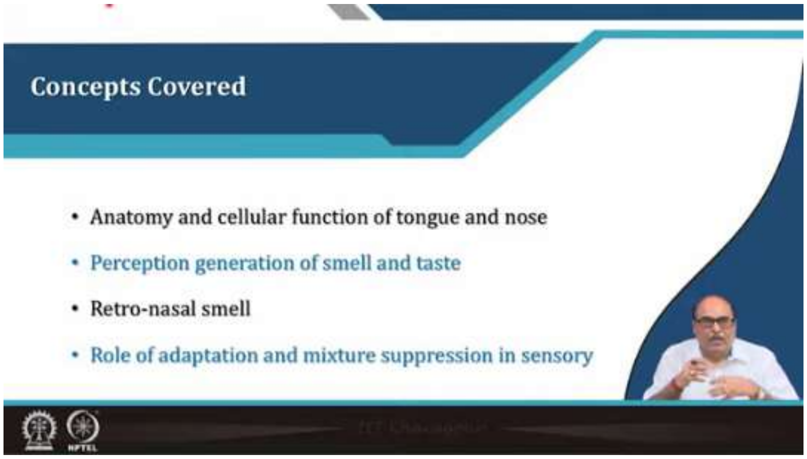
FOOD SCIENCE AND TECHNOLOGY

Lecture17

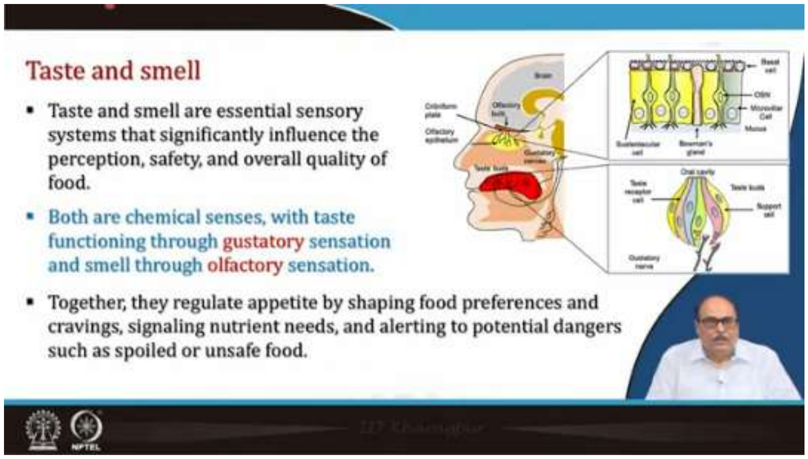
Lecture 17: Anatomy and Functions of Taste and Smell

Hello everyone, Namaskar.

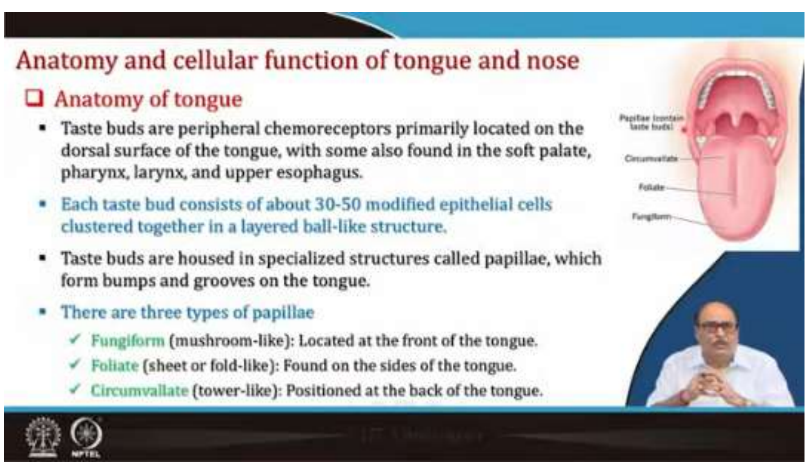
Now we are in the fourth module, which is devoted to sensory attributes of food. In the second lecture of this module, our overall lecture number 17 today, we will talk about the anatomy and functions of taste and smell.



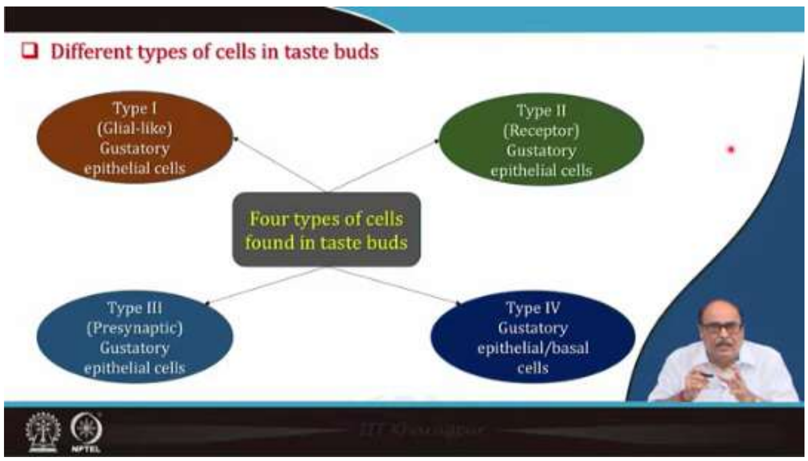
We will study the anatomy and cellular function of the tongue and nose. Then, the perception generation of smell and taste. We will also talk about retronasal smell. And finally, what is the role of adaptation and mixture suppression in sensory?



