**Science of Clothing Comfort**
**Prof. Apurba Das**
**Department of Textile Technology**
**Indian Institute of Technology, Delhi**

**Lecture – 09**
**Neurophysiological Processes in Clothing Comfort**

Hello everyone, our today's topic is Neurophysiological Process in Clothing Comfort. In our earlier talk, we have discussed the psychological aspects of clothing comfort, where we have tried to understand the various psychological aspects, laws of psychophysics, where are attitude aesthetic comfort. So, all these things are related to psychological comfort. That is very important, because a comfortable fabric may not give ultimate pleasure, if it is psychologically uncomfortable. So, our today's discussion will be neurophysiological process in clothing.

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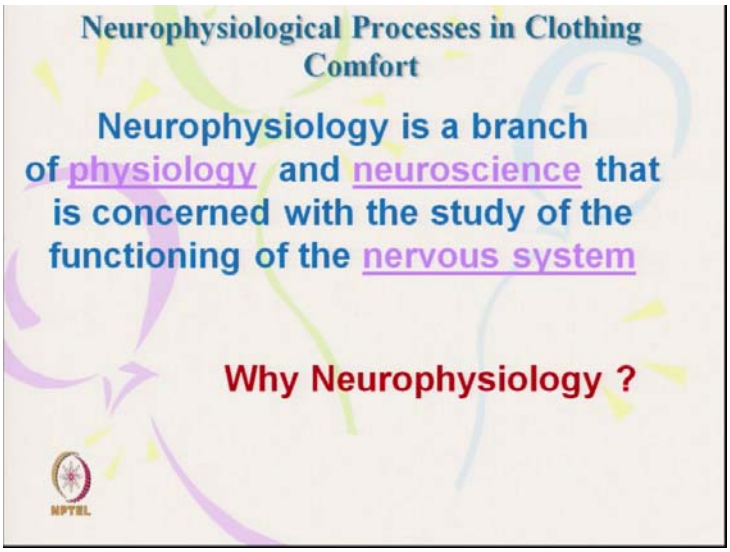


So, what is neurophysiology? So, the neurophysiology is the branch of physiology and neuroscience that is connected with the study of functioning of nervous system. So, basically, it is whatever sensation our body receives. Ultimately, it goes through nervous system and brain, which actually senses.

Now, neurophysiology is a different separate branch of physiology and neuroscience. But why do we need to understand neurophysiology, when we are trying to understand the clothing comfort. Because, as we know that when we wear clothing, it actually is in

contact with our whole body. And our body gets our signal through the contact with the skin, the fabrics in touch with the most of the part of the skin, it gives signal some stimulus, it gives and there are different receptors available in our skin, and which gets signal and ultimately the signal goes to our brain and we get some feeling may be comfortable, maybe uncomfortable.

All these sensations, which are received by our skin from the fabric may be in contact type sensation that is touch, tactile sensation, may be of pressure, maybe prickle type sensation, may be itching, may be warm, cool. So, all different types of sensations we receive. Here, we will discuss in detail, various types of sensations; we get from the fabric, what are the factors which control this type of sensation? How our skin receives this sensation through different types of receptors? And, how is it transmitted to the body to the brain? So, ultimately our brain gives the signal or average signal of comfort.

So, to understand the neurophysiology we must know our skin because our skin is directly in contact with the clothing.

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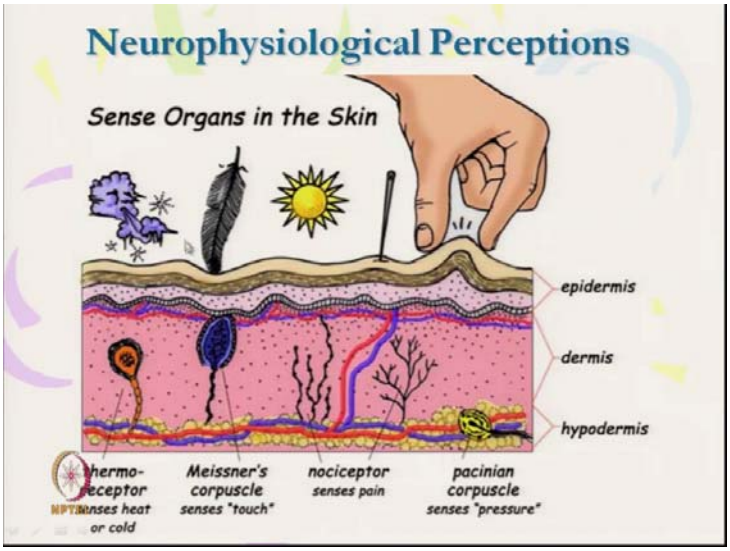


So, our skin gets different types of sensations, like soft touch sensation, pricking sensation; pain sensation, warm sensation, cold sensation, different types of sensation it gets stimulus it receives, and it is sensed through different types of sensors available inside the skin. Like this is thermo receptor, which receives whether the sensation is warm or cold, touch sensation maybe. Meissner's corpuscle one type of sensor

mechanical sensor, which get sensation of touch. It may not be sensing the pain, for pain there are different types of sensor, nociceptor, and receptors are there which actually sense the pain. Senses may be due to heat, may be due to cold, and may be due to other object, pressure sensations are Pacinian corpuscle, which senses the pressure. And all these receptors warm or cold receptors, their locations are at different depth depending on their location. Touch sensor has to be at the surface. Pain sensor which is at the depth, this phenomena will discuss.

