humidity (e.g., to control the opening or closing of spiracles).
- ✓ Zoologists have identified a variety of hygrosensory structures on the antennae, palps, underside of the body, and near the spiracles of insects.
- ✓ However, how a hygroreceptor transduces humidity into an action potential is not known.

❑ PHOTORECEPTORS

Photoreceptors (Gr. 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.

Examples:

- ✓ Certain **flagellated protozoa (Euglena)** that contain chlorophyll possess a mass of bright red photoreceptor granules called the stigma. Photoreceptor plus the stigma enable Euglena to orient itself so that its photoreceptor is exposed to light.

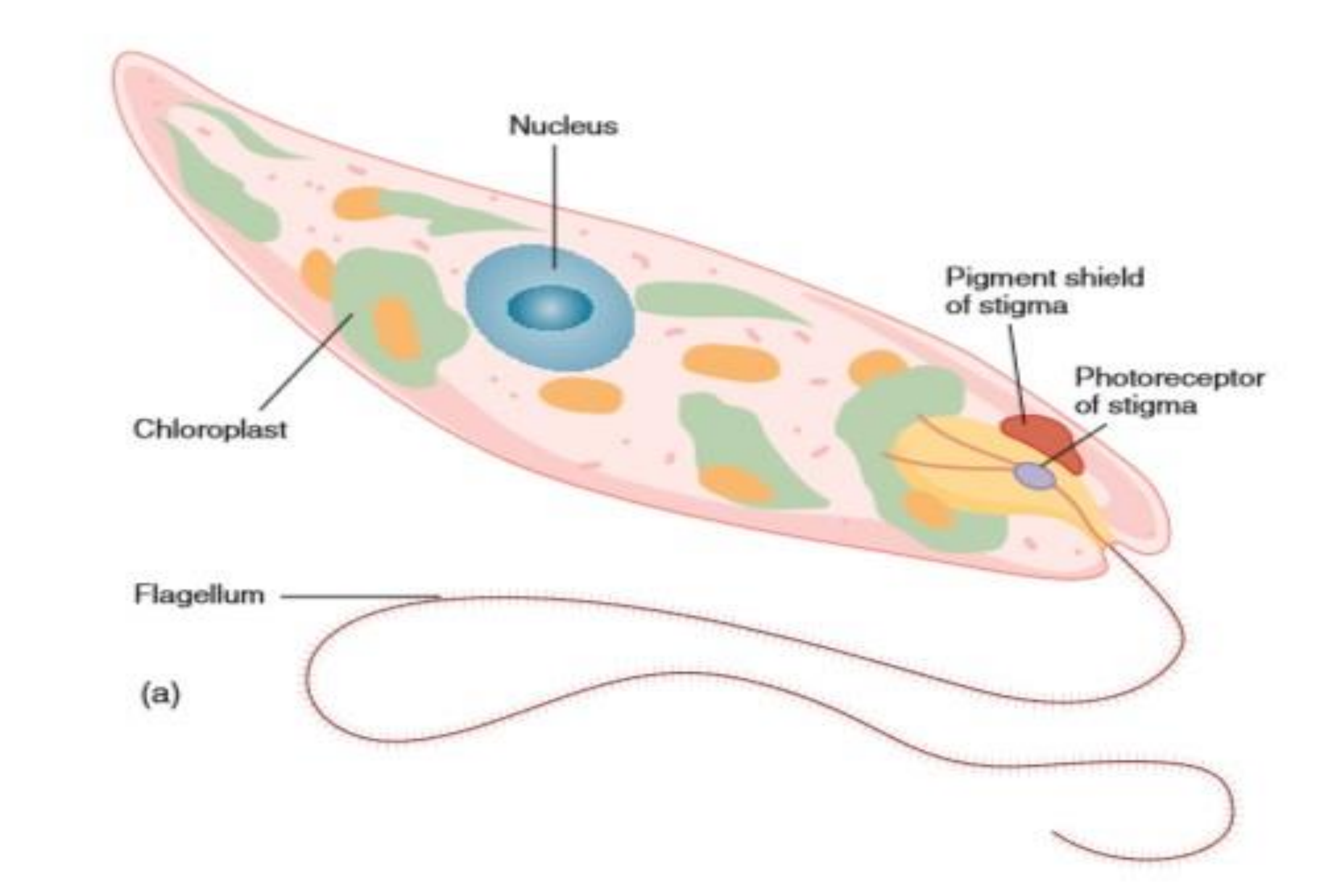


Fig: Invertebrate Photoreceptors. (a) Stigma. The protozoan, Euglena, contains a mass of bright red granules called the stigma. The actual photoreceptor is the swelling at the base of the flagellum.

- ✓ **earthworm Lumbricus**, have simple unicellular photoreceptor cells scattered over the epidermis or concentrated in particular areas of the body.
- ✓ Others possess multicellular photoreceptors that can be classified into three basic types:

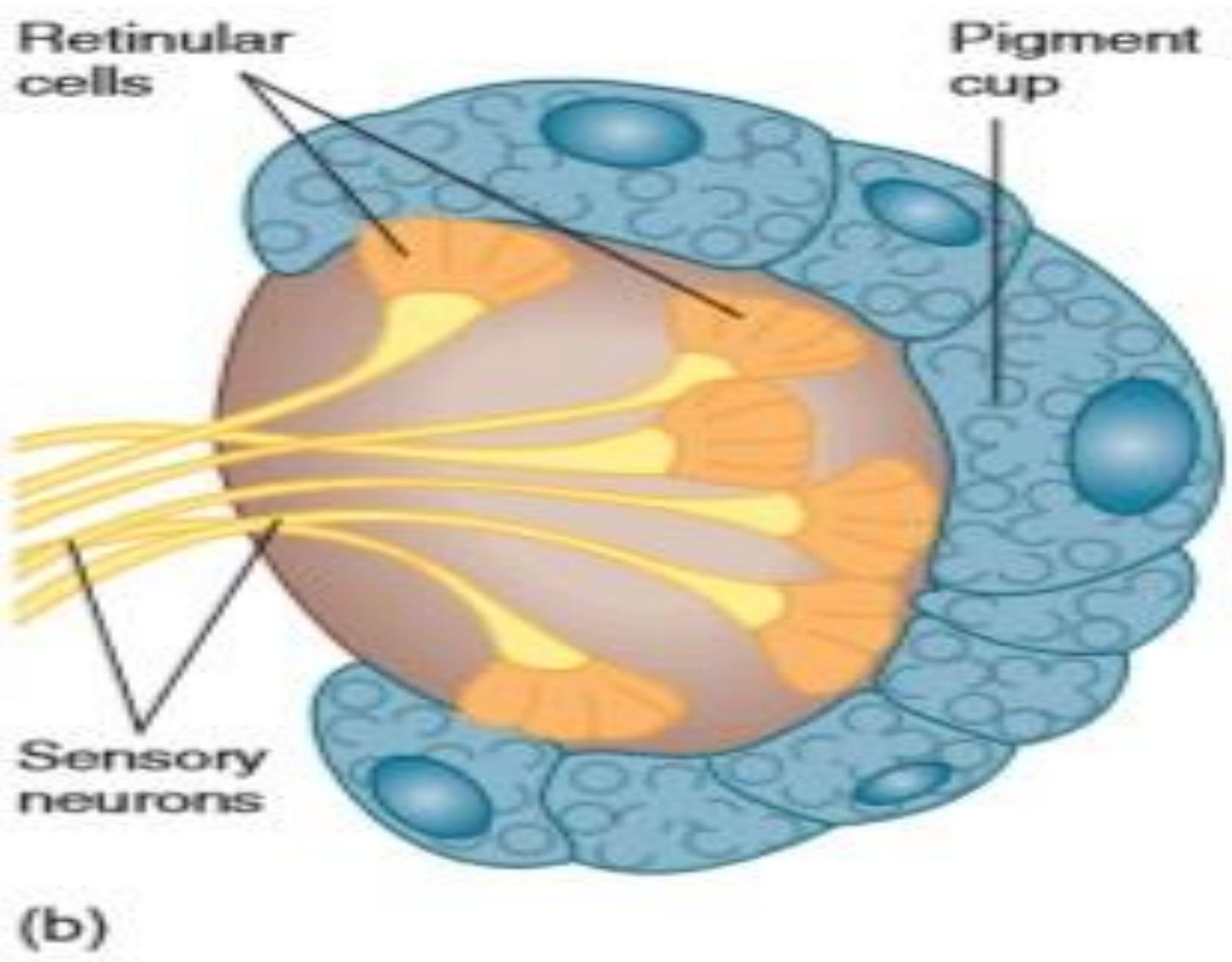
i. **Ocelli**

ii. **Compound eyes**

iii. **Complex eyes.**

i) Ocellus:

- ✓ An ocellus is simply a small cup lined with light-sensitive receptors and backed by light absorbing pigment.
- ✓ The light-sensitive cells are called retinular 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 (e.g., Annelida, Mollusca, and Arthropoda).



Fig(b): Ocellus. The inverted pigment cup ocellus of a flatworm.

ii) Compound eyes :

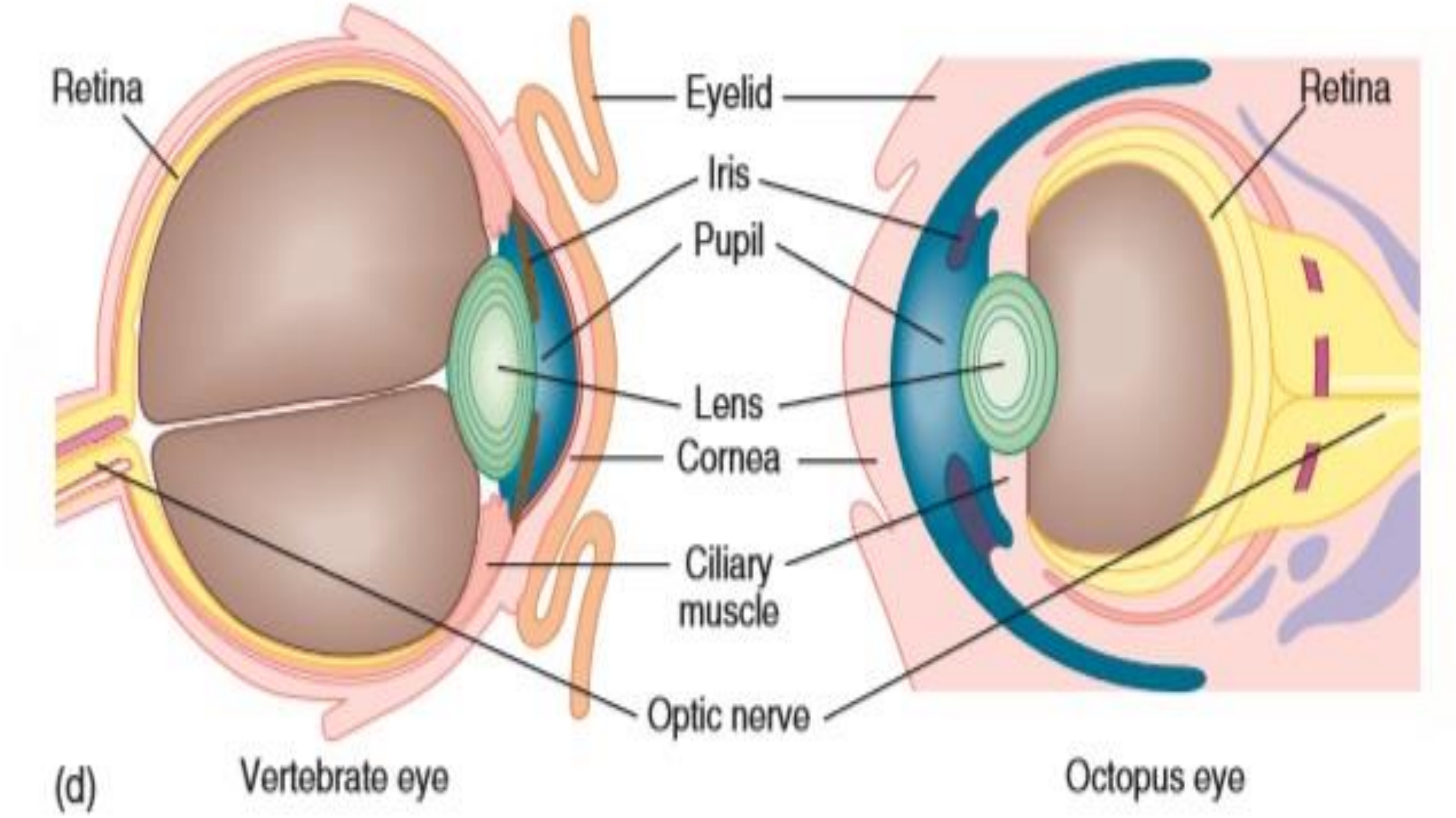
- ✓ consist of a few to many distinct units called **ommatidia.**
- ✓ The visual field of a compound eye is very wide.
- ✓ Each ommatidium has its own nerve tract leading to a large optic nerve.
- ✓ compound eyes are very effective in detecting movements and are probably capable of forming an image.
- ✓ most compound eyes can adapt to changes in light intensities.
- ✓ Color vision is particularly important in active, day-flying, nectar drinking insects, such as honeybees.