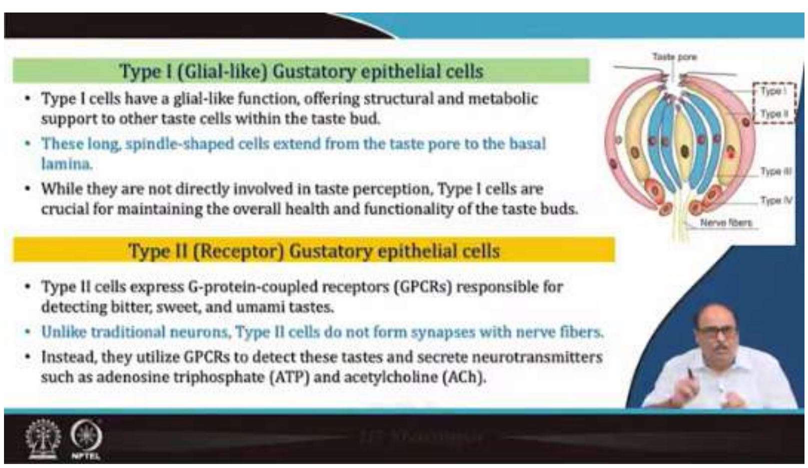
So, taste and smell. are essential sensory systems that significantly influence the perception, safety, and overall quality of food. Both taste and smell are chemical senses. With taste functioning through gustatory sensation, whereas smell functions through olfactory sensation. You can see here that these are the taste buds in the tongue; they take the message and send it to the gustatory nerve, etc., to the oral cavity where there are taste receptor cells, taste buds, support cells, etc. They analyze the data and finally send it to the central nervous system or brain. Whereas in the nose, there are olfactory valves, a cribriform plate, and olfactory epithelium. This sends the message to the brain through the olfactory system, which analyzes the data. So, together, taste and smell regulate appetite by shaping food preferences and cravings. They signal nutrient needs and alert to potential dangers, such as spoiled or unsafe food, etc. By chance, if you take any food that is not good in flavor or taste, etc. or the food is spoiled and does not have normal characteristics, these taste buds and smell receptors, etc., they analyze immediately. They judge the type, whether the food is good or bad, and accordingly, they send signals to the person.



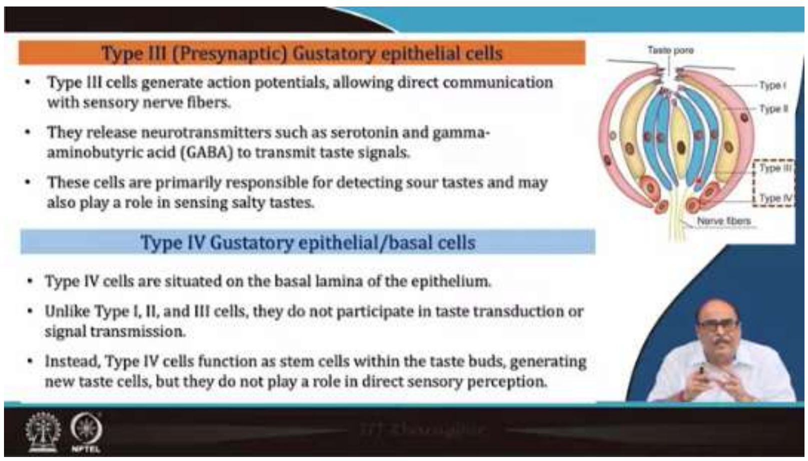
So now, let us talk about the anatomy of the cellular function of the tongue and nose, and first, we will talk about the anatomy of the tongue. So the taste buds are peripheral chemoreceptors primarily located on the dorsal surface of the tongue. Some are also found in the soft palate, pharynx, larynx, and upper oesophagus, as you can see. Each taste bud consists of about 30 to 50 modified epithelial cells clustered together in a layered ball-like structure. Taste buds are housed in specialized structures which are called papillae. Which form bumps and grooves on the tongue. There are three types of papillae. One is the fungiform, which is normally located at the front of the tongue. Then foliate or seat or fold-like. This is found on the sides of the tongue. And then circumvallate or tower-like. These are positioned at the back of the tongue.



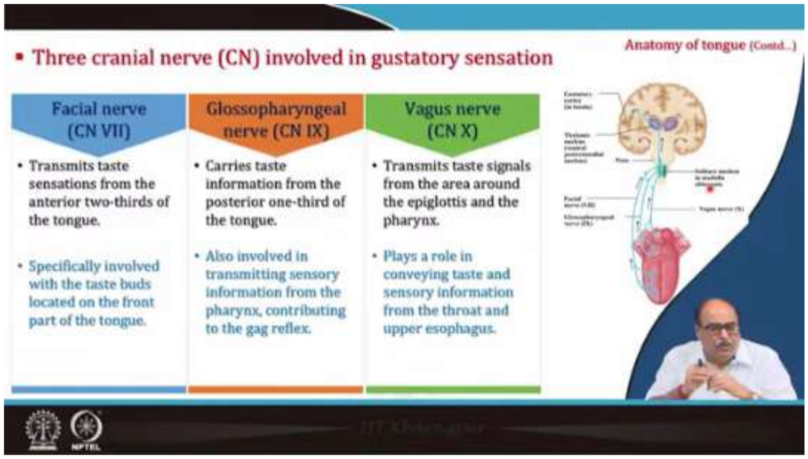
So, these are the different types of cells in the taste buds. There are type 1, like glial-like gustatory epithelial cells, then type 2, which are receptor; type 2, gustatory epithelial cells; type 3, which is presynaptic; and then type 4, gustatory epithelial or basal cells. So, these 4 types of cells are found in our taste buds.