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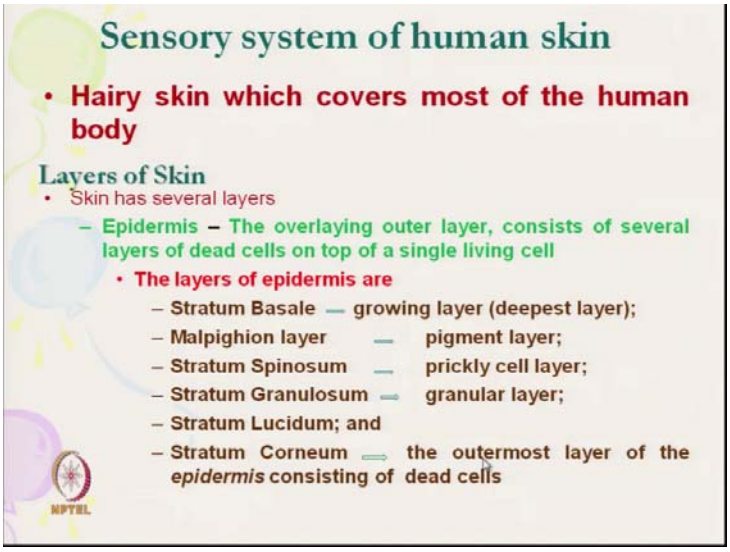


So, our body is covered with the hairy skin and skin has got different layers. So, the top most layer which is known as epidermis. So, epidermis is the overlaying outer layer, it consists of several sub layers. The epidermis has got different sub layers which have their different specific functions.

So, if you talk the stratum Basale, which is the bottom most, deepest layer of epidermis which is actually growing layer.

Malpighion layer is pigment colour of skin. Stratum spinosum is prickly cell layer, Stratum granulation is a granular layer, where our sensors can reach. Free nerve endings, we have discussed gradually up to this layer sensor can reach. Stratum Lucidum above that and the topmost layer is stratum called corneum, which actually consists of dead cell.

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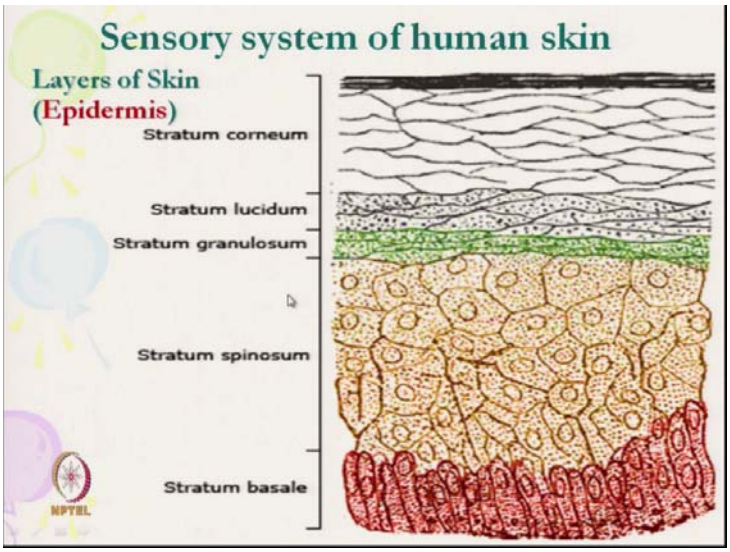


So, these are the different layers of the epidermis. The topmost layer as we have discussed that is a stratum corneum, corneum layer consists of the dead cell. And, this is the cell, it is which can grow. The nerve endings, which are the sensors they can reach up to this point stratum granulosum we will see later.

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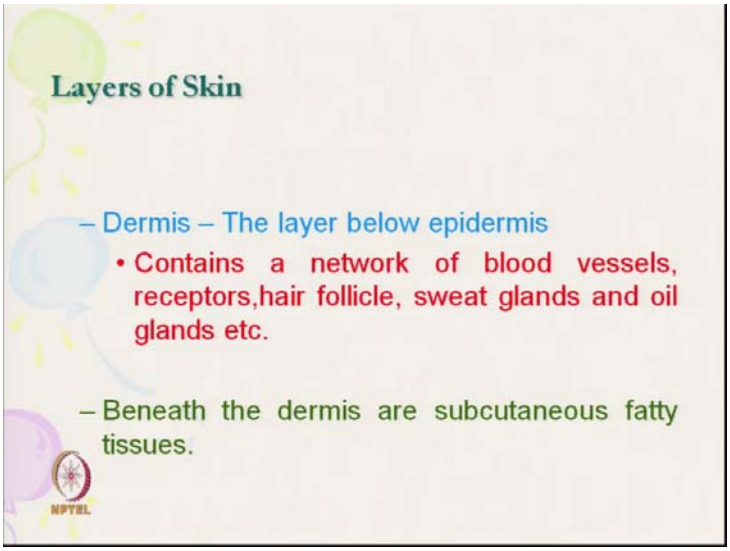


Then next layer, below the epidermis, next layer is called dermis layer. Which consists of network of blood vessels, different types of receptors, mechanical receptors, thermal receptors, hair follicle, this is also one type of receptor, which actually senses the

movement of hair, sweat glands responsible for excretion of sweat and oil glands. So, this dermis layer is most important layer for actually getting signal stimulus from outside. Beneath the dermis layer, there is a fatty tissues, which actually is host to the some pain sensors.

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Now, if we see the schematic diagram as we have discussed the epidermis is the topmost layer. And, dermis which consists of different types of nerves, sweat gland here, there is a fatty tissue and hair follicle. And, oil glands are there, which is responsible for excretion of oil into the body.

