Receptors

■ DEFINITION

Receptors are sensory (afferent) nerve endings that terminate in periphery as bare **unmyelinated endings** or in the form of specialized **capsulated structures**. Receptors give response to the stimulus. When stimulated, receptors produce a series of impulses, which are transmitted through the afferent nerves.

Biological Transducers

Actually receptors function like a transducer. Transducer is a device, which converts one form of energy into another. So, receptors are often defined as the biological transducers, which convert (transducer) various forms of **energy** (stimuli) in the environment into **action potentials** in nerve fiber.

■ CLASSIFICATION OF RECEPTORS

Generally, receptors are classified into two types:

A. Exteroceptors
B. Interoceptors.

■ EXTEROCEPTORS

Exteroceptors are the receptors, which give response to stimuli arising from **outside the body.**

Exteroceptors are divided into three groups:

1. *Cutaneous Receptors or Mechanoreceptors*

Receptors situated in the skin are called the cutaneous receptors. Cutaneous receptors are also called mechanoreceptors because of their response to **mechanical stimuli** such as touch, pressure and pain. Touch and pressure receptors give response to **vibration** also. Different types of cutaneous receptors are given in Figure 139.1.

2. *Chemoreceptors*

Receptors, which give response to **chemical stimuli,** are called the chemoreceptors.

3. *Telereceptors*

Telereceptors are the receptors that give response to stimuli arising **away from the body.** These receptors are also called the **distance receptors** (Fig. 139.2).

■ INTEROCEPTORS

Interoceptors are the receptors, which give response to stimuli arising from **within the body.**

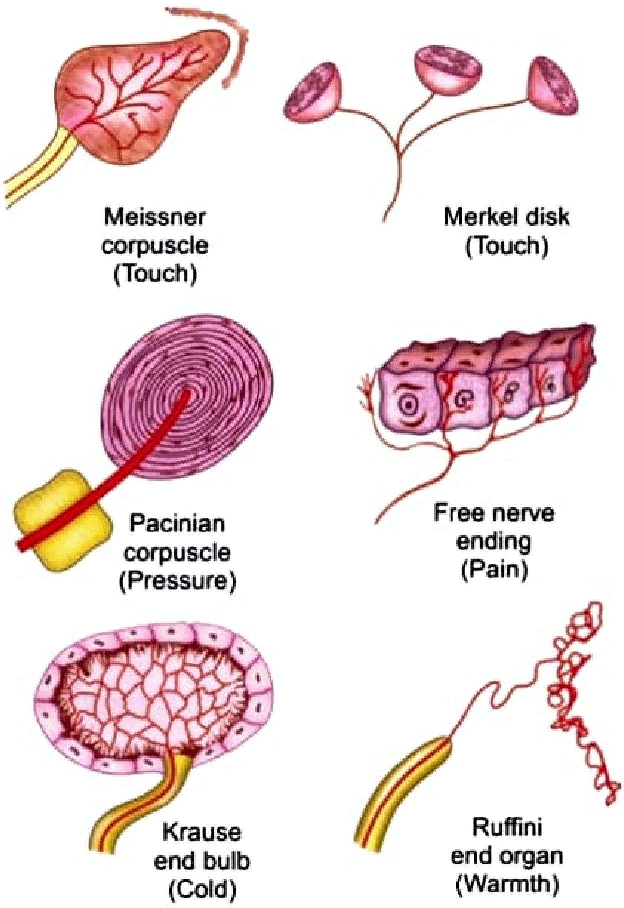


FIGURE 139.1: Cutaneous receptors

Interoceptors are of two types which are as follows:

1. *Visceroceptors*

Receptors situated in the viscera are called visceroceptors. Different visceroceptors are listed in Figure 139.3.