(c)

Fig(c): Compound eye. The compound eye of a fly contains hundreds of ommatidia. Note the eye's convex shape; no two ommatidia are oriented in precisely the same direction (SEM)

iii) Complex eyes:

- ✓ The complex camera eyes of squids and octopuses are the best image-forming eyes among the invertebrates.
- ✓ 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.
- ✓ 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.
- ✓ In the vertebrate eye, the retinal layer is inverted, and the receptors are the deepest cells in the retina.
- ✓ In fishes and cephalopods, light is focused by muscles that move the lens toward or away from the retina.



Fig**(d): Complex camera eyes. Comparison of a vertebrate eye and an octopus eye (vertical sections).**

❑ Tactile (touch) receptors:

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. These include various bristles, spines, setae, and tubercles.

❑ Mode of action:

- 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.

❑ Examples:

- **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 (Gr. therme, heat receptors) respond to temperature changes.

For example:

- the protozoan Paramecium collects in areas where water temperature is moderate, and it avoids temperature extremes.
- 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.
- rattlesnakes and other pit vipers have heat-sensitive pit organs on each side of the face between the eye and nostril

Fig: Thermoreception. A rattlesnake (Crotalus vergrandis) has a pit organ between each eye and nostril that detects heat and allows the snake to locate warm prey in the dark.

LATERAL-LINE SYSTEM AND MECHANORECEPTION

A **mechanoreceptor** is excited by mechanical pressures or distortions (e.g., sound, touch, and muscular contractions).

- The lateral line system of the more advanced fishes, and aquatic amphibians includes several different kinds of hair-cell mechanoreceptors called neuromasts

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- All neuromasts are responsive to local water displacement or disturbance

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- water near the lateral line moves, it moves the water in the pits and distorts the hair cells, causing a generator potential in the associated sensory neurons

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- For example, this sense enables a trout to orient with its head upstream