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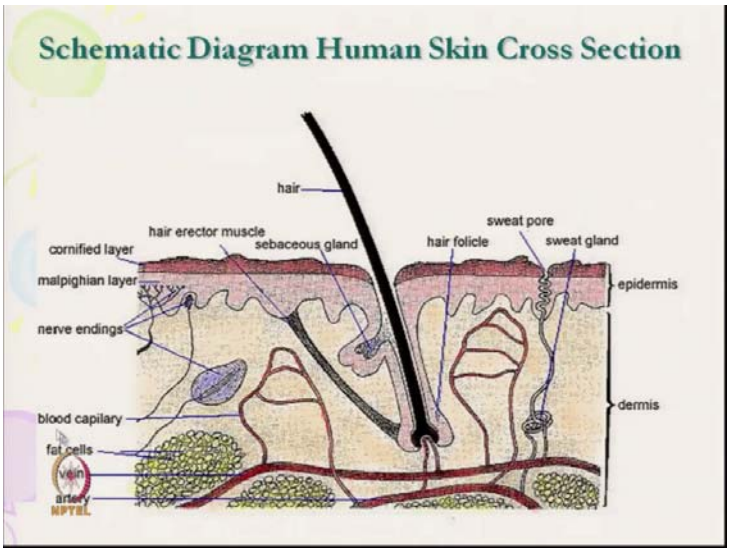


Now, these are the detailed locations of different types of receptors. The cornified layer is at the top stratum corneum we have discussed, Malpighian layer is a part of the epidermis we have discussed. And, you can see nerve endings. It is free nerve endings, which is reached above up to the epidermis. The free nerve ending can reach up to the epidermis, which is very sensitive. Free nerve endings are responsible for heat and touch sensation also even pain sensation.

Now, these are the different types of nerve endings these are corpus nerve, nerve ending, which has got specific shape. Blood capillaries are there which actually responsible to reach blood up to the skin. Then, artery veins are there and hair folicle. This is hair folicle at the bottom, it wrapped around the hair root with senses the movement of hair. If our hair at the skin moves, that is sensed by the hair follicle and which ultimately gives signal to the brain. Different process and sweat glands are there.

So, these are the different type of glands located in epidermis and dermis. Sweat pores are there. So, depending on the body physiology, our body generates sweat to keep our body temperature constant and to release the body heat, all this things, we will discuss.

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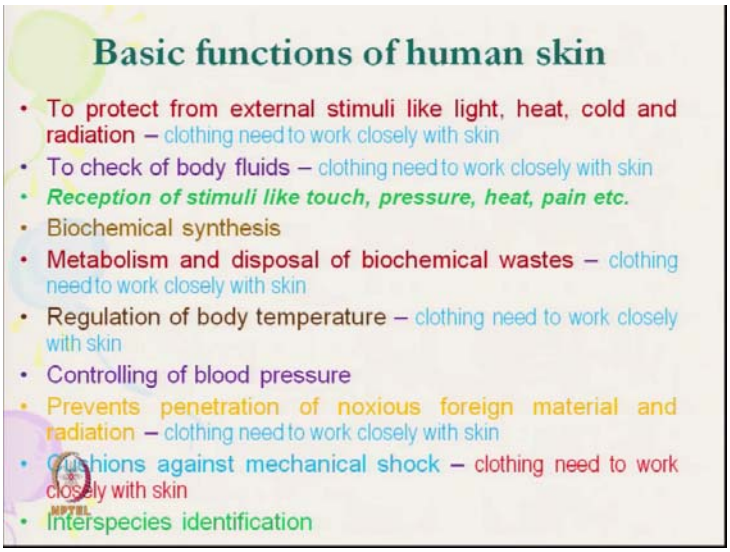


So, the basic functions of our skin is first to protect from external stimuli like heat, cold, radiations. So, these are our bare skin, but what our clothing does to help in protecting our skin? Like, if it has too hot, our clothing has to reduce the level of heat coming from environment to the body. Similarly, for cold it has to protect. So, skin has to protect our internal body and our clothing has to protect our skin. So, this clothing need to work closely with the skin. Otherwise skin may not be able to actually work properly at least at extreme environment.

Similarly, to check our body fluid so, our body fluid is transmitted through our skin in the form of sweat, sensible sweat or insensible sweat in the vapor form and again our clothing has to work very closely with skin. Suppose, our skin is releasing sweat, but if the clothing blocks the sweat by wearing impermeable clothing. So, that total physiological process will get hindrance.

So, we will not feel comfortable, then reception of stimuli like touch, pressure, heat, pain and that we get directly in when our clothing is in contact with the body. This is the basic function, which is actually directly very closely related with the clothing. A clothing gives direct sensation of touch, it may be harsh, may be soft, this type of touch even clothing can give pressure, if it is 2 types, it actually restricts our body movement. So, these touch heat pain. So, this function is very closely related with the clothing.

Biochemical synthesis is one of the important functions of skin. Then, metabolism and disposal of biochemical waste. And, clothing again has to work closely with the skin regulation of body temperature. So, if our body needs to hold the temperature, restricts the temperature body heat to flow out. So, that clothing has to do, it has to work very closely otherwise our body temperature will drop.

Similarly, if our clothing cannot stop the radiative heat or from environment to come in then our body temperature will go down. So, that body core temperature maintains although physiology or body physiology works very nice to maintain our body core temperature, but for extreme temperature zone, extreme climatic condition, our clothing has to work closely with skin controlling of blood pressure.

So, that is one of the functions of the skin, then comes to prevent penetration of noxious foreign material. And, radiation is the basic function of skin, but again here clothing has to work closely with it. If sensation or a radiation is harmful, then clothing has to do it is function Cushion against mechanical shock , our skin has to perform, it gives cushion, it is stretchable, again clothing has to work very closely with skin.

So, whatever function, most of the functions skin is doing for our body clothing has to help assist our skin, we can say clothing has to work as our second skin. So, and then inter species identification. So, for different types of species, we can identify based on their skin type So, in this segment, we will concentrate on the reception of stimuli like touch, pressure, heat, pain, as we are discussing the neurophysiology here. And, other functions we will discuss and in subsequent talk.

