GUIDELINES

Students' independent work during preparation to practical lesson

Academic discipline	HUMAN ANATOMY
Topic	**EMBRYOGENESIS OF THE CENTRAL NERVOUS SYSTEM. SPINAL CORD.**

Preamble

The main goal of this guidelines is description of all the lessons and exact information that should be prepared. During preparation students should use Textbook 'Human anatomy' (Cherkasov, Kovalchuk et al.), Work Book (Coloring book), 'Atlas of human anatomy' (Sobotta), 'Anatomy international nomenclature' (Cherkasov), 'Tests for preparation of anatomy practical classes' (Kancer) and all other sources that teacher proposes to use.

1. The relevance of the topic:

The nervous system is derived from the **ectoderm**, which is the outermost layer of the embryonic disc. The early central nervous system begins as a simple **neural plate** that folds to form a **neural groove** and then **neural tube**. This early neural is initially open initially at each end forming the neuropores. Failure of these opening to close contributes a major class of neural abnormalities (neural tube defects).

Within the neural tube stem cells generate the 2 major classes of cells that make the majority of the nervous system: neurons and glia. Both these classes of cells differentiate into many different types generated with highly specialized functions and shapes.

The brain development: on the fourth week (3,5-4 weeks) of an embryonal development the cranial extremity of a nervous tube owing to difficult transformations forms three primary cerebral bubbles:

the diamond-shaped brain *(rhombencephalon).*

the midbrain *(mesencephalon).*

the forebrain *(prosencephalon).*

These brain vesicles demarcated by a constriction of the neural tube. In 5 weeks by dividing a diamond-shaped and front bubbles which formed 5 secondary brain vesicles.

A diamond-shaped brain is divided into two secondary brain vesicles: the medulla oblongata *(myelencephalon),* and hindbrain *(metencephalon).*

The forebrain is divided into: diencephalon *(diencepholon)*, telencephalon *(telencephalon)*.

The spinal cord carries out the following major functions:

Electrical communication. Electrical signals are conducted up and down the cord, allowing communication between different sections of the body and with the brain.

Locomotion. During walking, several muscle groups in the legs are coordinated to contract repeatedly. Although the act of putting one foot in front of the other while walking may seem simple to us, but it has to be carefully coordinated by several groups of neurons known as central pattern generators in the spinal cord. These neurons send signals to the muscles in the legs, causing flexion or extension.

Reflexes. These are predictable involuntary responses to stimuli that involve the brain, spinal cord and nerves of the peripheral nervous system (PNS). Reflexes are further discussed later in this material.

2. Specific objectives:

- to identify a neural plate, a neural groov, neural crest and then neural tube;
- to understand **neurulation as a process;**
- **to determine the stages of the brain development;**
- to specify structure and functions of spinal cord;
- to determine and demonstrate sulci and fissures of spinal cord, places of entrance and exit of roots of spinal nerves, sensory ganglia of spinal nerves;
- to determine the structure of segments of spinal cord and skeletopy of segments of different parts;
- to determine the morphological basis of reflex arch, which mediates through spinal cord.

3. Basic level of student includes the knowledge of medical biology about the basic patterns of nervous system activity. The student must know features of structure of vertebra and bones of neurocranium.

4. Tasks for independent work during preparation to practical classes.

4.1. A list of the main terms, parameters, features that need to be learned by the student during the preparation for the lesson.

Term	***Definition***
Neuron	The neuron is the basic unit of the nervous system. It is an electrically excitable cell that communicates with other cells via specialized connections called synapses.
Glia (glial cells or neuroglia)	Non-neuronal cells in the central nervous system and the peripheral nervous system that maintain homeostasis, form myelin, and provide support and protection for neurons.
Gray matter	The gray matter consists of neuronal cell bodies (neurons).
White matter	The white matter refers to areas of the central nervous system that are mainly made up of myelinated axons of neurons.
Substantia gelatinosa	It is a collection of cells in the gray area (dorsal horns) of the spinal cord. Found at all levels of the cord, it receives direct input from the dorsal (sensory) nerve roots, especially those fibers from pain and thermoreceptors.
Neural crest	The neural crest is a transient embryonic structure (a temporary group of cells) that gives rise to most of the peripheral nervous system.
Cerebrospinal fluid (CSF)	Clear, colorless body fluid found in the ventricles of the brain and central canal of the spinal cord. It is produced by specialised ependymal cells in the choroid plexuses of the ventricles of the brain, and absorbed in the arachnoid granulations.
Meninges	Are the three membranes that envelop the brain and spinal cord.
Pia matter	Is the delicate innermost layer of the meninges, the membranes surrounding the brain and spinal cord. Pia mater is medieval Latin meaning "tender mother".