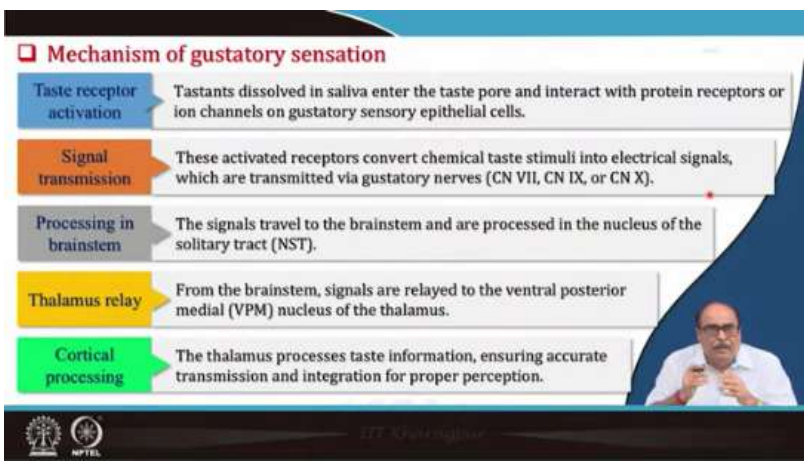
So, let us see briefly about that, that is type 1 cell. Type 1 cells have a glial-like function, offering structural and metabolic support to other taste cells within the taste buds. You can see these are the type 1 cells; they are found on the outside. These long spindle-shaped cells extend from the taste pore to the basal lamina, while they are not directly involved in taste perception. These type 1 cells are crucial for maintaining the overall health and functionality of the taste buds. Type 2 cells express G protein-coupled receptors. Which are responsible for detecting bitter, sweet, and umami tastes. Unlike traditional neurons, these type II cells, which are here you can see in the picture, these do not synapse with the nerve fibers. Instead, they utilize GPCRs to detect these tastes and secrete neurotransmitters such as adenosine triphosphate or acetylcholine.



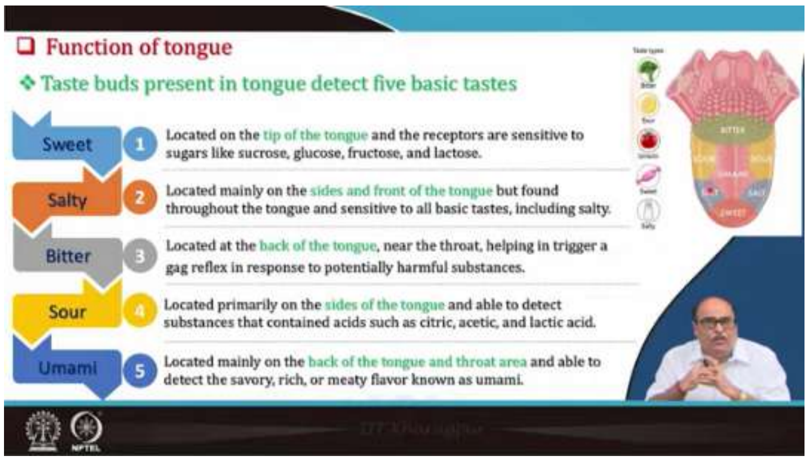
Then type 3 cells generate action. These are type 3 cells you can see in the figure. They generate action potentials, allowing direct communication with sensory nerve fibers. They release neurotransmitters such as serotonin. and gamma-aminobutyric acid (GABA), etc., to transmit taste signals. And these cells are primarily responsible for detecting sour taste, and may also play a role in sensing the salty taste. Then finally, the type IV gustatory epithelial or basal cells, which you can see here, are the ones. These type IV cells are situated on the basal lamina of the epithelium. Unlike type I, type II, and type III cells, they do not participate in taste transduction or signal transmission. These type IV cells function as stem cells within the taste buds, generating new taste cells, but they do not play a role in direct sensory perception.



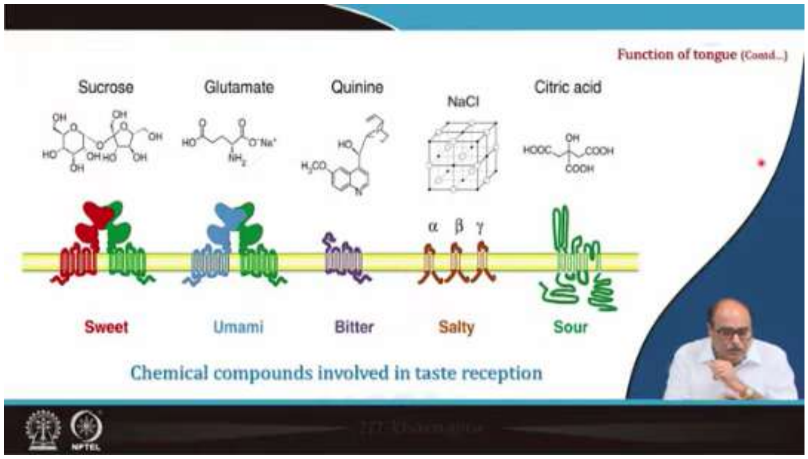
So, the three cranial nerves (CN) involved in gustatory sensations are the facial nerve (CN7), the glossopharyngeal nerve (CN9), and the vagus nerve (CN10 or CNX). So, CN7 transmits taste sensations from the anterior two-thirds of the tongue, specifically, these are involved with the taste buds located on the front of the tongue. CNX, that is the vagus nerve, carries taste information from the posterior one-third of the tongue and is also involved in transmitting sensory information from the pharynx, contributing to the gag reflex. CNX or vagus nerves transmit taste signals from the area around the epiglottis and the pharynx. It plays a role in conveying taste and sensory information from the throat and upper esophagus.



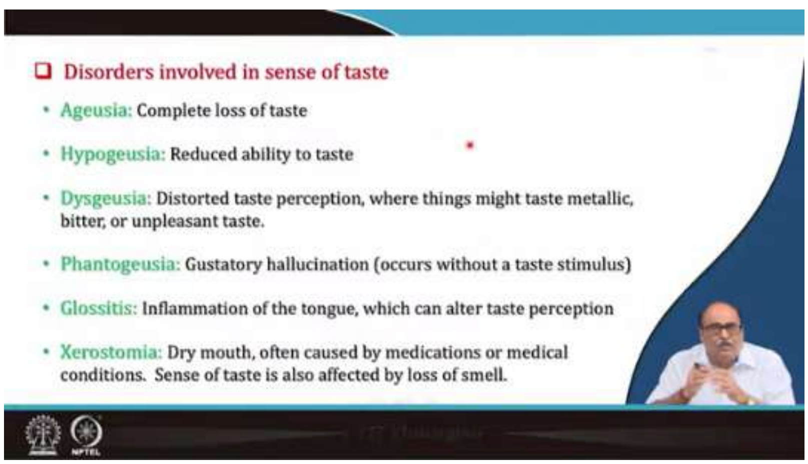
Now, let us talk about the mechanism of gustatory sensation. The first thing is that when anything is taken into the tongue, taste receptor activation occurs. The taste dissolves in saliva, enters the taste pore, and interacts with the protein receptors or ion channels on gustatory sensory epithelial cells. These activated receptors then convert the chemical taste stimuli into electrical signals, which are transmitted via the gustatory nerves CN7, CN9, or CN10. This is the signal transmission. The chemical taste is converted into electrical signals, and then these signals travel to the brainstem and are processed in the nucleus of the solitary tract, known as NST. These signals are processed in the brain, and then there is a thalamus relay from the brainstem, where these signals are relayed to the ventral posterior medial nucleus, known as VPM, of the thalamus. The thalamus processes the taste information ensuring accurate transmission and integration for proper perception, which is called cortical processing.



