EDO UNIVERSITY IYAMHO
Department of Physiology
PHS 201 Special Senses

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Lectures: Monday (1.00 ï 3.00 pm), Tuesday and Wednesday 8am ï 12.00 pm,
Venue: LT1, LT5 and TEL Laboratory. Phone: (+234) 8055763933
Office hours: Monday ï Friday 12.00 to 1.00 PM (just before class), Office: College Building Ground Floor Room 39.

Teaching Assistants: *Dr. Maero Origho*

General overview of lecture: The special senses consist of the senses of sight, hearing, taste and smell. The sense organs are located in the head and have connections with the brain. These senses allow the individual to detect and analyze light, sound and chemical signals in the environment. Since the vestibular apparatus is part of the ear in which the hearing apparatus is located, vestibular functions will also be covered in this section even though they are not strictly special senses.

Prerequisites: Introduction to special senses, definition of terminologies, basic concepts in special senses, mechanism of action, pathways, physiological regulations, pathophysiology and conclusions.

Learning outcomes:

1. Students must understand and know the mechanism(s) of sense of sight
2. Students must understand and know the mechanism(s) of sense of hearing
3. Students must understand and know the mechanism(s) of sense of taste
4. Students must understand and know the mechanism(s) of sense of smell.

Assignments: We expect to have 2 individual homework assignments throughout the course in addition to a Mid-Term Test and a Final Exam. Home works are due at the beginning of the class on the due date. Home works are organized and structured as preparation for the midterm and final exam, and are meant to be a studying material for both exams.

Grading: We will assign 10 % of this class grade to homework, 20% for the mid-term test and 70% for the final exam. The final exam is comprehensive.

Textbook:The recommended textbook for this class are as stated:

Ganong's Review of Medical Physiology

Authors: Kim E. Barrett, Scott Boitano, Susan M. Barman, Heddwen L. Brooks.
Publisher: (Twenty-Third Edition) a LANGE medical book. The McGraw-Hill Companies, Inc.
ISBN: 978-0-07-160568-7
MHID: 0-07-160568-1

Medical Physiology Principles for Clinical Medicine
Authors:Rodney A. Rhoades, Ph.D., David R. Bell, Ph.D.
Publisher:Lippincott Williams & Wilkins, a Wolters Kluwer business (Fourth Edition)
ISBN 978-1-60913-427-3

Essentials of Medical Physiology
Authors:K Sembulingam PhD andPrema Sembulingam PhD
Publisher:Jaypee Brothers Medical Publishers (P) Ltd (Sixth Edition)
ISBN 978-93-5025-936-8

Main Lecture:

Sight

Introduction: The organ of vision are the eyes. There are two eyes located in the sockets in front of the head in man. Each is roughly spherical and it is held in the socket by the extrinsic muscles of the eye. These muscles are also responsible for the movement of the eyeballs in various directions. The eye functions in a manner similar to a photographic camera. Like the camera, it has a lens system that helps to focus light rays on a photoreceptor, an aperture (the pupil) through which light enters the interior of the eyes and whose size can be varied and a photosensitive receptor (the retina) analogous to the film of a camera.

The eyeball, which is approximately spherical and about 2.4 cm in diameter, consist of three layers: a tough outer fibrous layer made up of the sclera and cornea; a middle layer comprising of the vascular choroid, the muscular ciliary body and the iris and an inner neural layer, the retina. The sclera is the white portion of the eyeball and the anterior portion of the sclera is the transparent cornea, through which light rays enter the eyes. The lens is a transparent, biconvex, encapsulated structure held in position by the suspensory ligaments which are attached to the ciliary muscle. The posterior pole of the sclera is pieced by the optic nerve which carries the nerve impulses originating in the retina into the brain.

Beneath the sclera is the uvea, which is composed of the choroid, ciliary body and iris. The choroid is a thin, highly vascular and pigmented layer beneath the sclera. It is the main nutritive tissue of the eyeball which supplies the retina with oxygen and foodstuffs. The retina is the innermost layer of the eyeball, lining the whole of the posterior chamber and terminating in a ragged line (ora serrata) behind the ciliary body. The structure of the retina is very complex, consisting of nerve elements, supporting cells and light sensitive rods and cones. The ratio of rods to cones in the human eye is about 20:1, so, there are ar more rods than cones. The rods and cones are the visual receptors and are responsible for the transduction of light energy into electrical energy.