Arachnoid matter	The middle layer of the meninges, named for its spiderweb-like appearance, is a thin, transparent membrane surrounding the spinal cord like a loosely fitting sac.
Dura matter	The outer layer of the meninges. Is a thick membrane made of dense irregular connective tissue that surrounds the brain and spinal cord.
Funiculus	Is a small bundle of axons (nerve fibres), enclosed by the perineurium.
Horns	Parts of the grey matter, there are sensory dorsal horns and ventral motor horns.
Roots	The spinal nerve roots are responsible for stimulating movement and feeling. The nerve roots exit the spinal canal through the intervertebral foramen, small hollows between each vertebra. There are sensory dorsal roots and ventral motor roots.
Neural plate	It is a key developmental structure that serves as the basis for the nervous system. Opposite the primitive streak in the embryo, ectodermal tissue thickens and flattens to become the neural plate.
Neural tube	In the developing chordate (including vertebrates), the neural tube is the embryonic precursor to the central nervous system, which is made up of the brain and spinal cord.
Prosencephalon	One of the primary vesicles. The prosencephalon develops at the rostral end of the recently closed neural tube, starting early in the second month of gestation. Through a series of cleavages, the prosencephalon develops the optic and olfactory apparatus and divides transversely into the **telencephalon** (which then divides in the sagittal plane to form the cerebral hemispheres) and the **diencephalon** (which goes on to form the thalamus, the caudate nucleus and putamen, and the hypothalamus).
Mesencephalon	One of the primary vesicles, developes the midbrain.
Rhombencephalon	One of the primary vesicles, developes the brain stem and cerebellum.
Primary brain vesicles	It is enlargement of the neural tube. There are three: prosencephalon, mesencephalon, and rhombencephalon.
Secondary brain vesicles	Primary brain vesicles developes the secondary brain vesicles. Prosencephalon is subdivided into the **telencephalon** and **diencephalon**, and the rhombencephalon into the **metencephalon** and **myelencephalon**.

4.2. Theoretical questions for the lesson.

1. Discuss nervous system phylogeny basing on its features in fish, amphibians, reptiles, mammals. Discuss nervous system emdriologycal development.
2. Receptors: classification and functional meaning. Neural plate, a neural groov, neural crest, neural tube, primary and secondary brain vesicles.
3. Derivates of the secondary brain vesicles.
4. Gray matter of CNS: structure and functions.
5. White matter of CNS: structure and functions.
6. The structure and functions of nerve fibers, fascicles, roots and nerves.
7. Classification, localization and functions of nervous ganglion.
8. The structure of simple and complex reflex arch.
9. Spinal cord: location and limits (skeletopy).
10. External structure of the spinal cord.
11. Where the puncture of spinal fluid is done? Anatomical interpretation.
12. Segments of spinal cord: definition, limits.
13. Departments of spinal cord and their segments.
14. The structure of spinal cord on the vertical section.
15. Anatomical enlargements (thickenings) of the spinal cord. What is the reasone of their appearance?
16. Cauda equina: topography, appearance.
17. Spinal nerves: appearance and branches.
18. Posterior roots of spinal cord: origin, functional significance.
19. Anterior roots of spinal cord: origin, functional significance.

4.3. The list of standart practical skills:

cervical enlargement
lumbosacral enlargement
medullary cone
terminal filament
anteromedian fissure
posterior median sulcus
anterolateral sulcus
posterolateral sulcus

funiculi of spinal cord:
ventral funiculus
dorsal funiculus
lateral funiculus
central canal
gray matter (anterior horn, posterior horn)
white matter

5. Sources:

Anatomy international nomenclature	**http://anatom.ua/anatomical-terminology/**
LECTURE	**https://anatom.ua/basis/english/lectures/**
Textbook 'Human anatomy'	PP. 324-342 **http://anatom.ua/basis/english/online-book-in-english/**
Work Book (Coloring book)	PP. 92-93
Atlas of human anatomy (Sobotta, Vol. 3)	PP. 228-229, Page 329, 334-336
QUIZES	**https://anatom.ua/basis/english/tests/**
VIDEO	**https://anatom.ua/basis/video/**

6. WRITE A SHORT DESCRIPTION!

Check yourself.