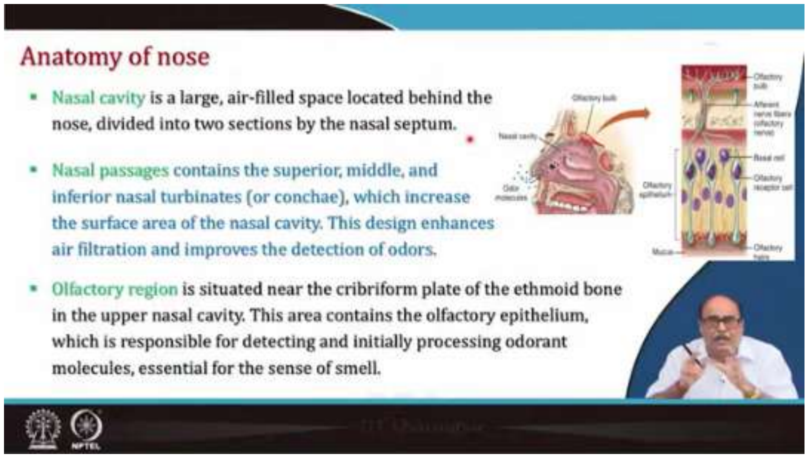
So, this is how the test works, when the chemicals you are taking in the test boards, etcetera. and how it happens, and finally, we recognize the test. So, the taste buds present in the tongue detect five basic tastes. Number one is the sweet, which is located on the You can see the tip of the tongue, and the receptors are sensitive to sugars like sucrose, glucose, fructose, lactose, etc. So, the receptors on the tongue of the test are more sensitive to these substances. Then comes the salty. Then number two, that is, these are located mainly on the sides, just above the sweet. You can say on both sides. Then, salty tastes are located in the front of the tongue and are found throughout the tongue and are sensitive to all basic tastes, including salt. Then comes the bitter taste, that is, these bitter taste buds are located at the back of the tongue. You can see that is the back of the tongue. You can see here in the figure, near the throat, and they help in triggering a gag reflex in response to potentially harmful substances. Then, sour taste buds are located primarily on the sides of the tongue, below the bitter ones, on both sides of the tongue. They are able to detect substances such as citric acid, acetic acid, lactic acid, and so on. That is the acidic taste they are able to detect. And finally, the umami taste buds are located mainly on the back of the tongue and throat area. They are able to detect savory, rich, or meaty flavors, which are normally known as umami flavors.



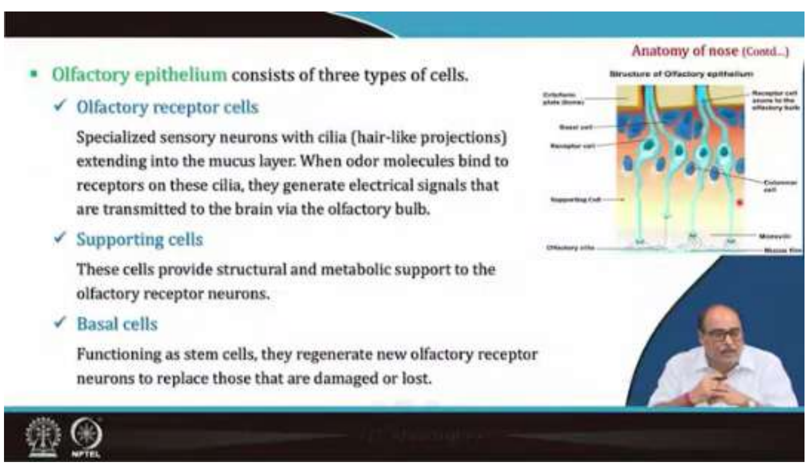
So, these are the various compounds, actually the chemical compounds, which are generally responsible for the sweet taste, and these are the chemicals we are testing, which you have seen in the earlier mechanism that is, the chemical compounds that are fairly converted into electrical signals of different types and then it goes, and our system understands the taste for the sweet taste, which is basically sucrose. For umami, glutamate is responsible; quinine is mainly responsible for the bitter taste and sodium chloride, more popularly known as the salty taste, and citric acid or other such organic acids, etcetera, represent the sour taste in taste reception.