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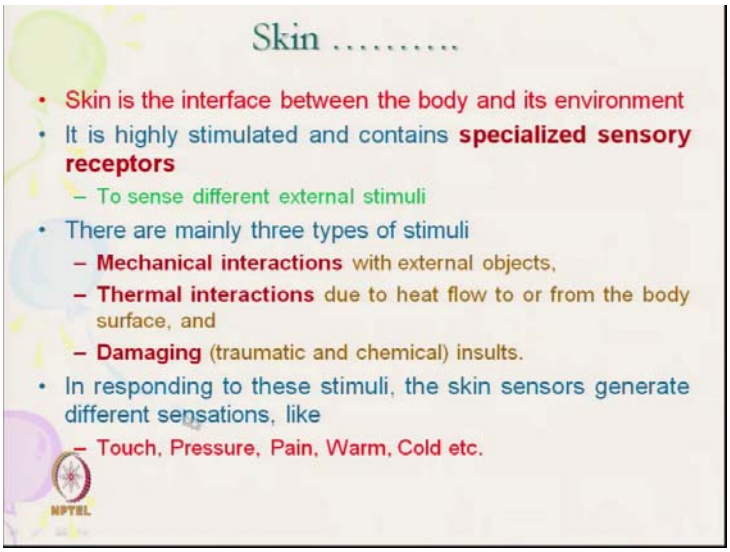


So, the skin is the interface between our environment and body. So, the interface is highly stimulated and contains specialized receptors, different types of receptors are there. So, receptors sense different types of stimuli, these stimulations are of basically 3 types of stimulation; one is mechanical stimulation. Mechanical simulation with the external object normally, but when we are clothed external objects become the cloth and it senses the touch, pressure, tickling, or prickly sensation. So, all this type of sensation, it receives from the clothing and it gives ultimately comfort sensation.

Similarly, thermal receptors sense whether it is a warm or cold and send signal to the brain and brain evaluates and ultimately gives the sensation and third one is damaging. So, one is mechanical, then thermal and third one is damaging. The chromatic or chemical type; is a pain type of receptors, which responds to this stimuli, the skin sensor generates different types of sensations like touch, pressure, pain, touch and pressure by mechanical receptors, pain is by nociceptors, warm, cold by the thermal receptors .

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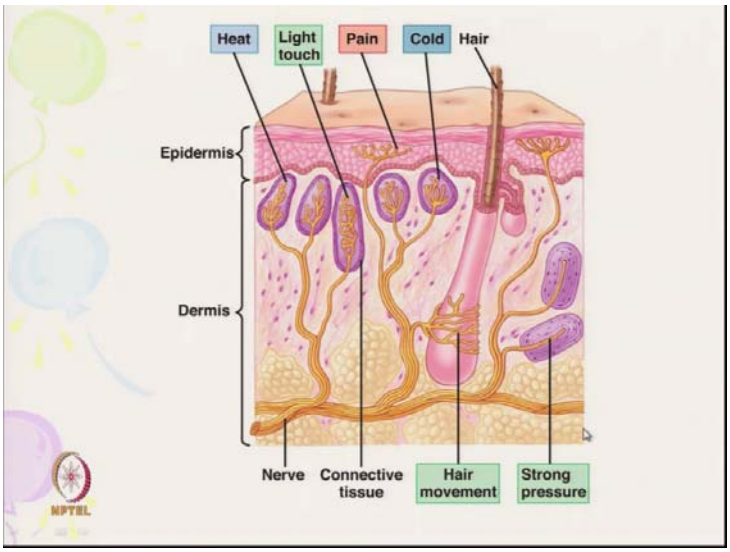


Now, if you see the locations of different types of sensors, we can see that heat sensor is here. This is heat sensor, this is like touch sensor, pain sensor, as we have discussed earlier, and this is the free nerve ending which goes up to the epidermis. And, raised other sensor, you can see, these are located in dermis is here, cold sensor. And, here strong pressure sensor at little bit in the deep zone, when our body is pressed hard then this sensor will work.

And, for a light touch, this sensor will work, connective tissues are there and this is the hair follicle which actually gets signal by movement of hair, when hair moves, this gets signal. So, this type of sensor, ultimately sensation goes through the nerves, then through spinal cord and ultimately through the chemical sensation, it goes to the brain. And, brain receives all these signal.

And, we have discussed in our psychological part that brain actually tries to weigh and evaluates the level and gives ultimate sensation.

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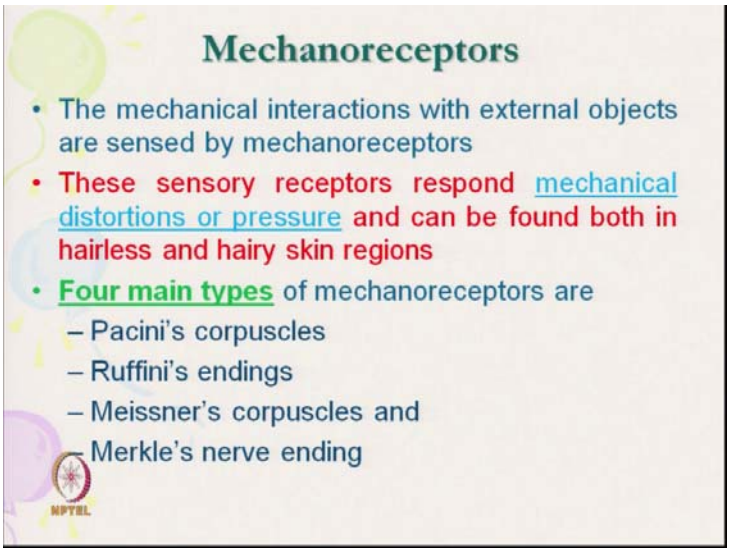


So, we will start with the mechanoreceptors, so, mechanoreceptors actually interact with the external body for any mechanical sensation. Actually these are the receptor which respond to mechanical distortions or pressure, if we touch our body, our skin gets little bit distorted. And, that distortion is sensed by the mechanical receptors. And, this can be found throughout the body; with the hairy part of the body and also with hairless part of the skin.

There are different types of mechanical receptors but mainly 4 major receptors are there. Pacini's corpuscle, Ruffini ending, Meissner's corpuscle and Merkle's nerve ending; they have specific functions. And, these receptors are presents at different portion of our body, but density of number of sensors per unit area are different at different zones.

