Mechanoreceptors, Encapsulated & Unencapsulated and Free Nerve Ending (FNE)

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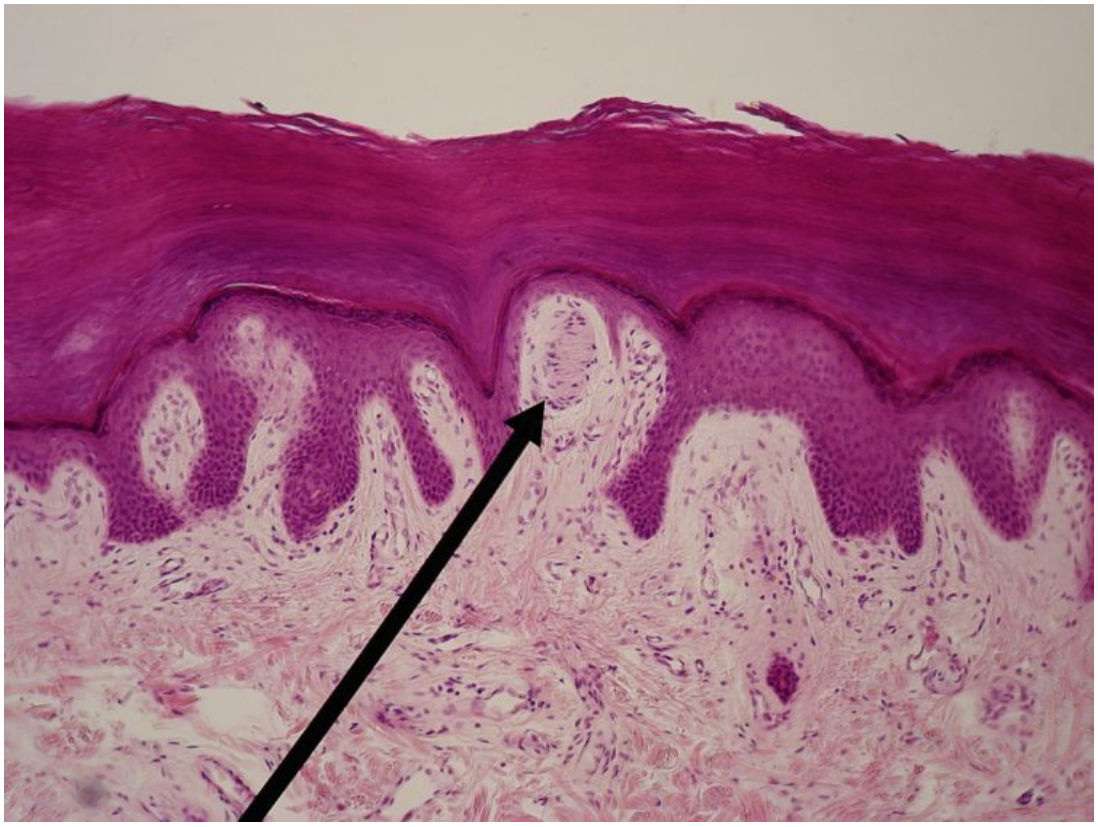
A mechanoreceptor is a sensory receptor which detects the mechanical stimulus of stretch and distortion. It is also known as the tactile receptor. In human beings, four types of mechanoreceptors are present in the hairless skin, which will be discussed in this article along with encapsulated and unencapsulated nerve endings and free nerve endings.

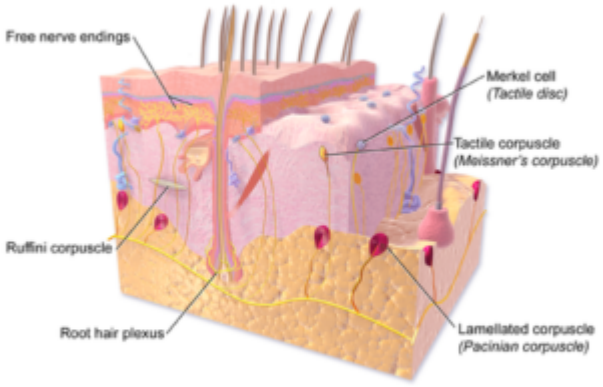


Mechanoreceptors

A mechanoreceptor is a **sensory receptor** that detects the mechanical stimuli of **stretch** and **distortion**. It is also known as the **tactile receptor**. In human beings, four types of mechanoreceptors are present in hairless skin: Pacinian corpuscles, Meissner's corpuscles, Merkel's cells, and Ruffini endings. They are discussed in detail below.