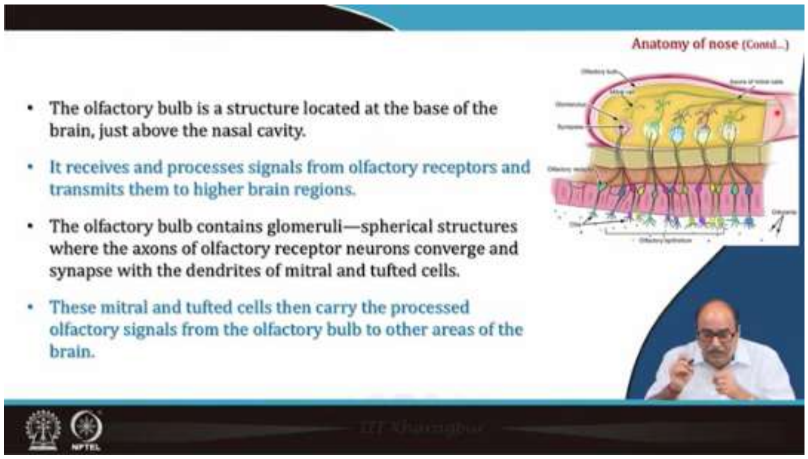
So however, if some taste buds are not properly functional, there may be some disorders involved in the sense of taste, like ageusia, where there is a complete loss of taste, hypogeusia, reduced ability to taste, or distorted taste perception where things might taste metallic, bitter, or unpleasant, it is known as dysgeusia. A gustatory hallucination, which occurs without a taste stimulus, is known as phantogeusia. Glossitis is the inflammation of taste buds or inflammation of the tongue, which can alter taste perception. Xerostomia is dry mouth, which is often caused by medication or medical conditions. The sense of taste is also sometimes affected by the loss of smell. If there is a loss of smell, you can also get taste defects, etcetera, as taste bud functioning gets affected.



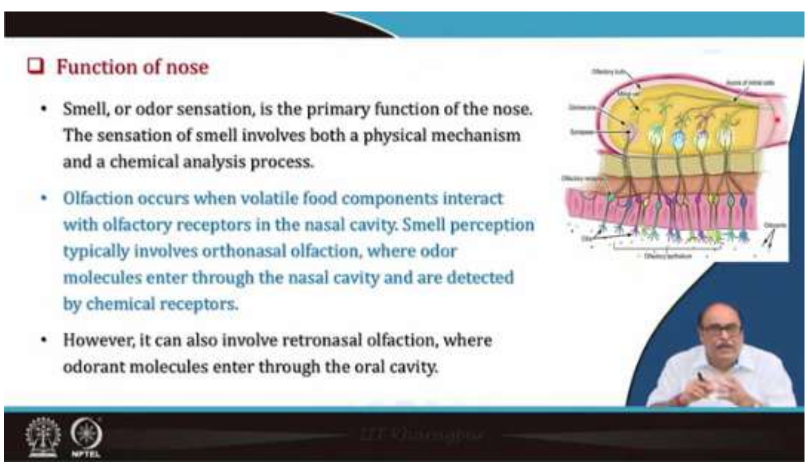
After having discussed the anatomy of taste buds and the tongue, let us now talk about the anatomy of the nose, which is mainly responsible for sensing flavor or smell. The nasal cavity, as you can see, is a large air-filled space located behind the nose, and it is divided into two sections by the nasal septum. Nasal passages contain the superior, middle, and inferior nasal turbinates or conchae, which increase the surface area of the nasal cavity. This design of the nose or nasal cavity enhances air filtration and improves the detection of odors. Then comes the olfactory region. The olfactory region is situated near the cribriform plate of the ethmoid bone in the upper nasal cavity, and this area contains the olfactory epithelium, which is responsible for detecting and initially processing odorant molecules or odour molecules and is essential for the sense of smell.



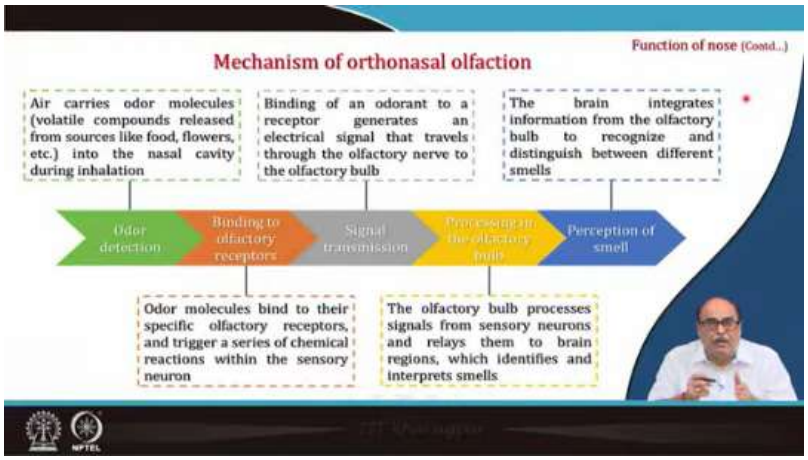
The olfactory epithelium consists of three types of cells, such as olfactory receptor cells. These are specialized sensory neurons with cilia. There are hair-like projections extending into the mucus layer. When odor molecules bind to the receptors on these cilia, they generate electrical signals that are transmitted to the brain via the olfactory bulb. Then there are supporting cells, which provide structural and metabolic support to the olfactory receptor neurons. Basal cells function as stem cells; they regenerate new olfactory receptor neurons to replace those that are damaged or lost.



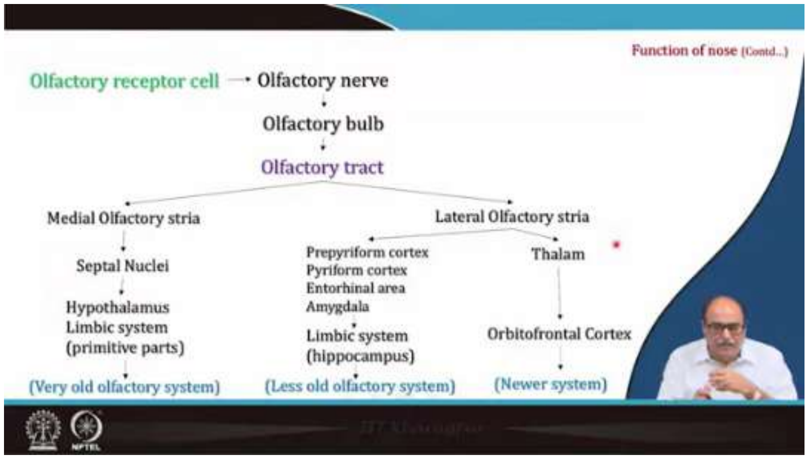
The olfactory bulb is a structure located at the base of the brain, just above the nasal cavity. It receives and processes signals from the olfactory receptors and transmits them to higher brain regions. The olfactory bulb contains glomeruli, which are spherical structures where the axons of olfactory receptor neurons converge and synapse with the dendrites of mitral and tufted cells. These mitral and tufted cells then carry the processed olfactory signals from the olfactory bulb to other areas of the brain.