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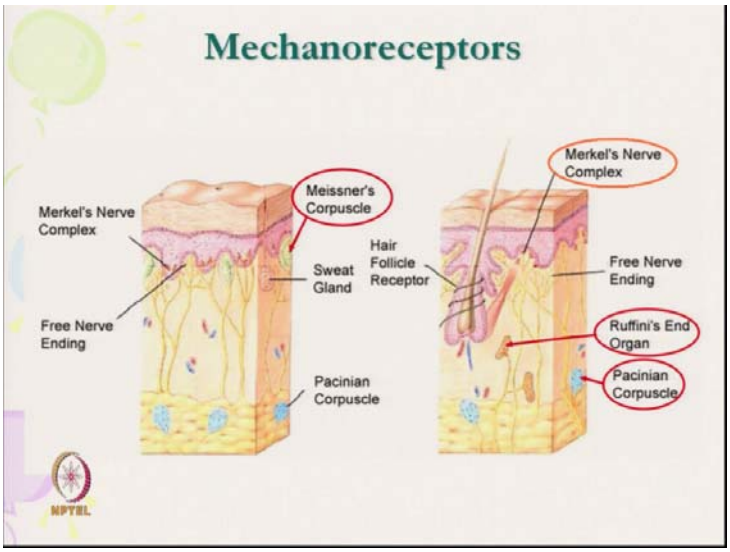


So, if we see the locations of these 4 different types of sensor; major sensors that, you see the Meissner's corpuscle. It is very close to epidermis gap, which is very close to the surface; Merkel's Nerve Complex, this is also very close, Ruffini's End Organ, nerve free ending is little bit deep. And, Pacinian corpuscle are at the deeper most out of these 4.

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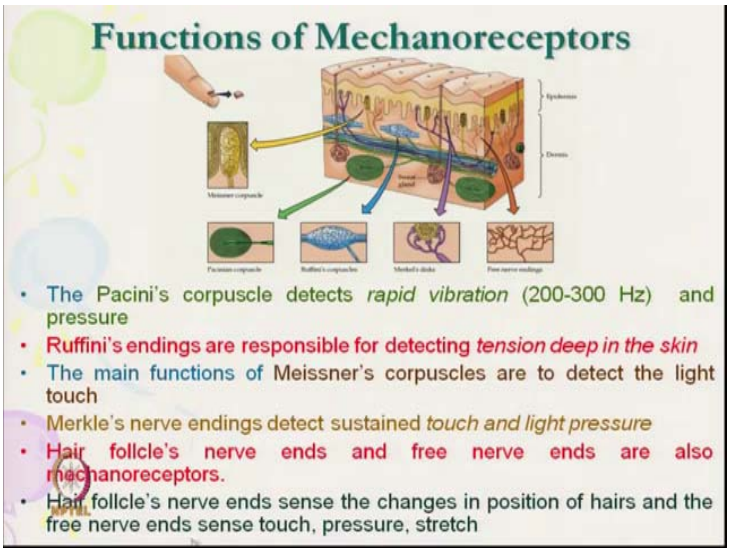


Which means you can see in this picture also, different types of location. So, Meissner's corpuscle you can see that is close to the skin in layer, Pacinian as we have discussed, it

is green color, it is at the deep portion. Merkel nerve ending is also close to the skin top, and nerve endings are at the surface. So, they have got their specific functions, now, we will discuss one by one their function.

Now, Pacini's corpuscle detects rapid vibration and pressure. So, actually responsible for detecting rapid vibration, very high frequency like frequency is 200 to 300 hertz, it can sense. Other corpuscle will not be able to sense. This is specifically for rapid vibration and also pressure.

So, Pacini, you can see it is located at the deep portion. So, if it vibrates at very high, it senses and also due to depth location it senses the pressure. Ruffini's ending which is responsible for detecting the tension deep in the skin.

So, any shock of tension, it is in the skin it senses. Like, when we move our body part, the skin gets stressed or strained. So, it actually senses. Suppose, our cloth moves, slips through the skin, it may get stressed. So, this type of sensation, it is given by Ruffini's. The Meissner's corpuscle are to detect light touch. So, Meissner's corpuscle, if you see it is located at the surface and senses. So, it is called tactile corpuscle, it gives tactile sensation, touch sensation, and handle touch.

And, Merkel's nerve ending is to detect touch and light pressure also, these two actually gives the touch sensation. And, hair follicle nerve ending that we have discussed, in earlier picture, it actually receives signal when our hair moves. It is a free nerve ending, it is a mechanoreceptor. So, when there is change in position of the hair, free nerve ends senses touch, pressure and stretch.

So, these are the major nerve endings mechanoreceptors.

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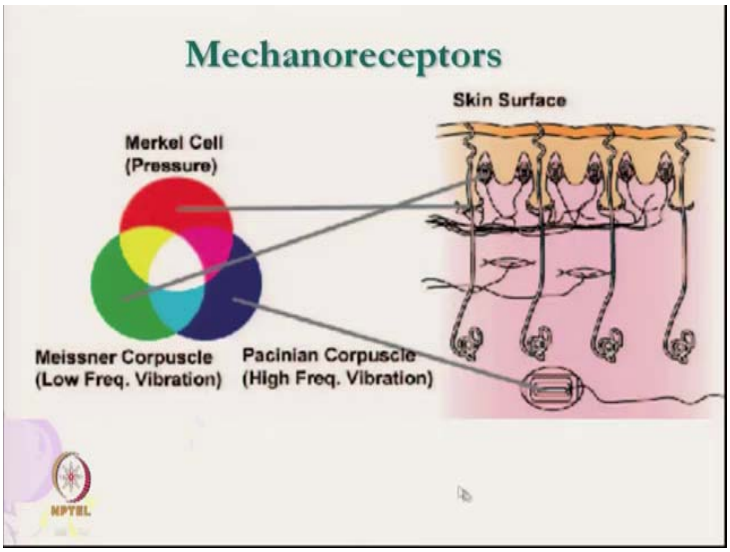


And, if you see the presence of nerve ending in this picture, it gives 3 major nerve endings; Merkel nerve endings, it senses pressure as we have discussed, Pacinian corpuscle senses high frequency, and Meissner's corpuscle senses low frequency vibration or a touch.