You should be able to describe, compare and classify:

1. Nervous system: function classification.
2. Neuron: definitions, parts of the neuron, morphological classification of neurons, their structure, topography, function.
3. Neuron: functional classification, topography, the relationship between the functional types of neurons.
4. Receptors: functional value, classification by topography and functions.
5. The gray matter of the central nervous system: structure, function.
6. White matter of the central nervous system: structure, function.
7. Nerve fiber bundles, roots, nerves: ix structure.
8. Ganglia: classification, topography, function.
9. The structure of simple and complex reflex arc.
10. The development of the central nervous system in embryogenesis. The main stages of the nervous system in phylogenesis.
11. The development of the spinal cord in embryogenesis. Development defects.
12. Spinal cord: topography, superior and inferior borders, the outer structure.
13. Where make cerebrospinal fluid puncture? Anatomical reasoning.
14. Cauda equina: topography, formation.
15. Segments of spinal cord: definition, bourders.
16. Parts of the spinal cord and their segments.
17. The structure of the spinal cord at the longitudinal section.
18. The structure of the spinal cord in cross section: horns, their relation to the segments.
19. The gray matter of the spinal cord: posterior horn of the types of neurons that form them, nucleuses and functional characteristics in different segments.
20. Gray matter of the spinal cord: lateral horn types of neurons that form them, nucleuses and functional characteristics in different segments.
21. Gray matter of the spinal cord: anterior horn types of neurons that form them, nucleus and functional characteristics.
22. White matter of the spinal cord: anterior funiculus, their boundaries, pathways that form them.
23. White matter of the spinal cord: the lateral funiculus, their boundaries, pathways that form them.
24. White matter of the spinal cord: posterior cord, their boundaries, pathways that form them.
25. Meninges of the spinal cord spinal spaces between them and their contents.

6. Materials for self-control:

1. It was necessary to get spinal fluid from 45-years old patient with suspision of inflammation of meninges. Exploratory puncture between arch of lumbar vertebra (L3-L4) was done. Which ligament should needle penetrate during the puncture?
A. iliolumbar ligament
B. ligamentum flavum
C. anterior longitudinal ligament
D. posterior longitudinal ligament
E. intertransverse ligament

2. Central part of sympatic nervous system was impaired because of tumor. Where pathological process is located?
A. medial intermediate nucleus of lateral horn
B. lateral intermediate substance of lateral horn
C. posterior nucleus of lateral funiculus
D. proper nucleus of posterior horn
E. nuclei of anterior horns

3. A 54-years old patient has got trauma of proper nuclei of posterior horns of spinal cord. What type of sensibility will not be noticed?
A. temperature and nociception
B. tactile
C. stereognosis
D. sense of vibration
E. proprioceptive

4. A patient has involuntary movements and disturbances of tone of muscles of trunk. Which conductive tract of spinal cord was impaired?
A. Tractus tectospinalis.
B. Tractus corticospinalis.
C. Tractus corticonuclearis.
D. Tractus spinothalamicus lateralis.
E. Tractus rubrospinalis
5. Differential diagnostics of spinal fluid is performed in order to diagnose meningitis. Where is it safe to perform puncture?
A. Th XII — L I.
B. L II — L III.
C. L I — L II.
D. L III — L IV.
E. S II — S IV.

6. 34- years old man with spinal cord injury was taken to the hospital. X-ray showed fracture of 11 thoracic vertebra. What segment of spinal cord was injured?
A. 11 thoracic
B. 9 thoracic
C. 10 thoracic
D. 2-3 lumbar
E. 12 thoracic

7. A patient is unable to contract the muscles of the neck after the injury of cervical part of vertebral column. What conductive tract is responsible for innervation of skeletal muscle?
A. Tr. rubrospinalis.
B. Tr. corticospinalis anterior et lateralis.
C. Tr. olivospinalis.
D. Tr. bulbothalamicus.
E. Tr. reticulospinalis.

8. Gray matter of spinal cord was impaired as a result of compression by a tumor. Which nucleus is in posterior horn of spinal cord?
A. Nucl. ambiguus.
B. Nucl. proprius.
C. Nucl. centralis.
D. Nucl. anterolateralis.
E. Nucl. spinalis

9. A patient had lost ability to react to pain and themperature stimuli as a result of tumor growth in lateral funiculus of spinal cord. Which conductive tract is responsible for conduction of information about pain?
A. Fasciculus gracilis.
B. Tr. spinothalamicus anterior.
C. Tr. spinothalamicus lateralis.
D. Tr. spinocerebellaris posterior.
E. Tr. tectospinalis.

10. A man has a trauma as a result of car accident. Posterior columns of gray matter of spinal cord are impaired. Which function might be lost?
A. sense of pain and temperature
B. concious proprioceptive sensibility
C. subconcious proprioceptive sensibility
D. auditory sensitivity
E. visual sensitivity

11. How many meninges does spinal cord have?
A. 1
B. 2
C. 3
D. 4
E. 31

12. Spinal cord extends from the …?
A. medulla spinalis
B. medulla oblongata
C. metencephalon
D. cervical enlargement
E. pons

13. What is the lower limit of the spinal cord?
A. C1
B. T12
C. L1

D. T11-T12
E. L1-L2

14. Where is conus medullaris?
A. near the C1
B. near the C8
C. near the T12
D. near the L1-L2
E. near the S1

15. How many sensory nerve rootlets are going from one segment of the spinal cord?
A. ten pairs
B. one pair
C. two pairs
D. three pairs
E. four pairs