The **afferent neurons** carry the signals from the sensory receptors to the **dorsal column nuclei.** From there, the second order neurons carry the message forward to the

thalamus. The second order neurons synapse with the third order neurons in the **ventrobasal complex**. The third order neurons deliver the signals to the **somatosensory cortex,** which sends appropriate signals via the **motor neurons**.



Tactile Receptors in the Skin

Image: "Mechanoreceptors in the Skin." by Blausen.com Staff. "Blausen gallery 2014". Wikiversity Journal of Medicine. DOI:10.15347/wjm/2014.010. ISSN 20018762. – Own Work.

The afferents from the Pacinian corpuscle, Meissner's corpuscle, and Ruffini ending are thought to link directly the muscle activation.

There are receptors in the **hair follicle** which detect a change in the hair's position. Mechanoreceptors are also present in the **hair of the cochlea,** which transmits vibration signals to the brain.

Baroreceptors are a type of mechanoreceptor in **large blood vessels**. They detect a rise in blood pressure and send the signal to the **vasomotor center** in the brain.

Pacinian corpuscles

Image: “Pacinian Corpuscle” by Henry Vandyke Carter, Henry Gray (1918) Anatomy of the Human Body. Bartleby.com: Gray’s Anatomy, Plate 935. License: Public Domain

Pacinian corpuscles, also known as **lamellar corpuscles**, are **type II fibers** which detect vibration and pressure. They can detect **rapid vibrations of 200-300 Hz**.

They are the largest of the major types of corpuscles, measuring around 1mm in length, with an oval-cylindrical shape. They are also the fewest in number. There is an outer capsule present, comprised of **fibroblasts** and **fibrous connective tissue,** which is mainly a type II and type IV collagen network.

They are rapidly adapting receptors with a large receptive field. Any disruption in their lamellae causes the sodium channels to open, creating an **action potential**. The magnitude of the disruption dictates the response. The greater the pressure change, the larger the impulse.
However, as mentioned earlier, they adapt very rapidly, and impulses are not generated after some time. Pacinian corpuscles are present in the **skin** and **fascia**.
The **pancreas** also has these corpuscles, which detect vibration changes.

Meissner’s corpuscles

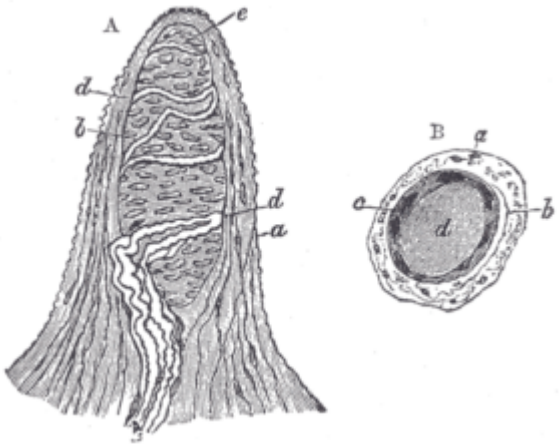


Image: “A Meissner’s corpuscle. a. Cortical layer. b. Nerve fiber. c. Outer layer of the tactile body, with nuclei. d. Clear interior substance.” by Henry Vandyke Carter, Henry Gray (1918) Anatomy of the Human Body. Bartleby.com: Gray’s Anatomy, Plate 936. License: Public Domain

Meissner’s corpuscles, or **tactile corpuscles,** are **type II fibers** and respond to a **light touch**. They have the lowest threshold and are sensitive to **vibrations of 10-50 Hz**. The length of the corpuscle is twice its diameter. It is an **encapsulated, unmyelinated nerve ending**, where the cells are arranged in the form of horizontal lamellae, surrounded by a capsule of connective tissue.

Any physical deformation of the corpuscle generates an action potential; however, they are also very rapidly adapting nerve endings. These nerve endings are concentrated in the **thick, hairless skin,** such as the finger pads and lips. Their number declines with increasing age.