Now, the location; it shows in the red color, this is shown in green color, and this is in blue color, but when something touches, presence of these senses are very close to each other; that means, ultimately more than one sensor gets the same signal. When we are touching, if it is little bit higher pressure, the touch sensor will also act. Meissner will also act and Pacinian also will act, they will give us the pressure sensor. They will give us a touch sensation and at the same time, some overlap zones are also there in yellow color; that means, it gives touch and pressure and similar is for the pressure and high frequency vibration.

So, ultimately this overlap and individual sensation give same signal to the brain, brain evaluates and gives signal. So, these are different, this is the Pacinian, we have discussed at greater depth.

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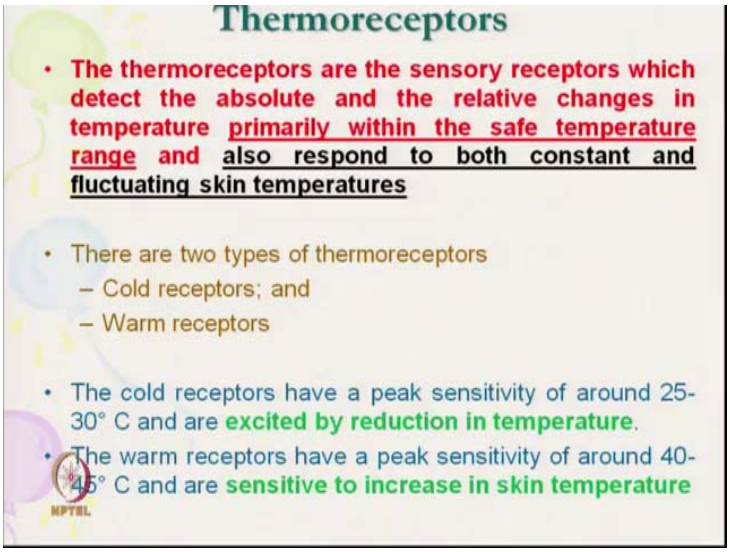


Next comes the Thermoreceptors, thus thermoreceptors are the sensor receptors, which detect absolute and relative change in temperature. These are the receptors present in our mainly dermis zone, primarily within the safe temperature range which is important safe temperature zone, the thermal receptors will work, but beyond this receptors will stop working.

And, then there will be another receptors which are called we can take this receptors within the thermoreceptors, which are called cold pain receptors and hot pain receptors ok. And, this receptors work on constant temperature as well as and the fluctuating skin temperature. And, we will see the, at the sensation is very high at fluctuating skin temperature.

There are mainly 2 types of sensing; one is cold receptor and warm receptors ok. And, if we subdivide the cold receptors and normal cold receptor and pain cold receptors ok, and warm receptor and pain. So, like below say 5 degree Celsius below 5 degree Celsius the cold receptors stop working, cold receptors range is typically from say 5 to 7 degree to 35-36 degree Celsius. And, then or warm receptors work up to say around 50 degree Celsius beyond 50 it is stops working.

We will discuss these issues like, we have discussed the cold receptors at the peak sensitivity level around 25 to 30 degree Celsius, like it start sensing from say 5 degree or 7 degree Celsius and goes up to say 35 degree, or 40 degree Celsius, but peak sensation,

peak frequency is at around 25 to 30 degree Celsius. And, excited by reducing temperature, when we reduce the temperature, it gets excited sudden reduction means; it will suddenly excited. So, this part we will discuss.

Similarly, the warm receptors are highly sensitive at 40 to 45 degree Celsius. And, here sensitivity increases with increase in temperature for cold receptors. Sensitivity increases with reduction in temperature and here with the increase in skin temperature. And, nociceptors are separate segment of receptors within mechanical or thermal receptors, these basically sense the pain.

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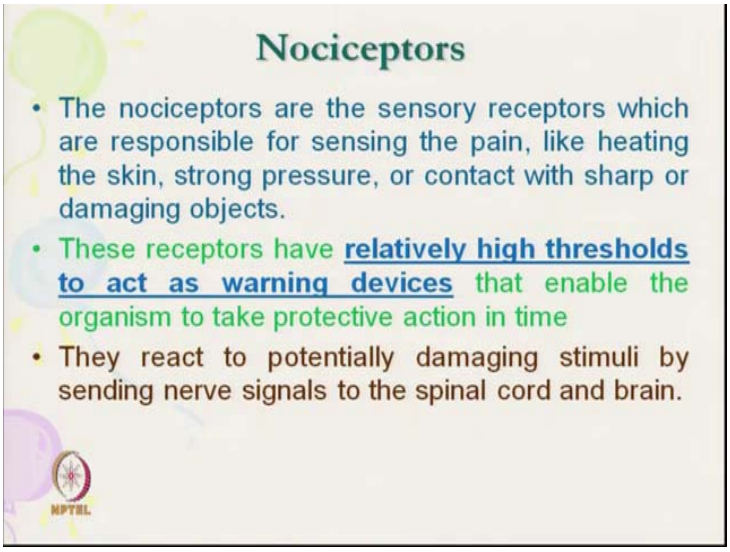


Nociceptors are the sensory receptors, which are responsible for sensing the pain like hitting the skin, strong pressure or constant in touch, with the eyes damaging object these are the different types of sensation, which is received by this nociceptors. And, these receptors have relatively high threshold to act as warning device. It gives signal to the brain. There is some damaging sensations and then our body due to its physiology, it takes action.

