Ministry of health Republic of Belarus
Establishment of education "Gomel state medical university"

Department of histology, cytology and embryology

MANUAL
for 1-st year students of faculty of foreign students on gynecology

Topic: 14:
HISTOPHYSIOLOGY OF THE SENSE ORGANS

Duration 4 hours

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THE MOTIVATIONAL CHARACTERISTIC OF THE THEME

The knowledge of structure sense organs is necessary for concept not only normal function, but also for correct diagnostics and preventive maintenance of diseases. All sense organs or analyzers, provide the review of irritations from the external and internal environment; transformation of energy of irritation in a nervous impulse and carrying out of impulses on nerves to the centers of the maximum analysis .

Object of studying of a teaching material is the peripheral part of analyzers.

THE PURPOSE

Studying of a microscopic and ultramicroscopic structure and morph functional features of sense organs.

PROBLEMS

The student should know:

1) Development of peripheral departments of analyzers
2) To explain histogenetic features of primary and secondary cells

The student should be able:

1) To define under a microscope peripheral part of analyzers
2) To identify receptor cells of sense organs at a ultramicroscopic level

REQUIREMENTS TO THE INITIAL LEVEL OF KNOWLEDGE

For full mastering a theme it is necessary for student to repeat questions of an anatomic structure of sense organs from a rate of normal anatomy.

CONTROL QUESTIONS FROM RELATED SUBJECTS

1) The anatomic structure of the eye
2) The anatomic structure nasal cavities
3) The Anatomic structure of organs of a mouth
4) The Anatomic structure of an ear

CONTROL QUESTIONS ON THE THEME OF EMPLOYMENT

1) Concept about the analyzer and sense organs
2) Classification of receptor cells
3) Compound components of the visual analyzer
4) Development of eye
5) The general structure of eye
6) Environments of an eyeball. Their tissue structure
7) The structure of a cornea
8) The structure of a crystalline lens and iris
9) The retina as the nervous center of screen type
10) Organ of smell
11) Organ of taste. Localization, function structure
12) Development of an internal ear
13) The structure a membranous labyrinth: cochlear labyrinth, vestibular labyrinth
14) Corti organ: localization, morphofunctional characteristics of Corti organ’s cells.

15) Hair cells of the cochlear and vestibular labyrinth.

16) Structure of macula and the crista ampularis

THE PRACTICAL PART OF EMPLOYMENT

1) The Scheme of structure receptor cells – to enter a designation to specify localization (Exercise № 1 in album)

2) The Scheme « Body of sense of smell » – to enter designations (Exercise № 2 in album)

3) The Scheme « Body of taste » – to enter designations (Exercise № 3 in album)

4) The Scheme « Development of an eye » – to enter designations and to specify derivatives (Exercise № 4 in album)

5) The Scheme of a structure of an eyeball – to enter designations (Exercise № 5 in album)

6) The Scheme of a structure retina, layers of a retina, a direction of light beams, a course of nervous impulses (Exercise № 7 in album)

7) The Scheme of taste bud – to enter designations (Exercise №1 in album)

8) The Scheme «Three divisions of ear» – to enter designations (Exercise № 2 in album)

9) The Scheme of internal ear structure – to enter designations (Exercise 3 in album)

10) The Scheme «Sound transmission trough the ear» – show by arrows (Exercise № 4 in album)

11) The Scheme of a structure of Corti organ – to enter designations (Exercise №5, № 6 in album)

12) The Scheme «Macula of the utricle and saccule – to enter designations (Exercise №7 in album)

13) The Scheme of structure of the crista ampularis – to enter designations (Exercise №8 in album)

14) The Scheme of hair cells of vestibular labyrinth – to enter designations (Exercise №9 in album)

SLIDES

1. A cornea of an eye.
2. A back wall eyes (retina).
3. Organ of Corti
4. Organ of taste.
5. Organ of Corti
6. Organ of taste

QUESTIONS FOR SELF-CHECKING KNOWLEDGE

1) Think over, what functional value environments of an eye and their derivatives have. Make the table.

2) Functional devices of an eyeball

3) Study features of an ultramicroscopic structure and a chemical compound (receptor fibers) neurosensory cells of a retina. Make the table.

4) Think over features of a structure (organization) olfactory cells

5) Study the scheme of a structure of an ear and balance, think over topography and functions receptor cells.

