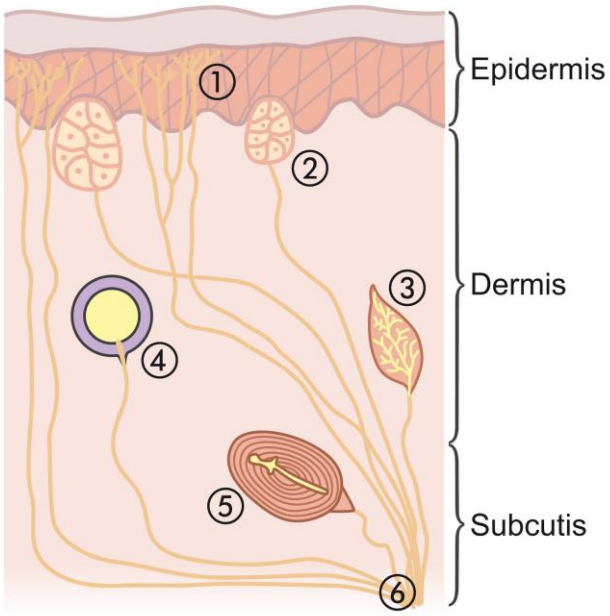
Sensors in the skin

Skin can be roughly divided into three layers:

- Epidermis
- Dermis
- Subcutis

The nerve endings and receptors that react to pain, pressure, and temperature are each located in specific layers of the skin.



① Pain receptor (free nerve endings)
② Meissner's corpuscle (tactile corpuscle)
③ Heat receptor
④ Cold receptor
⑤ Vibration receptor (Pacinian corpuscle)
⑥ Sensory nerve fibers

Free nerve endings

These receptors can sense pain, itch, and tickling. Because pain sensitivity is especially important for survival, free nerve endings extend into the epidermis to enable people to experience ideally all pain stimuli. One square centimeter of skin contains up to 170 free nerve endings. This explains why – other than areas covered by thick calluses – there are no areas of skin where the surface is impervious to pain. Deeper pain receptors in areas where the skin is insensitive on the surface react to substances that are released when tissue is damaged.

Meissner's corpuscles (tactile corpuscles)

These receptors react to changes in pressures and thus to light touch and shear forces, and are especially numerous in the fingertips and the oral mucosa, i.e., places where we do the most testing of objects and substances in the environment. They are less numerous on our backs. Meissner's corpuscles provide information on the surfaces of objects. There are other types of tactile corpuscles.

Heat receptors

These receptors are located in the dermis. They react to a rise in temperature and are thus involved in sensing heat. On the back of the hand, there is less than one receptor per square centimeter of skin on average. Overall, there are few fewer heat receptors than cold receptors.

Cold receptors

These receptors are also located in the upper region of the dermis and are responsible for the perception of cold. Unlike a thermometer, they are incapable of measuring absolute temperatures and can perceive only temperature differences. They react to a drop in temperature and trigger a sensation of cold, and are most sensitive at ambient temperatures of around 25 °C. On the back of the hand, there are up to eight receptors per square centimeter of skin; in contrast, there are up to 20 receptors per cm^2 on the tongue.

Vibration receptors (Pacinian corpuscles)

These receptors are involved in sensing fast vibrations and react to changes in the shape of the skin. They're mostly located in the transitional area between the dermis and the subcutis.

Frequency encoding of nerve signals

Both types of thermoreceptors are constantly sending impulses to the brain. The particular receptors transmit an impulse to dendrites (cytoplasmic extensions of nerve cells) of the subsequent nerve cell. The impulse passes through the cell body to the axon, which conveys it to the end-bulbs. From there, a transmitter transfers the impulse to the adjacent cell. In this way, the information makes its way to the brain.
The frequency of the impulses depends on the temperature. Heat and cold receptors change the impulse frequency in response to cold and heat stimuli: cold receptors send more action potentials per unit of time as the temperature decreases. Heat receptors do the opposite, that is, they send more action potentials as the temperature increases. After a certain amount of time, the frequencies of the action potentials sent by cold and heat receptors adjust to the prevailing temperature. No additional temperature change is perceived until there is another change in temperature. At this point, more action potentials are sent and the receptors in the "warm hand" register cold water while those in the "cold hand" register warm water.