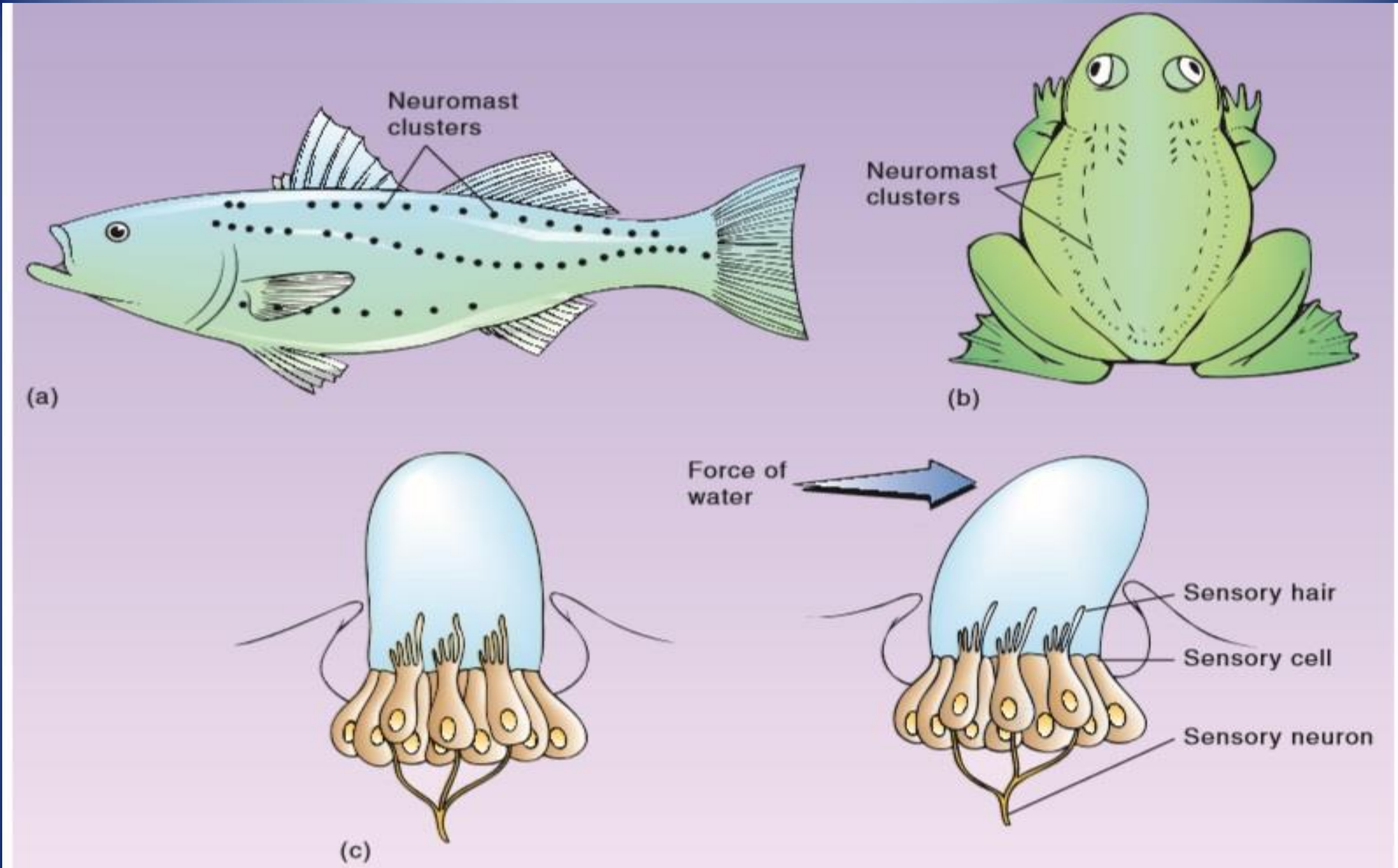

Fig: Lateral-Line System and Mechanoreception. The lateral-line system of (a) a bony fish and (b) a frog, showing the various neuromast clusters. (c) Action of neuromast stimulation. The water movement (blue arrow) forces the cap-like structure covering a group of neuromast cells to bend or distort, thereby distorting the small sensory hairs of the neuromast cells, producing a generator potential. The generator potential causes an action potential in the sensory neuron.