Merkel’s cells

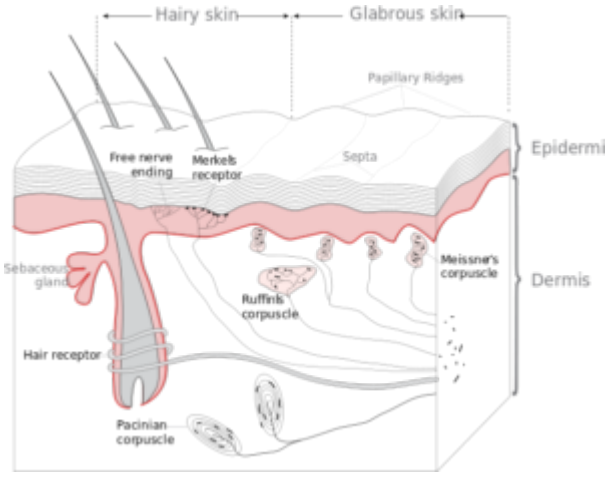


Image: “Arrangement of Mechanoreceptors in the Skin.” by Thomas.haslwanter – Own Work. License: CC BY-SA 3.0

Merkel’s cells consist of type II fibers. They detect **sustained pressure** and **deep static touch**. They are slowly adapting, unencapsulated, and myelinated nerve endings.

Merkel’s disc, or **Merkel’s neurite** complex, refers to a group of Merkel’s cells linked to a single afferent nerve fiber. They have a small receptive field and, therefore, are capable of **two-point discrimination**. They are found in the **basal epidermis of the glabrous,** as well as the **hairy skin,** and are usually lost in case of skin burn.

Ruffini endings

Ruffini endings, or **bulbous corpuscles,** are type II fibers that detect **pressure tension deep in the skin and fascia**. They are slow adapting, enlarged dendritic endings with elongated capsules. They are responsible for detecting **angle changes of the joints,** up to 3 degrees. They also detect **slippage of an object or sustained holding**. They are most abundant around the **fingernails**.

Overview of encapsulated mechanoreceptor afferents

Pacinian corpuscles	Meissner corpuscles	Ruffini endings	Hair cell	Merkel´s disk
• Sense vibrations (40-500 Hz range) • Adapt rapidly • Wide receptive field	• Touch and fluttering sensations (2-40 Hz range) • Adapt rapidly • Narrow receptive field	• Stretch sensation (100-500 Hz range) • Adapt slowly • Wide reception field	Root hair plexus nerves • Free nerve endings that plexus around the hair follicle • Detects hair deflection • More fully developed in some comparative species	• Sense light pressure (< 0.2-2.0 Hz range) • Adapt slowly • Narrow receptive field

Encapsulated Nerve Ending

Encapsulated nerve endings are specialized structures, consisting of **non-neural components** which enhance their physiological properties. The non-neural component is a **cluster of connective tissue** surrounding the axon.

Examples of the encapsulated nerve endings include the Meissner’s corpuscle, the Pacinian corpuscle, the Ruffini nerve endings, and the neuromuscular junctions.

Unencapsulated Nerve Ending

Unencapsulated nerve endings consist of a **terminal neuron,** which is not surrounded by any other tissue. Free nerve endings and the Merkel’s disc are examples of unencapsulated nerve endings.

Free Nerve Ending (FNE)

A free nerve ending is an **unspecialized, unencapsulated nerve ending,** which usually carries the signal from the body’s periphery to the brain. They are frequently found in the **skin,** where they penetrate the dermis and end in the **stratum granulosum**.

They do not have any complex structure and resemble the branches or roots of a tree. Free nerve endings mostly detect **pain**. In addition, they may also recognize **temperature**, **mechanical stimuli,** or **danger (nociception)**. They express **polymodality**. The fibers are mostly **type III or type IV**.

Temperature and pain

Nociceptor-activating chemicals

Source	Chemical
Mast cells	Histamine
Mast cells, traumatized skin cells	Prostaglandins
Stressed skin cells	K^+; Bradykinin; H^+
Sensory afferents	Substance P
Cholinergic efferents	Acetylcholine

Transient Receptor-Potential Channels (TRP)

TRPV1: noxious heat (capsaicin)

TRPM8: cold (menthol)

TRPA1: noxious cold (mustard)

References

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Notes