Like, suppose, our skin is in touch with the very hot object. Immediately our body, our hand by reflex is removed, how is it happening? Because, Nociceptors come into picture, these send signal to our brain. And, it again sends back the signal to the muscle, our muscle contracts. So, nociceptors, but in our clothing comfort, nociceptors function is

not that major. So, they react to potentially damaging stimuli by sending nerve signals to the spinal cord and brain. So, they send separate signal.

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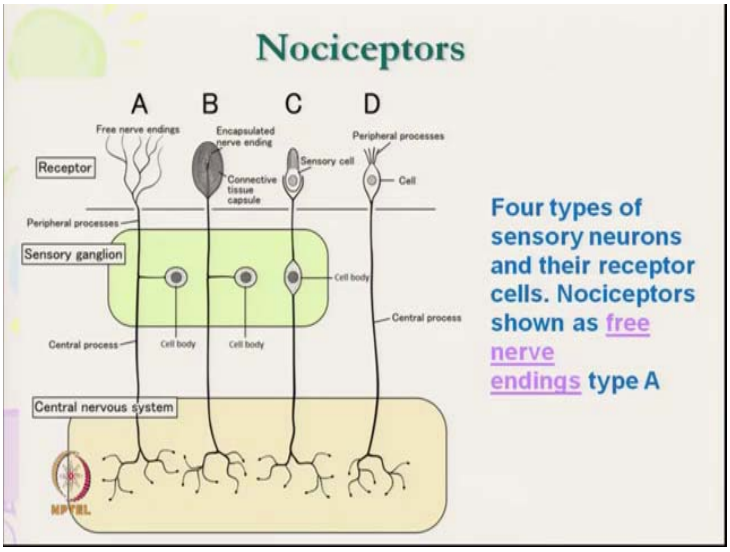


And, these are the different types of sensors available. The structure of the sensor, this is a free nerve ending, this is one type of sensor and most of the nociceptors are this type of free nerve endings, nociceptors will get the phenomenon which is close to our skin.

Then another type of sensors are the encapsulated sensors. And, then sensory cells are there and peripheral processes cell. So, these are the different types of sensory receptors present in the skin and they get signal like nociceptors.

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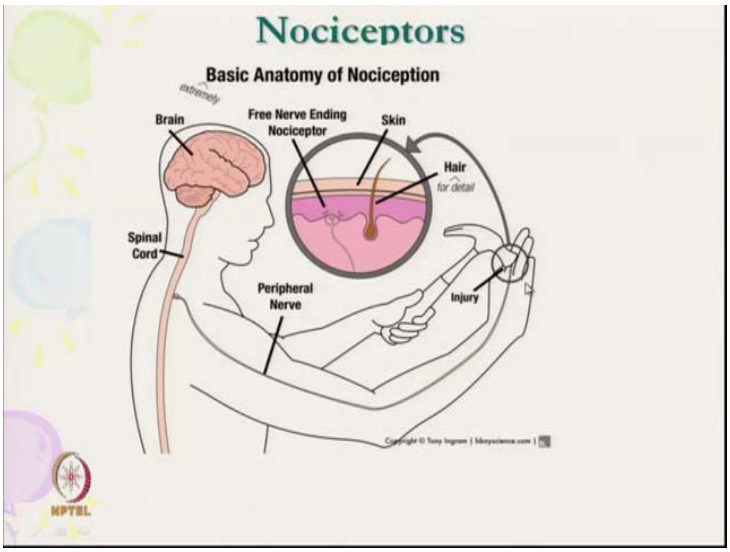


It sends the damaging sensation. Ultimately it sends signal to the brain, through the free nerve ending nociceptors which are present at the surface of the skin, these nociceptors get signal of the damaging.

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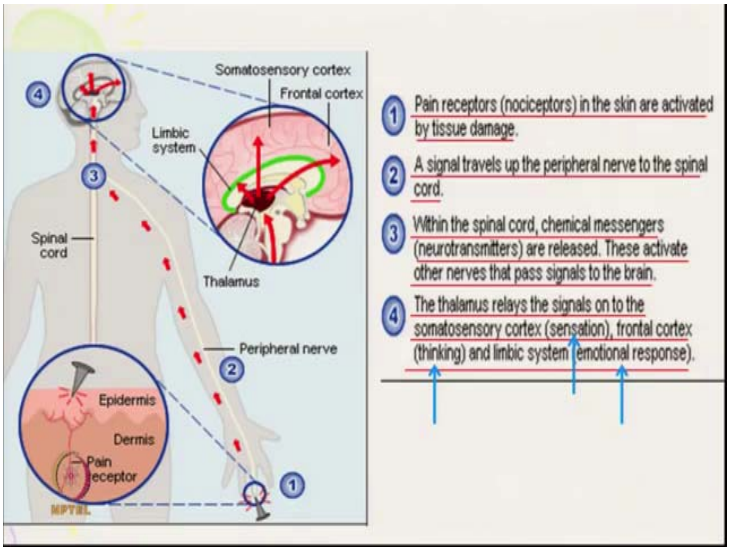


Now, try to see how the nociceptors send signal to the brain. Pain receptors that is nociceptors, in the skin are activated by tissue damage, when something penetrates. Some heavy some damaging sensations are there or some damaging heat is there. By the tissue that damaged, they get signal.

A signal travels up to the peripheral nerve these are the peripheral nerve. So, this signal it travels up to the peripheral nerve. And, then it goes up to the spinal cord. This is the spinal cord and with the spinal cord the chemical messengers are there, this is neurotransmitters, the chemical messengers. The chemical say nature of the fluid gets changed due to nociceptors.

And, the chemical messengers are released, this activates other nerves and the signal goes to the brain. And, at the brain, thalamus is there, it releases different types of sensations. One is the normal sensation it senses, then it releases the sensations, we think and emotional responses? So, nociceptors work in this type of closed loop system. And, then it sends signal to the muscle and muscle get contracted or moved.