2. *Proprioceptors*

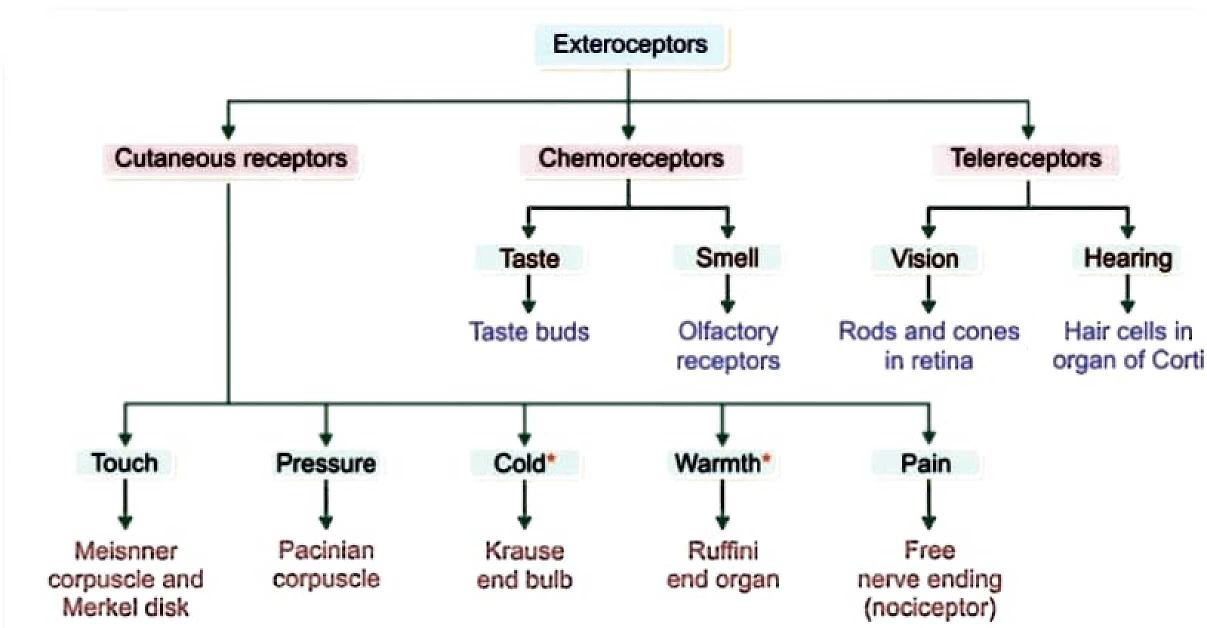
Proprioceptors are the receptors, which give response to **change in the position** of different parts of the body. Proprioceptors are explained in Chapter 156.

PROPERTIES OF RECEPTORS

1. SPECIFICITY OF RESPONSE – MÜLLER LAW

Specificity of response or Müller law refers to the response given by a particular type of receptor to a specific sensation. For example, pain receptors give response only to pain sensation. Similarly, temperature receptors give response only to temperature sensation. In addition, each type of sensation depends upon the part of the brain in which its fibers terminate.

Specificity of response is also called **Müller's doctrine** of specific nerve energies.



*Receptors of cold and warmth are together called temperature receptors (thermoreceptors)

FIGURE 139.2: Exteroceptors

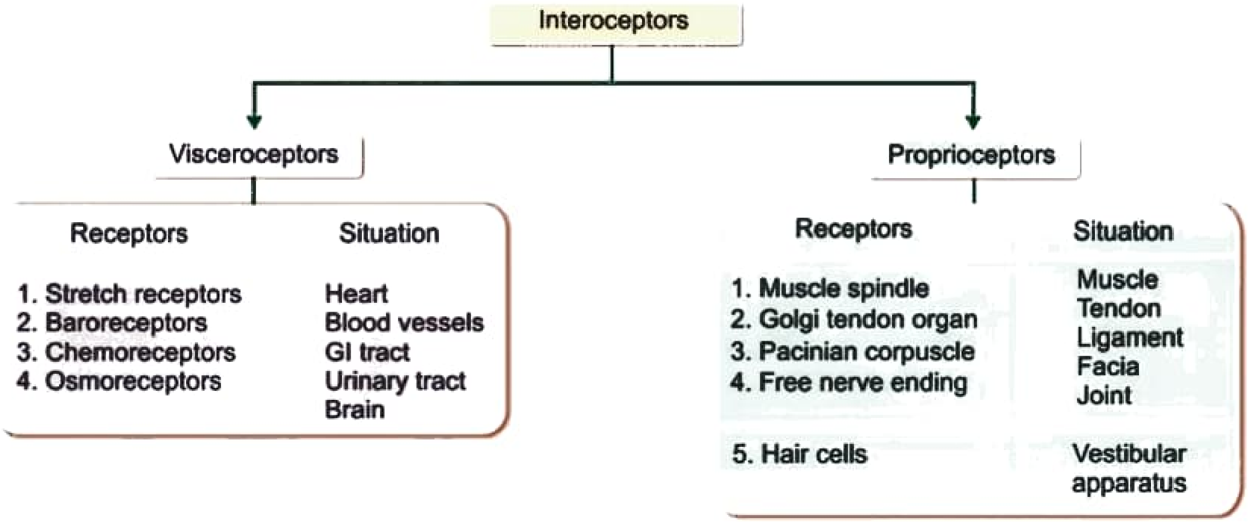


FIGURE 139.3: Interoceptors

■ 2. ADAPTATION – SENSORY ADAPTATION

Adaptation is the decline in discharge of sensory impulses when a receptor is stimulated continuously with constant strength. It is also called sensory adaptation or desensitization.