16. How many pairs of spinal nerves cauda equina contain?
A. 2
B. 4
C. 11
D. 12
E. 20

17. Where is the cervical enlargement located?
A. C2-C8 level
B. C4-C7 level
C. C5-Th1 level
D. Th1-Th12 level
E. Th11-L1 level

18. Where is the lumbar enlargement located?
A. C2-C8 level
B. C4-C7 level
C. C4-T1 level
D. T1-T12 level
E. T11-L2 level

19. Where is lower motor neuron of the corticospinal tract located?
A. in the dorsal root ganglia
B. in the dorsal horn of the spinal cord
C. in ventral roots
D. in the ventral horn of the spinal cord
E. in the medulla oblongata

20. Select ascending tracts:
A. fasciculus gracilis
B. fasciculus cuneatus
C. tectospinal tract
D. rubrospinal tract
E. anterior spinothalamic tract

21. How many synapses does knee reflex has?
A. one (between afferent and efferent neurons)
B. one (between interneuron and efferent neuron)
C. two (between afferent and interneuron, between interneuron and efferent neuron)
D. one (between afferent and interneuron)
E. three (between receptor and afferent neuron, between afferent neuron and interneuron, between interneuron and efferent neuron)

22. Where is substantia gelatinosa located?
A. in the dorsal root ganglia
B. in the dorsal horn
C. in the ventral horn
D. in the ventral root
E. in the lateral horn

23. What are the afferents of the nucleus proprius?
A. dorsal root fibers concerned with senses position and movement (proprioception)
B. dorsal root fibers concerned with senses pain
C. dorsal root fibers concerned with senses temperature
D. dorsal root fibers concerned with senses touch
E. visceral afferents

24. What are the structures that attach to the arachnoid mater and suspend the spinal cord in the vertebral canal?
A. denticulate ligament
B. yellow ligament
C. dura mater
D. arachnoid mater
E. pia mater

25. What is the name of the groove in the ventral side of the spinal cord?
A. posterior median sulcus
B. anterior median fissure
C. the conus medullaris
D. cervical enlargement
E. lumbar enlargement

26. The dorsal root ganglia consist of …
A. the cell bodies of the sensory pseudounipolar neurons
B. the cell bodies of the multipolar motor neurons
C. the cell bodies of the interneurons
D. of afferent fibers
E. of efferent fibers

27. Where are lateral horns present?
A. in the cervical segments of the spinal cord
B. in the thoracic segments of the spinal cord
C. in the lumbar segments of the spinal cord
D. in the sacral segments of the spinal cord
E. in the coccygeal segments of the spinal cord

28. What is the innermost layer of the connective tissue that surrounds the vertebral canal and protects the spinal cord?
A. epidural space
B. subarachnoid space
C. dura mater
D. arachnoid mater
E. pia mater

29. Dorsal roots consist of …
A. cell bodies of the sensory pseudounipolar neurons
B. cell bodies of the multipolar motor neurons
C. cell bodies of the interneurons
D. afferent fibers
E. efferent fibers

30. Ventral roots consist of …
A. the cell bodies of the sensory pseudounipolar neurons
B. the cell bodies of the multipolar motor neurons
C. the cell bodies of the interneurons
D. afferent fibers
E. efferent fibers

31. Which layer of the trilaminar disc gives rise to the nervous system?
A. Endoderm
B. Mesoderm
C. Mesenchima
D. Ectoderm
E. All of the above

32. Which term describes the formation of the neural tube?
A. Neurolisation
B. Neurulation
C. Neurology
D. Neuroectodermisation
E. Fertilization

33. What is critical to patterning the development, but does not contribute to the final nervous system?
A. Ectoderm
B. Notochord
C. Endoderm
D. Mesoderm
E. Neural crest

34. Which structure is responsible for inducing differentiation of ectoderm to neuroectoderm?
A. Ectoderm
B. Endoderm
C. Mesoderm
D. Neural crest
E. Notochord

ANSWERS:

1	**B**	**18**	**E**
2	**B**	**19**	**D**
3	**A**	**20**	**A, B, E**
4	**E**	**21**	**A**
5	**D**	**22**	**B**
6	**D**	**23**	**B, C**
7	**B**	**24**	**A**
8	**B**	**25**	**B**
9	**C**	**26**	**A**
10	**A**	**27**	**B, C**
11	**C**	**28**	**E**
12	**B**	**29**	**D**
13	**E**	**30**	**E**
14	**D**	**31**	**D**
15	**B**	**32**	**B**
16	**C**	**33**	**B**
17	**C**	**34**	**E**