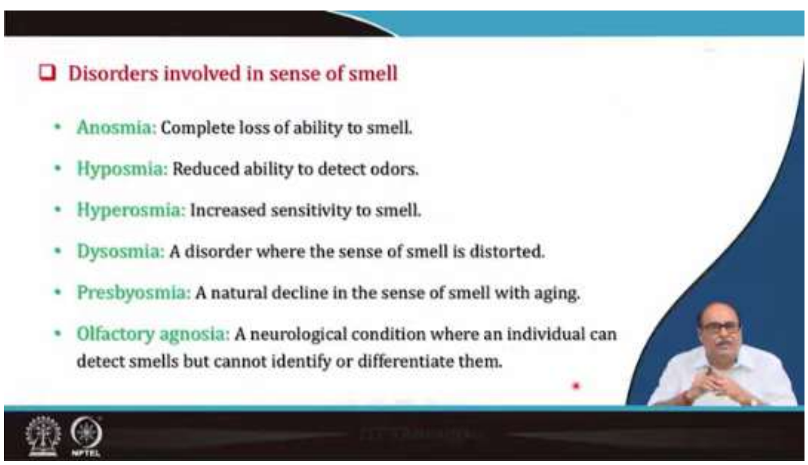
Then let us see how the nose functions. You can also see it has been depicted in this picture. Like smell or other sensations are the primary functions of the nose. The sensation of smells involves both a physical mechanism and a chemical analysis process. So, normally olfaction occurs when volatile food components interact with the olfactory receptors in the nasal cavity. Smell perception typically involves orthonasal olfaction where odor molecules enter through the nasal cavity and are detected by chemical receptors. However, it can also involve retronasal olfaction, where odour molecules enter through the oral cavity. You can see here these are the olfactory receptors, these are synapses, and these are mitral cells in the olfactory bulbs, and these are axons of the mitral cells.



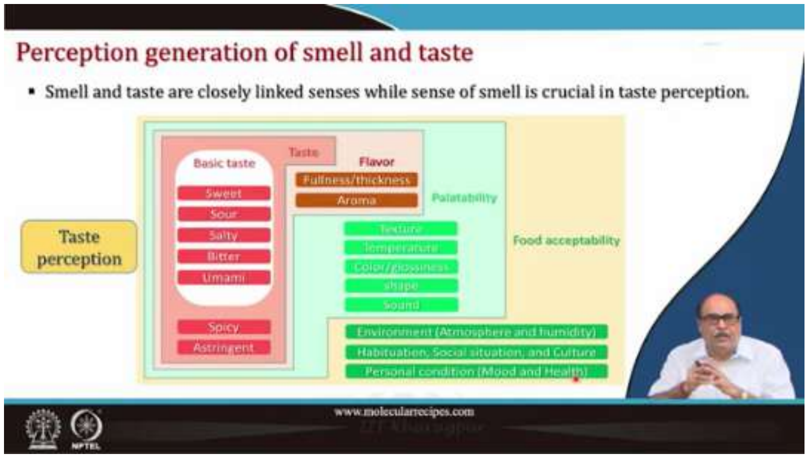
So, let us see the mechanism of orthonasal olfaction. How does it happen? The first thing is odor detection, that is, the air carries Air carries odor molecules like volatile compounds which are released from the food or even sometimes flowers, etc. That is, odor compounds enter the nasal cavity during inhalation. When we inhale these flavors, they enter the nasal cavity, all right. Then, after they enter, they bind to the olfactory receptors, that is, these molecules. They bind to their specific olfactory receptors and trigger a series of chemical reactions within the sensory neurons. Following this, there is a signal transmission; the binding of an odorant to a receptor generates an electrical signal. As we have seen in the case of tongues, similarly here also these electrical signals. Travel through the olfactory nerve to the olfactory bulb, where these signals are processed. That is, the signals from the sensory neurons are processed in the olfactory bulb. And it relays them to the brain regions which identify and interpret the smell, like the brain there is a. Actually, the perception of the smell is received. The brain integrates the information from the olfactory bulb to recognize and distinguish between different smells.



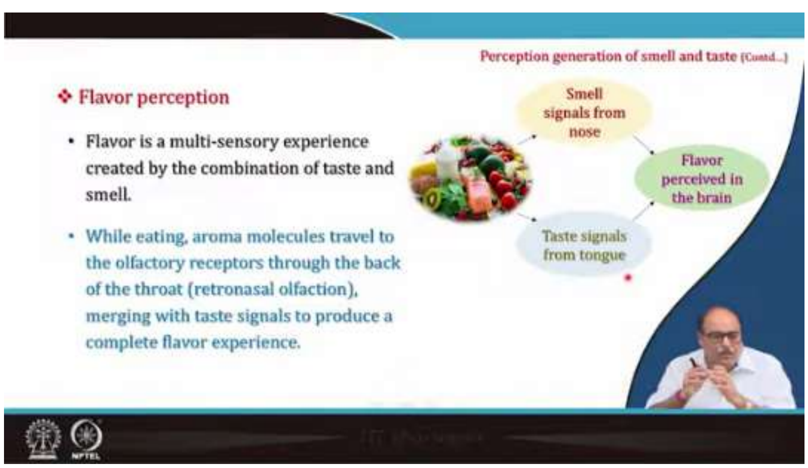
The same thing is shown here also. Like from olfactory receptor cells, it goes to the olfactory nerve, from where it comes to the bulb, and then there is the olfactory tract. In the olfactory tract, there may be medial olfactory stria or lateral olfactory stria. And in the medial olfactory stria, it comes to the septal nuclei and then the hypothalamus limbic system. That is the primitive part of the very old olfactory system. In the lateral olfactory stria, it comes to the peripheral cortex and then the limbic system. That is the hippocampus, which is the less old olfactory system. Or it goes through the thalamus to the orbital cortex and the newer system. So, in this way, there are various ways that the data from the receptors are processed. Finally, the sense is recognized.