Depending upon adaptation time, receptors are divided into two types:

i. **Phasic receptors,** which get adapted rapidly. Touch and pressure receptors are the phasic receptors

ii. **Tonic receptors,** which adapt slowly. Muscle spindle, pain receptors and cold receptors are the tonic receptors.

■ 3. RESPONSE TO INCREASE IN STRENGTH OF STIMULUS – WEBER-FECHNER LAW

During the stimulation of a receptor, if the response given by the receptor is to be doubled, the strength of stimulus must be increased 100 times. This phenomenon is called Weber-Fechner law, which states that intensity of response (sensation) of a receptor is directly proportional to logarithmic increase in the intensity of stimulus.

Derivation of Weber-Fechner Law

Weber-Fechner law is derived as follows:

$$R = k \log S$$

Where,

R = Intensity of response (sensation)
k = Constant
S = Intensity of stimulus

■ 4. SENSORY TRANSDUCTION

Sensory transduction in a receptor is a process by which the energy (stimulus) in the environment is converted into electrical impulses (action potentials) in nerve fiber (transduction = conversion of one form of energy into another).

When a receptor is stimulated, it gives response by sending information about the stimulus to CNS. Series of events occur to carry out this function such as the development of receptor potential in the receptor cell and development of action potential in the sensory nerve.

Sensory transduction varies depending upon the type of receptor. For example, the chemoreceptor converts chemical energy into action potential in the sensory nerve fiber. Touch receptor converts mechanical energy into action potential in the sensory nerve fiber.

■ 5. RECEPTOR POTENTIAL

Definition

Receptor potential is a **non-propagated** transmembrane potential difference that develops when a receptor is stimulated. It is also called **generator potential**. Receptor potential is short lived and hence, it is called **transient receptor potential**.

Receptor potential is not action potential. It is a graded potential (Chapter 31). It is similar to excitatory postsynaptic potential (EPSP) in synapse, endplate potential in neuromuscular junction and electrotonic potential in the nerve fiber.

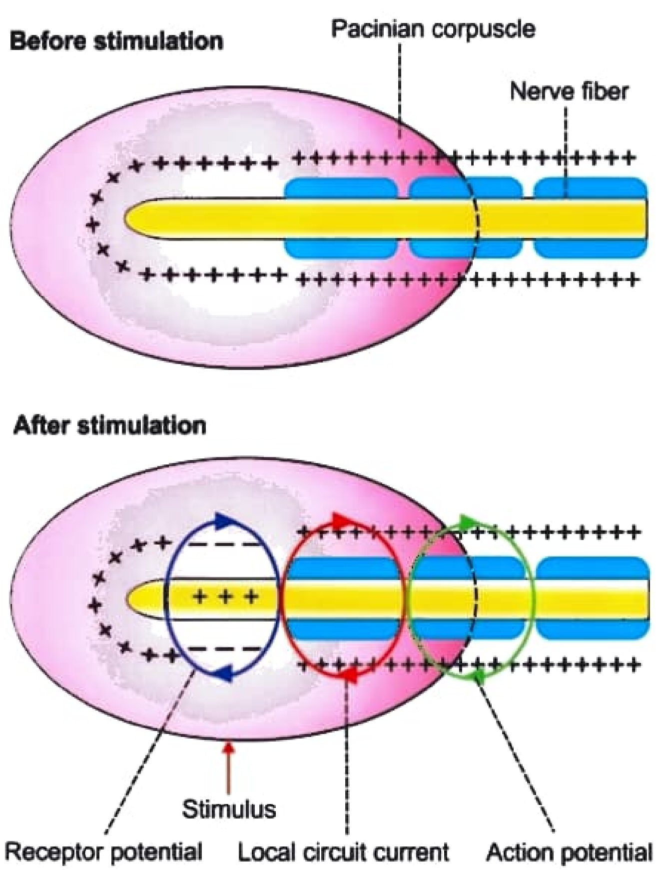


FIGURE 139.4: Receptor potential in pacinian corpuscle. Receptor potential leads to development of local circuit which spreads up to first node within the capsule. It leads to development of action potential in the first node of nerve fiber.

Properties of Receptor Potential

Receptor potential has two important properties.

i. Receptor potential is **non-propagated;** it is confined within the receptor itself
ii. It does not obey **all-or-none law.**

Significance of Receptor Potential

When receptor potential is sufficiently strong (when the magnitude is about 10 mV), it causes development of action potential in the sensory nerve.