The lacrimal glands, located beneath the lateral portion of the upper eyelid secretes tears. The fluid secreted is drained via the lacrimal duct located on the inner part of the nasal side of the lower eyelid into the nasal cavity.

Hearing and Equilibrium

The ear has twofunctions, hearing and equilibrium. The external ear, middle are, and the cochlea serve the function of hearing, while the semicircular canals, the utricle and saccule of the inner ear are concerned with equilibrium. Although maintenance of equilibrium is a sensorimotor function of the central nervous system, the function of the vestibular apparatus will be discussed here since the receptors for equilibrium are in the inner ear. The external ear consists of the pinna (auricle) and the external auditory meatus. It is separated from the middle ear by the tympanic membrane. The middle ear is an air filled cavity. It is irregular, it measures 15 mm and also from front to back. It is bound laterally by the tympanic membrane, medially by the inner ear and posteriorly, it is connected to the mastoid antrum and the mastoid air cells.

The inner ear is contained in the osseous labyrinth within the temporal bone. It consists of the cochlea apparatus. The scala tympani and scala vestibule are filled with perilymph, a fluid that is similar in composition to cerebrospinal fluid (CSF). The scala media is filled with endolymph, a fluid that has a high K^+ concentration and a low Na^+ concentration just like intracellular fluid.

The organ of Corti, which contains the auditory receptor cells, is located along the entire length of the basilar membrane, from its base to its apex. It consists mainly of receptor hair cells, which are arranged in two groups (the outer and inner hair cells). The perilymph in the scala vestibule and scala tympani is formed mainly from plasma. It resembles the extracellular fluid, especially cerebrospinal fluid, in composition. It has Na^+ concentration of 150 mEq/L and K^+ concentration of 5 mEq/L. On the other hand the endolymph is produced by blood vessels lining the membranous labyrinth, both from the stria vascularis in the cochlea duct and by blood vessels in the vestibular apparatus. After circulating through the membraneous labyrinth, the endolymph is returned to the blood vessels surrounding the endolymphatic sac. Endolymph has a high K^+ concentration (150 mEq/L) and a low Na^+ concentration (1 mEq/L)

Sound travels in form of waves. Sound waves can be transmitted through air, fluid or solids. Sound transmission in human ear is normally through air and fluid. However, in deaf people, transmission of sound through solid (bone conduction) may become important. Sound waves travelling in air enter the ear via the external auditory meatus. The sound waves hit the tympani membrane and set it vibrating. The vibration of the tympani membrane is transmitted to the ossicles of the middle ear which transmit the vibrations to the oval window of the inner ear. The footplate of the stapes moves in and out at the oval window. This results in movement of the perilymph in the scala vestibule.

Taste

The sense of taste (gustation) is important in the selection and enjoyment of food. In addition, the texture of the food as detected by touch sensations in the mouth and in the fingers in many Avricans who eat with their hands, visual and olfactory inputs and the presence of condiments, such as pepper in the food (pepper stimulates pain endings) contribute to the overall taste and enjoyment of food.