6) Study the scheme of a structure of an ear and balance, think over topography and functions receptor cells

HISTOPHYSIOLOGY OF THE SENSE ORGANS

Information about the external and internal environment is conveyed to the central nervous system by sensory system. S*ensory system consists of the* peripheral part – *sensory organs* that provide only perception of different irritations, such as sound, light waves; middle part – *nerves,* providing transmission and central part – *brain,* containing different centers for the analysis.

Receptor cells are main components of the sense organs. There are three types of sensory cells:

1. Primary receptor cells (nerve-sensory), which are nerve cells and developed from neural tube. They are present into visual and olfactory organs.
2. Secondary receptor cells (senso-epithelial). They are specific epithelial cells and developed from ectoderm. They are present into taste, vestibular (equilibrium) and acoustic (hearing) organs.
3. The third group (from neural tube and neural crests origin) is neurons, forming sensory nerve endings; these are responsible for touch, pressure, pain, and temperature [1–3].

ORGAN OF OLFACTION

The organ of olfaction is located in the mucous membrane of the nasal cavity and provides the sense of smell.

The olfactory epithelium is a tall pseudostratified epithelium. It consists of three types of cells.

1)*Supporting cells* are tall cells with microvilli on the surface.

2)Between the bases of the supporting cells the small *basal cells* are situated.

3)*Olfactory cells* are present bipolar nerve cells. The apical portion of the cell is a modified dendrite; it has a bulbous head with six or eight olfactory cilia. The basal part of cell continues as axon. Cilia are exited by contact with odorous substances. The lamina propria in the olfactory area contains the *olfactory glands,* secretion of which keeps the surface moist and furnishes the necessary solvents.

4)The olfactory nerve is formed by axons of the olfactory cells, passes through the ethmoid bone to the brain into the olfactory center [1– 3].

VISUAL ORGAN

The ***eyes*** are the peripheral parts of visual system.

The wall of the eyeball is composed of 3 layers: 1) an external layer **that** consists of the **sclera** and the **cornea;** 2) the middle – also called the **vascular layer or** *uvea*— consisting of the **choroid, ciliary body**, and **iris;** 3) innermost layer – the photosensitive *retina.*

Sclera is made of dense connective tissue.

The *cornea* contains the following layers:

-The *anterior epithelium* – stratified squamous, contains numerous free nerve endings and has a remarkable capacity for regeneration.

-*Bowman's membrane* consists of collagen fibrils.

- *Stroma* or *substantia propria* – is a transparent connective tissue. It devoids of vessels.

- *Membrane of Descemet* is a very thick basal membrane.

- Corneal *endothelium* or posterior epithelium, which is a layer of large squamous cells.

The cornea is avascular. It gets nutrition from anterior chamber and oxygen comes directly from the atmosphere [3– 6].

Uvea

The uvea consists of loose connective tissue containing a lot of vessels and melanocytes and is divided on three regions – the *choroid,* the *ciliary body* (which is connected to the *lens)* and the *Iris.*

The choroid underlies the photosensitive retina.

Towards the *ora serrata* the choroid is continued into the ciliary body.

The ciliary body forms a belt, contains the smooth muscle and with the circular ligament (suspensory ligament, zonula ciliaris) keeps the lens. The muscle component makes accommodation.

The iris consists of connective tissue with numerous pigment cells and muscles. In the centre of the iris there is an aperture (opening) – the *pupil,* which can be reduced or expanded of the constrictor and dilator muscles of the pupil. In this way, the iris functions as an optic diaphragm, regulating the amount of light entering the eye.

Between the cornea and the iris there is a narrow space – anterior chamber, and posterior chamber is enclosed by the iris, ciliary body and lens. They are filled with aqueous humor and are the transparent dioptric media. The aqueous humor is secreted by the epithelium of the ciliary body.

The next of the transparent media is the crystalline *lens.* This is the elastic biconvex body, suspended from the inner surface of the ciliary body by a circular ligament and consists at the periphery from the flattened epithelial cells, which toward the equator lose nuclei and are transformed into lens fibers (crystalline). The shape of the lens changes during the process of accomodation.

The cavity of the eyeball is filled with a viscous transparent substance (humor), the *vitreous body.* It is a colorless, gelatinous mass with a glasslike transparency. Nearly 99 percent of the vitreous body consists of water. There is a liquid phase — hyaluronic acid and a solid phase – collagen [7].