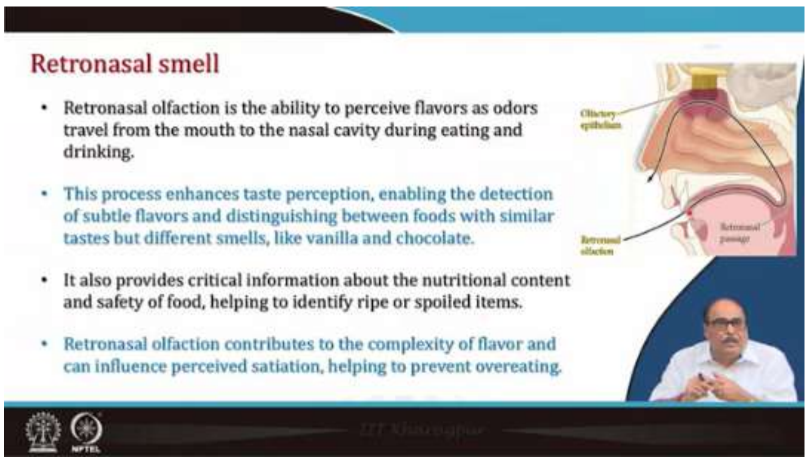
So, the disorders which are involved in the sense of smell may be anosmia, like the complete loss of the ability to smell, or hyposmia, which is the reduced ability to detect odors. Then hyperosmia, increased sensitivity to smell, or dysosmia, a disorder where the sense of smell is distorted. Then also, a natural decline in the sense of smell with aging is called presbyosmia, and a neurological condition where an individual can detect smells, but cannot identify or differentiate them. It is known as olfactory agnosia. So, these are the various disorders associated with the sense of smell.



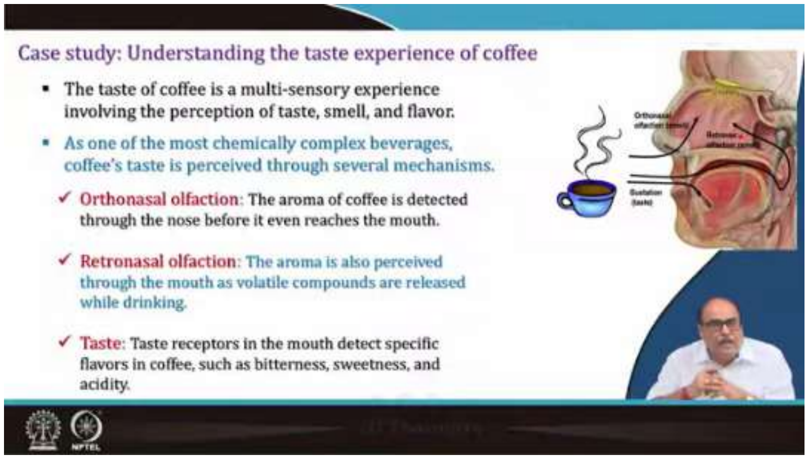
Now, let us talk about the perception and generation of smell and taste. Smell and taste are both very closely linked senses. While the sense of smell is crucial in taste perception and the joint appreciation, that is, to our brain, it is the joint appreciation of smell and taste that is also popularly known as the flavor of the food. So, you get the taste perception like sweet, sour, salty, spicy, and all these things taste, and then your smell, that is the fullness, thickness, all those things together give the aroma, If a food has a pleasing aroma, a good aroma, it also influences the palatability of the food, as its texture, even the temperature, color, glossiness, shape, sound, all those things contribute to the palatability and aroma, and then environmental or atmospheric factors like atmosphere and humidity, habituation, social institution, and culture, as we discussed earlier, also in this aspect, personal condition, mood, and health, all these things finally, they influence the palatability as well as the acceptability of the food, so in the To accept food, its good flavor as well as taste and smell, they contribute to a great extent.



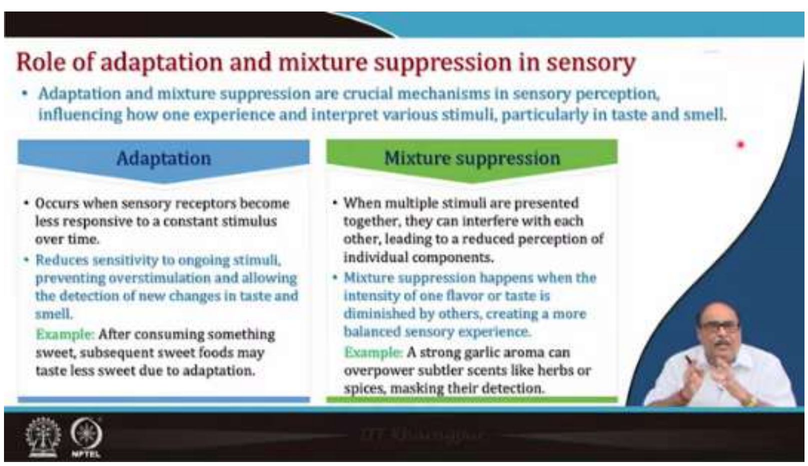
So, let us see flavor perception, as I told you, that joint appreciation, joint signal that is, when you take any food, there is a smell signal from the nose and a taste signal from the tongue and these two signals are sent to the brain, and then the brain sometimes jointly processes these signals and gives the impression about the food material that is called flavor. That is the flavor perceived in the brain from the smell signals as well as the taste signals. So, you can say flavor is a multisensory experience created by the combination of taste and smell. While eating, aroma molecules travel to the olfactory receptors through the back of the throat like retronasal olfaction and merge with the taste signal to produce a complete flavor experience.