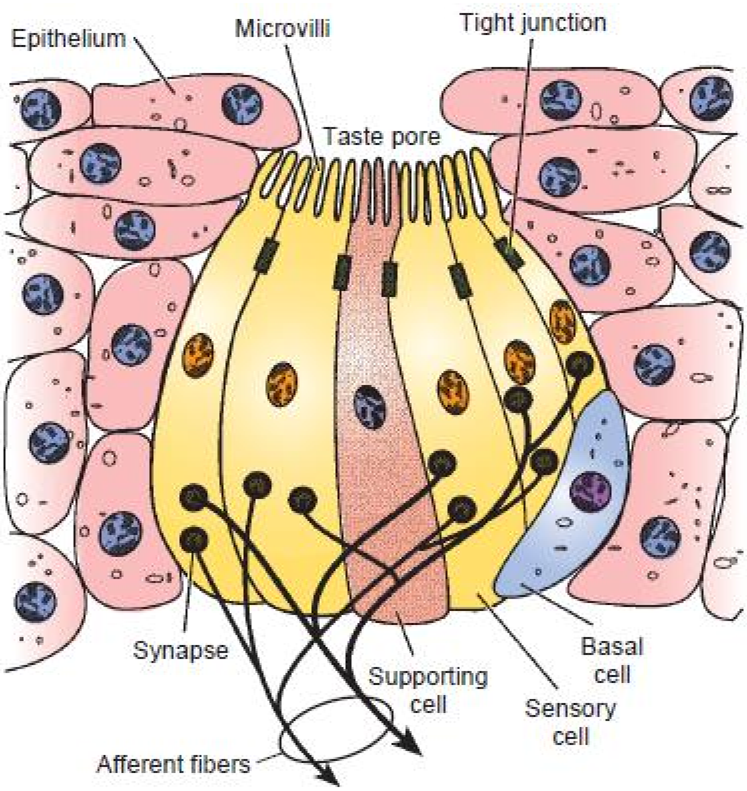

Figure 1: The sensory and supporting cells in the taste bud.

Among thousands of different taste sensations, humans candiscriminate between five specific tastes received by the gustatory receptors. These are salty, sweet, bitter, sour, and***umami***, which means ñsavoryò or ñmeatyò in Japanese. Thereare also two ñaccessory qualitiesò of taste sensation, alkaline(soapy) and metallic. Recently, another taste sensationð fattyð has been proposed, because scientists have identifieda sensory receptor for long-chain fatty acids. In some Asiancountries, piquancy (spiciness) is also considered a basictaste. Sensory receptor cells respond in varying degrees to all five specific tastes, but perhaps preferentially respond to oneof the taste sensations. Although these receptors have beentraditionally represented as occupying specific parts of thetongue (i.e., the receptors for sweetness just behind the tipof the tongue, sour receptors predominately along the sides,salt at the tip, and bitter across the rear), this ñtongue mapòtheory has been refuted.

Smell

The olfactory system has a much broader function than doesthe gustatory system. It not only participates in the selectionand enjoyment of food but also is involved in detecting smellfrom the surrounding environment (e.g., fragrance of flowers,other people, and dangerous odors that can be harmfulto the body). Appreciation of flavors is especially importantand compliments the gustatory system. For example, savoringthe aroma of a glass of red wine oft en surpasses the gustatorysystem. Many patients who complain about the loss of taste often have an olfactory disorder.Humans, compared with other mammals, have a relativepoor sense of smell. However, the olfactory systemis still quite extraordinary insofar as the nose contains>5 million olfactory receptors (10 times more than tastereceptors) that can differentiate between 1,000 differentodorants. The main olfactory system detects odorantsthat are inhaled through the nose, where they contact themain olfactory epithelium, which contains various olfactoryreceptors. The receptor organ for olfaction is locatedin the olfactory epithelium in the roof of the nasal cavity.Normally, there is little airflow in this region of the nasaltract, but sniffing serves to direct air upward, increasingthe likelihood of an odor being detected. In contrast tothe taste sensory cells, the olfactory cells are neurons and,as such, are *primary receptors*. These cells are interspersedamong supporting (sustentacular) cells and basal cells thatbind the cells together at their sensory ends.

Signal transduction appears to involve the binding of amolecule of an odorous substance to a GPCR on a sensory cell. This binding causes the production of cAMP, which bindsto, and opens, sodium channels in the ciliary membrane. Theresulting inward sodium current depolarizes the cell to producea generator potential, which causes action potentials in the afferent fiber. The frequency of the action potential isdependent on the concentration of the odorant. The sense ofsmell shows a high degree of adaptation, some of which takesplace at the level of the generator potential and some of whichmay be a result of the action of efferent neurons in the olfactorybulb. Discrimination between odor intensities is not well defined; detectable differences may be about 30%. The mechanism of the olfactory system can be dividedinto a peripheral mechanism, one that senses an externalstimulus and encodes it as an electrical signal, and a centralone where the signal in the neurons are integrated and processedin the CNS.