The retina

The retina consists of 10 parallel layers from outside inward.

- *Pigment epithelium.* There is one layer of pigment cells, which have cuboidal shape. The cell apex, which faces the next layer gives rise the process between the photoreceptor cells. The apical cytoplasm has numerous melanin granules, which absorb light.. The pigment granules migrate among the photoreceptors upon illumination and they return to the cell body in the dark. Also they play a phagocytic role.

- *Layer of rods and cones* — rods and cones are the peripheral processes of rods and cones cells, which are arranged below. These peripheral processes are the modified dendrites.

- *Outer limiting membrane* (neuroglial) is formed by the processes of glial cells.

- *Outer nuclear layer* contains the bodies and nuclei of rods and cones cells, that is layer of the photosensitive cells.

- *Outer plexiform layer* consists only of nerve fibers that form a plexus. The axons

of rods and cones synapse here with the dendrites of bipolar neurons of the next layer [1–3].

-*Inner nuclear layer* contains the neurons of three types: a) the bipolar neurons are the typical neurons which sent their dendrites into the outer plexiform layer to synapse with the axons of rods and cones cells, and their axons run to the next layer;

-b) the horizontal neurons. Their processes go back into the outer plexiform layer and synapse with axons of the rods and cones and dendrites of bipolar cells. They regulate synaptic transmission between rods and cones and bipolar cells; c) the amacrine cells also lie horizontally in the retina. Their processes enter into the next layer where they synapse with the axons of bipolar cells and dendrites of the next layer cells. They play a role in maintaining of sharpness and contrasting images.

-*Inner plexiform layer* consists of synapsing nerve fibers – the axons of bipolar ceils synapse with the dendrites of ganglion cells.

-*Layer of ganglion cells.* These cells are the biggest nerve cells in retina. Dendrites of these cells enter into the inner plexiform layer to synapse with axons of bipolar cells. Each ganglion cell sends its axon into the next layer.

-*Layer of optic nerve fibers* is made of axons of ganglion cells. The fibers converge on the optic disc, and form the optic nerve, travelling to the brain.

-*Layer of inner limiting membrane, lines* the vitreous body. This layer like the layer of outer limiting membrane consists of processes of neuroglial cells, which are arranged in the inner nuclear layer and function as support cells and provide the nutritive function.

So, there are two parts in retina: layer of pigment epithelium and photosensitive part, including chains of three neurons.

The ultrastructure of rod and cone cells. The ***rods and cones*** are the modified dendrites of these cells which are sensitive to light waves.

Each cell has the outer and inner segments. The outer segment of rod cell is composed of a very large number of membrane flattened disks oriented transverse to the axis of the rod. The inner segment contains a great number of mitochondria.

All rods contain visual purple or rhodopsin – the substance, responsible for absorption of light. The rhodopsin molecules are localized in the membrane disks of outer segment. When the retina is exposed to light, rhodopsin breaks down, but it is constantly produced anew.

The cone is similar to rod, but the outer segment is a conical structure and shorter. The disks membranes are continuous with the cell membrane.

The outer segment of cone contains iodopsin, sensitive to blue, green and red lights. That is the cone cells provide the perception of colour [4– 7].

The body of cone and rod cells contains a nucleus. Last part of the cell is axon.

The place of the optic nerve exit is called **opticus papilla** or blind macula. Slightly laterally is the place of the most distinct vision, where cones are present in great number than elsewhere, and all rest layers of the retina are displaced laterally, producing depression, are called the central fovea or yellow macula.

The embryogenesis of the eye

The eye is developed from the different sources. The mane source is primary brain.

It is protruded toward the ectoderm forming *optic vesicle* connecting with the brain through *optic stalk.* The optic stalk is transformed into the optic nerve. The optic vesicle invaginates and forms double-layered *optic cup.* Outer layer of the optic cup is transformed into the pigment epitheiium of the retina, while inner is the precursor of the photo-

sensitive part of the retina.

The nearest ectoderm thickens and forms a *lens placode.* Lens placode becomes *lens vesicle,* which eventually detaches from the ectoderm. Surface ectoderm again thickens and forms the corneal epithelium.