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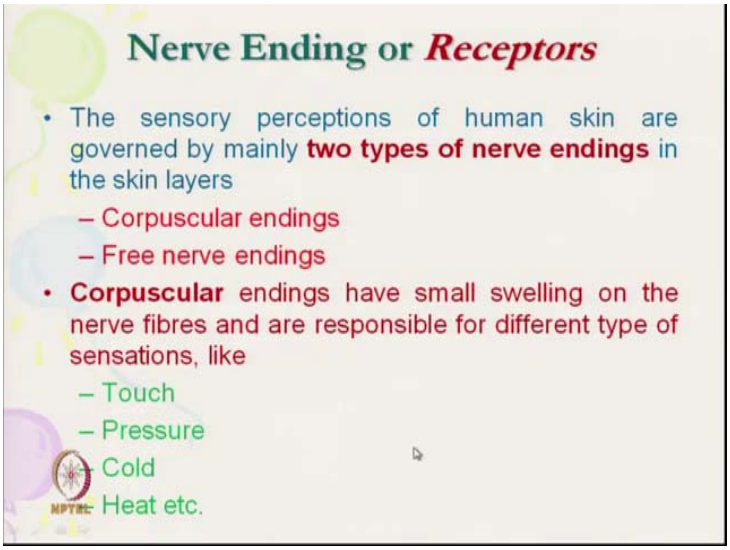


The Nerve Endings basically are called receptors where nerve actually ends at the skin. Maybe in dermis or maybe in epidermis. This nerve endings broadly, if we divide one is of a specific. We can divide into 2 types; one is one type of nerve ending that we have seen Pacinian nerve endings are of different specific shape.

Another nerve ending, which are called the free nerve ending, which they do not have any specific shape. And, they can sense different types of sensation, but corpuscular nerve, nerve endings are responsible for a particular sensation. Like, nerve ending like pacinian nerve ending is responsible for pressure, but it will not sense the touch, but free nerve endings are of different types. They do not have any specific shape, some time a

free nerve ending may be of poly modality means, it can sense the press touch, it can sense the pressure, and it can sense the heat, cold. So, this type of nerve endings are there.

So, the corpuscular endings have small swelling on the nerve fibres at the end and are responsible for different types of particular sensation; like touch, pressure, cold, heat, they are corpuscular nerve endings.

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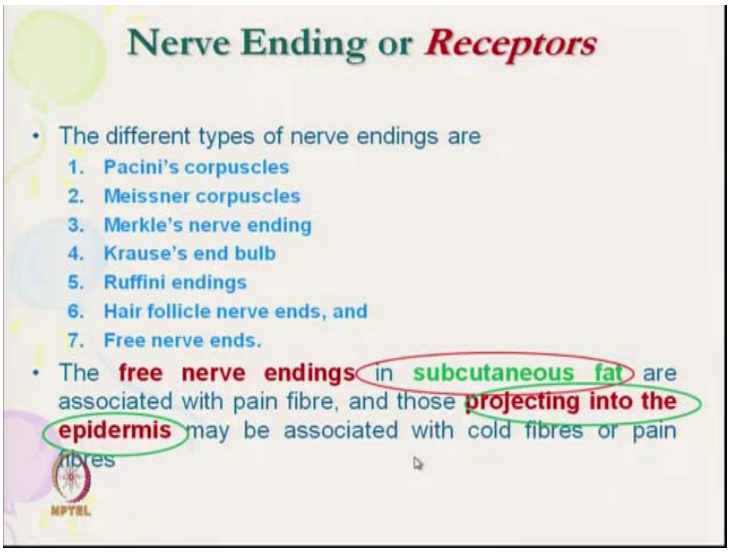


If we now divide, these nerve endings are of different types; Pacinian corpuscle, Meissner's corpuscle, Merkel's nerve ending, Krause's end bulb, Ruffini's ending, Hair follicle nerve ending and Free nerve ending, all this nerve endings are responsible for mechanical sensation.

Now, we will discuss one by one in detail their functions. How are they correlated with the clothing comfort, clothing sensation? These free nerve endings are also in subcutaneous fat, in addition to the epidermis, they are associated with the pain fibres. And, the projection into the epidermis from the subcutaneous fat these are projected to the epidermis, may be associated with cold fibres or pain fibres. Now, we will discuss in detail the different types of nerve endings.

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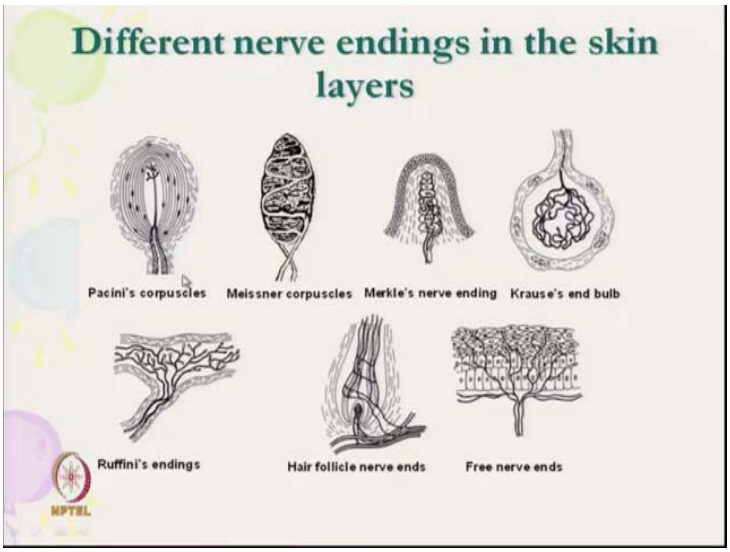


So, this is the Pacinian's corpuscle. Meissner's corpuscle, Merkel's nerve ending, Krause's end bulb, Ruffini's ending, hair follicle nerve ending and free nerve ending.

So, we will discuss in detail about the functions of an individual nerve ending one by one. So, we will start this discussion in the next class till then.

Thank you.