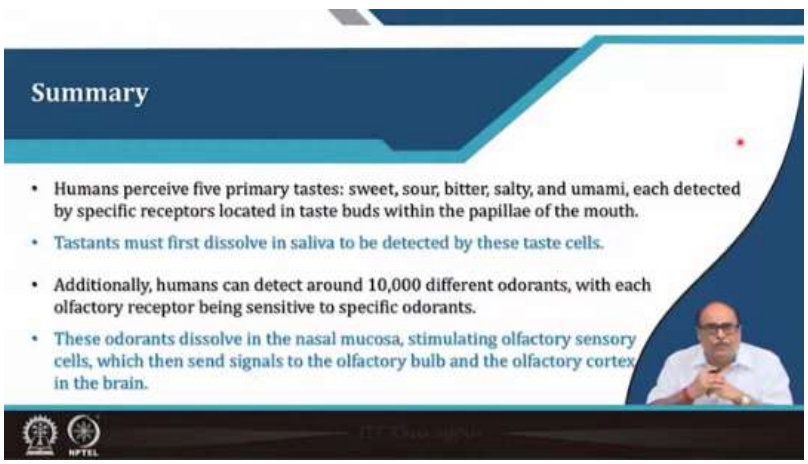
Then retronasal smell, that is retronasal olfaction, is the ability to perceive flavors as odors travel from the mouth to the nasal cavity during eating and drinking. All these things you see, olfactory epithelium and retronasal olfaction, there retronasal passage is there. So, this process enhances taste perception, enabling the detection of subtle flavors and distinguishing between foods with similar taste but different smells like vanilla, chocolate, etc. It also provides critical information about the nutritional content and safety of food, helping to identify ripe and spoiled items. Retronasal olfaction contributes to the complexity of flavor and can influence perceived satiation, helping to prevent overeating.



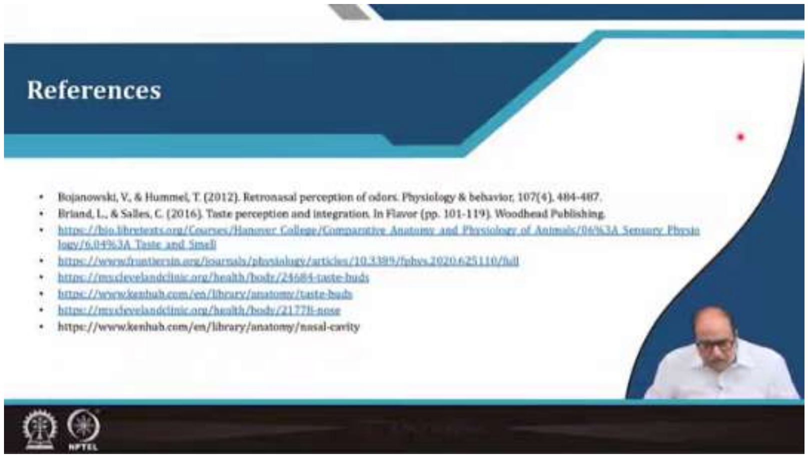
Then let us take one case study, that is, understand the taste experience of coffee. The taste of coffee is a multi-sensory experience involving the perception of taste, smell, and flavor. As one of the most chemically complex beverages, coffee's taste is perceived through several mechanisms. One is the orthonasal olfaction. The aroma of coffee is detected through the nose before it reaches the mouth. Then, retronasal olfaction occurs, where the aroma is also perceived through the mouth as volatile compounds are released while drinking. Finally, the taste receptors in the mouth detect specific flavors in coffee. They detect whether the coffee is bitter, sweet, acidic, etc., depending upon the manner in which the coffee is brewed or the type of coffee. Finally, you get a joint appreciation of whether the feel-good factor is present or sometimes, if it is too bitter, people may not like it.



Finally, let us talk about the role of adaptation and mixture suppression in sensory perception, which is a very common phenomenon that occurs, namely adaptation and mixture suppression, which are crucial mechanisms in sensory perception that influence how one experiences and interprets various stimuli, particularly in taste and smell. Adaptation occurs when sensory receptors become less responsive to a constant stimulus over time. It reduces sensitivity to ongoing stimuli, preventing overstimulation and allowing the detection of new changes in taste and smell. For example, after consuming something sweet, if you subsequently take Other sweet foods, you may not get the real taste of sweet food after sweet food Generally, it takes the less sweet because that is mainly due to the adaptation Because your tongue's taste buds are adapted to that particular sweet taste. So, the sweetness of other foods will not be really clearly evident. On the other hand, mixture suppression, like when multiple stimuli are presented together, they can interfere with each other, leading to a reduced perception of individual components. That is, mixture suppression happens when the intensity of one flavor or taste is diminished by another, Creating a more balanced sensory experience. For example, a strong garlic aroma. Can overpower subtle scents like herbs or other spices, masking their detection. So, if you are taking any strong flavour, etcetera, That is, our stimuli take that flavour, and then it overpowers. That is, it masks the detection of the other flavour. So, that is called mixture suppression.



So, finally, I would like to summarize this lecture. By saying that humans perceive five primary tastes like sweet, sour, bitter, salty, and umami, and each is detected by specific receptors located in the taste buds within the papillae of the mouth. Tastants must first dissolve in saliva to be detected by these taste cells. That is why when you chew the food, the saliva and the taste buds ensure that the food is properly mixed, and then you get the real taste. Additionally, humans can detect around 10,000 different odorants, with olfactory receptors being sensitive to specific odorants. And these odorants dissolve in the nasal mucosa, stimulating olfactory sensory cells, which then send signals to the olfactory bulb and the olfactory cortex in the brain. So, this is all. I am sure that you got a clear and good picture of how when we eat any food or when we smell any food. So, how is this data taken by the taste buds or nasal buds, how are they analyzed, how Does it help in making our perception of that particular food and whether we like that food or dislike that food, or how we differentiate different tastes, how these buds work, etc.



All these things we discussed today; these are the references used in this lecture.

Thank you very much for your patient hearing. Thank you.