Mechanism of Development of Receptor Potential

Pacinian corpuscles are generally used to study the receptor potential because of their large size and anatomical configuration. These corpuscles can be easily dissected from the mesentery of experimental animals. In the pacinian corpuscle, the tip of the nerve fiber is unmyelinated. This unmyelinated nerve tip extends through the corpuscle as **center core fiber.** The concentric layers of the corpuscle surround the core fiber of the nerve.

Pacinian corpuscles give response to pressure stimulus. When pressure stimulus is applied, the Pacinian corpuscle is compressed. This compression causes elongation or change in shape of the corpuscle. The change in shape of the corpuscle leads to the deformation of center core fiber of the corpuscle. This results in the opening of mechanically gated **sodium channels** (Chapter 3). So, the positively charged sodium

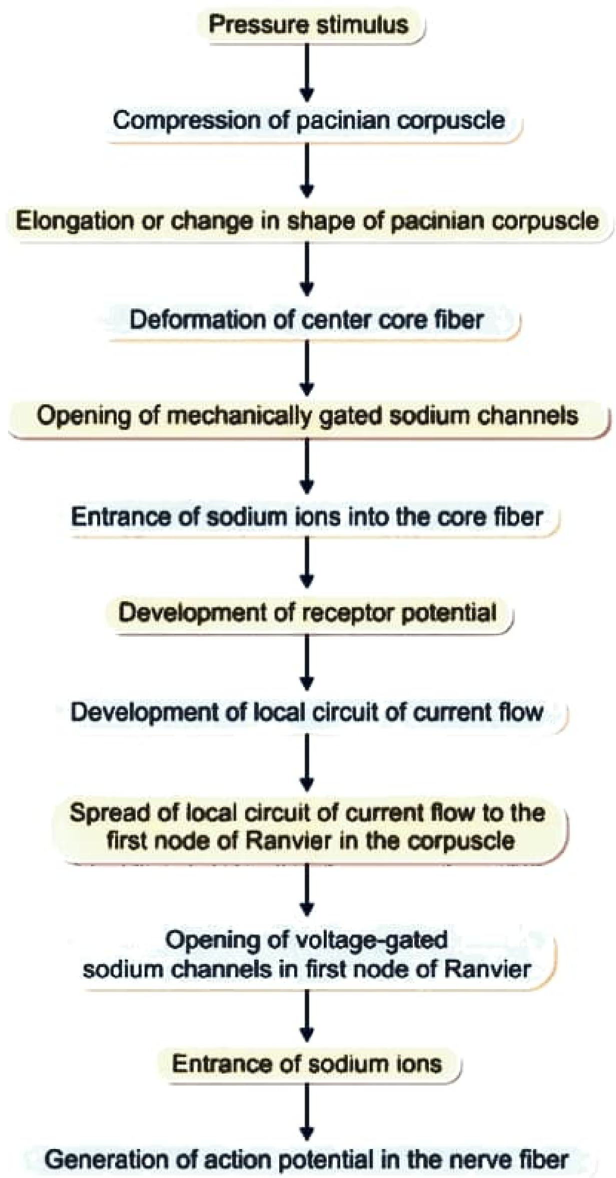


FIGURE 139.5: Schematic diagram showing development of receptor potential and generation of action potential in nerve fiber.

ions enter the interior of core fiber. This produces a **mild depolarization,** i.e. receptor potential (Fig. 139.4).

Generation of Action Potential in the Nerve Fiber

Receptor potential causes development of a **local circuit** of current flow, which spreads along the unmyelinated part of nerve fiber within the corpuscle.

When this local circuit of current reaches the first node of Ranvier within the corpuscle, it causes opening of voltage-gated sodium channels and entrance of sodium ions into the nerve fiber. This leads to the development of action potential in the nerve fiber (Fig. 139.5).

■ 6. LAW OF PROJECTION

When a sensory pathway from receptor to cerebral cortex is stimulated on any particular site along its course, the sensation caused by stimulus is always felt (referred) at the location of receptor, irrespective of site stimulated. This phenomenon is known as law of projection.

Examples of Law of Projection

i. If somesthetic area in right cerebral cortex, which receives sensation from left hand is stimulated, sensations are felt in left hand and not in head.
ii. Sensation complained by amputated patients in the missing limb **(phantom limb)** is the best example of law of projection. For example, if a leg has been amputated, the cut end heals with scar formation. The cut ends of nerve fibers are merged within the scar. If the cut end of sensory fibers are stimulated during movement of thigh, the patient feels as if the sensation is originating from **non-existent leg.** Sometimes, the patient feels pain in non-existent limb. This type of pain is called **phantom limb pain.**