Mesenchyme forms the rest part of the cornea, vitreous body, uvea, sclera [4, 5].

ORGAN OF HEARING (ACOUSTIC) AND EQUILIBRIUM

The ear is peripheral parts of sensory system.

Inner ear (or labyrinth) is situated in the temporal bone and is the peripheral parts of acoustic and vestibular sensory systems.

Inner ear is a bony labyrinth, which contains *vestibule,* continues into snail-shaped canal – *cochlea* and three *semicircular canals.* Vestibule, cochlea and three semicircular canals are filled with the fluid – perilymph and contain the membranous labyrinth filled with the endolymph. That is within the bony labyrinth there is the second membrane-enclosed cavity – membranous labyrinth. This membranous labyrinth is a closed system, surrounded with the sheath of connective tissue, lined with flattened epithelium. In the cochlea membranous labyrinth is called the cochlear duct.

The cochlea consists of a canal that forms 2-3 spiral turns around the conical pillar, called the *modiolus.* The cells bodies of bipolar sensory neurons are found in the spiral ganglion within the modiolus. The peripheral processes of nerve cells travel to the cochlear hear cells which they innervate. Their axons form the nervus cochlearis.

Two spiral membranes, vestibular and basilar, divide the cochlear canal into 3 canal (or cavities on the section). They are: 1) *scala vestibuli* (upper one), 2) *scala tympani* (lower one) and 3) *cochlear duct* – middle canal.

The cochlear duct contains the organ of Corti – organ of hearing.

There are 3 walls of the cochlear duct. 1. The *basilar membrane,* layer of the connective tissue, covering by the flattened epithelium. 2. The *vestibular membrane,* which is a thin layer of connective tissue, lined, with the squamous epithelium. 3. The *stria vascularis,* is layer of stratified epithelium with capillaries, covering the spiral ligament. Cells of this epithelium secrete the endolymph.

Organ of Corti is situated on the basilar membrane [1– 3].

In the middle of the organ of Corti *the pillars* are situated. They have broad bases, that rest on the basilar membrane and the conical bodies which forms *a* tunnel *(small canal) between inner and outer pillar cells.*

The next cells – inner phalangeal cell (one in the section) is arranged on the inner surface of the inner piliar cell, and the inner hair cell is situated on the upper surface of the inner phalangeal cells.

The outer phalangeal cells – 3 or 4 – are located laterally from the outer pillar cells, they act as supporting elements for the 3 to 4 outer hair cells, which are arranged laterally from the tunnel. There are about 20000 outer hair cells along the length of the cochlea.

And there are several supporting cells adjacent to the outer phalangeal cells, which continue into the epithelium of the lateral wall of the cochlear duct [3– 5].

Microstructure of the hair cells.

The hair cells are columnar with basally located nuclei. The most characteristic feature is the W-shaped (outer hair cells) or linear (inner hair cells) array of stereocilia, which are actually highly specialized microvilli. The stereocilia increase in height from one side of the array to the other.

The tips of the tallest stereocilia of the inner hair cells are embedded in the tectorial membrane, a glycoprotein-rich gelatinous mass.

The sound waves provides the vibrations of the basilar membrane and stereocilii bend over. Depolarization of the hair cells is results in.

The basal parts of the hair cells are surrounded by dendrites of sensory neurons of spiral ganglion. The axons of these cells form the acoustic nerve [7].

The mechanism of hearing. The sound waves pass into the extema! auditory meatus and the tympanic membrane begins to vibrate. Through the chain of ossicles vibrations pass to the perilymph in vestibule – in the bony labyrinth through the oval window. The movement of the perilymph is possible due to the presence of the other window – round, which can bulge outward thereby relieving the pressure.

The vibration of the perilymph calls the vibration of the endoiimph, filling the cochlear duct, the vibration of the tectorial membrane over the hair cells and eventually the irritation of the hairs arises. The arising in the hair cells nerve impulse travels through the afferent nerve cells of the spiral ganglion to the brain

The length of the fibers of the basilar membrane is not equal in different parts of the cochlear canal. They are the shortest in the basal turn of the cochlea and the longest in the apical turns. That is why the high-frequency sounds irritate the hair cells of the low part of cochlea, while the low-frequency sounds are percepted in the top part.

And the inner hair cells percept the weak sounds, while the outer hair ceils percept the strong (intense) sounds [3].

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