Biology MSc – Final exam topics – 2019

Neurobiology and Human Biology

THEMES FOR ALL STUDENTS

1. Ontogenesis of neural cells

Major neuronal tissue types, their general and specific features. Stem cells of the nervous system, their potential. Development of embryonal nervous tissue, and its perinatal development. Fate of the adult nervous system cells (lifetime, proliferation, cell death)

2. General organization of the mammalian nervous system

Structure and basic functions of the spinal cord. Major anatomical structures and pathways of the brain. Microscopic structure of the neocortex and the hippocampus (characteristic cell types and their connections)

3. Microscopy in neuroscience and human biology

Light and electron microscopic techniques. Fluorescence microscopy in neuroscience. Polarization microscopy in human biology. Microscopic methods suitable to detect fixed and live cells, tissues and organism including changes in their structure. Superresolution microscopy.

4. Methods in behavioural neuroscience

Behavioural tests and their interpretation. Opto- and chemogenetics in behavioural neuroscience. Neuronal networks controlling reproductive behaviours. Maternal adaptation of the brain, regulation of caring behaviours.

5. Stages of human prenatal development

Proontogenesis, insemination, impregnation, the fetus. Important prenatal developmental events.

6. Stages of human postnatal development

Developmental processes in the neonate, during childhood and puberty. Most important factors in the development of the body. Genetic and neuroendocrine regulations. The role of environmental factors in the regulation of the development of the human body.

7. Structure of the motor system of human

General characteristics of human skeleton and musculature. Adult skull, spine and pelvis. Musculature of the trunk and extremities. Characterization of functionally distinct muscle groups.

8. Research methods

Types of grants. Structure of research grant applications. Ethical aspects of scientific investigations. Ethical permits. Scientometry. Statistical methods used in neurobiology and human biology.

9. Neuroendocrinology

Structure of the hypothalamus. Growth hormone system. Prolactin and the regulation of its secretion. Reproductive hormones. Magnocellular neurosecretory system. Regulation of body temperature.

10. Systems biological approaches in neuroscience

The essence of genomics and proteomics techniques. Bioinformatical analysis of gene expressional datasets.

FACULTATIVE HUMAN BIOLOGICAL THEMES

1. Development of human bones and muscles

Development of the skull and dents. Normal development and defects in the development of the spine, chest, shoulder, pelvis, and the bones and muscles of the extremities. Bone development.

2. Development and structure of human circulation and respiratory system

Development of the heart and the blood vessels. Developmental defects. Fetal circulation. Normal development and defects in the development of the respiratory system.

3. Structure and development of the human digestive, excretory and reproductive systems

Prenatal development and developmental defects of the human gastrointestinal tract. Development and developmental defects of the human urinary system.

4. Structure and development of the human reproductive systems

Male and female reproductive organs. Processes and defects of sexual development. Syndromes related to chromosomal abnormalities.

5. Methods to estimate biological age in auxology

Age of the bones, dents. Techniques to estimate morphological and physiological age. Areas of the application of these methods. Growth standards, and methods to asses their defects. Disease-specific growth patterns of chronically ill children

6. Human biological estimations of body structure and composition, nutritional status

The Kretschmer typology. Sheldon's and Heath-Carter's somatotype. Conrad's growth type. Characteristics of the methods of estimating body components. Methods for estimating nutritional status. The most important features of the morphological body and the age changes of the body components.

7. Primatology

The taxonomy of today's non-human primates. The general characteristics and spread of primates. Primate evolution: initial steps in the evolution of primates. Early real apes, New World monkeys, Old World monkeys. The appearance and characteristics of apes.

8. The evolution of hominids is the I. Praeanthropus phase.
Early hominids at the end of the Miocene. The formation of two legs. The Gracilis and Robust Australopithecines / Paranthrops.

9. Evolution of Hominids II. Archantropus phase.
The appearance and spread of Homo's early representatives (Homo rudolfensis, habilis, erectus and heidelbergensis). Use of equipment and fire.

10. Evolution of Hominids III. Paleanthropus and Neanthropus phases
Neanderthals, denisovan people and Homo floresiensis. The appearance of the modern Homo sapiens and the paths of inhabiting the Earth and the time of migration on the basis of the findings. The emergence of culture.

11. Evolution of hominids IV. Biodiversity
The spread and diversity of modern Homo sapiens on Earth. Characteristics of the biodiversity of Homo sapiens geographic variants. European, mongolid, amerindid, negrid and australonesid geographic varieties.

12. Characterizing today's body structure and its physical development processes in the mirror of man's development
Evolutionary changes and characteristics of the human growth and maturation pattern. The anatomical features of the two-lane walking, the evolution of the human organs of the body. Evolution of human chewing apparatus. The evolution of sexual maturation. Evolution of brain volume.

13. Human Research of Historical Population I.
The possibilities and limitations of classical human research methods in the 21st century. Biological age estimation on bone marrow. Definition of morphology. Taxonomic and craniometric studies.

14. Human Research of Historical Populations II.
Possibilities for analyzing human remains of buried rites. Historical human investigation of the remains of children. Examination of mummies. Paleoradiology.

15. Humanitarian examination of historical age populations III.
Use of modern molecular methods to answer population history questions. Archaeogenetics and studies using stabile isotopes in the detection of migration. Reconstruction of the diet with isotopic analyzes.

16. Data management methods in anthropological research
Handling of historical human data. Types of data and usability. The concept of biological distance between populations - possibilities of craniometric comparisons. Biarcheological

evaluation of the results. Methodology for representative surveys of recurrent human populations. Sampling, basic statistical characterization, univariate and multivariate statistical analyzes.

17. Archeogenetics
Examination methods of archeogenetics. Comparison of the Archaic Genome (Neanderthal and Denisovan Genome) with the human reference genome. The Earth's population based on mtDNA haplotypes.

18. Illnesses of former populations I.
Possibilities and limitations of paleopathological examination. Macroscopic, radiological and molecular methods in the history of disease history. Traumatic lesions. Developmental abnormalities. Bone metastases caused by blood and metabolic disorders.

19. Illnesses of ancient populations II.
Infectious illnesses. Possibilities for identifying non-specific and specific lesions caused by infections. Paleooncology. Mouth pathological examinations. Research of stress markers.

FACULTATIVE NEUROBIOLOGY THEMES

1. The structure of the nerve cell membrane, its mosaic nature
Characteristics of the neuronal membrane, its components and structure. Neuronal polarization, axon-dendritic specification. The formation and structure of the myelin and the axon initial segment. Their functional roles.

2. Neuronal activity
Changes in membrane potential during neuronal function, formation of synaptic potential and action potential. Integrative functions of the neurons. Activity-dependent changes in neuronal gene expression, transcriptional and translational processes, pre- and post-synaptic effects. The role and significance of intracellular transport in cellular integration.

3. The operation of chemical synapse
The formation and functioning of the synaptic structure, anterograde and retrograde signal transduction. The characteristics of pre- and post-synapse elements and their functional roles. Uptake and release of synaptic vesicles.

4. Importance and control of non-synaptic communication in nerve tissue
The structure and role of gap junctions and hemichannels in the functioning of neuronal cells under normal and pathological conditions. Effects through adhesion molecular systems in the nerve tissue.

5. The role and significance of glia and neuron relationships
The importance of co-operation between neurons and glial cells in maintaining and

pathologically altering neuronal function (metabolic, signal and cellular effects). The physiological and pathological role of microglia.

6. Regulation of intracellular Ca^{2+} level, its role and significance in neuronal function
Overview of cellular processes affecting the intracellular Ca^{2+} level in nerve tissue (ion channels, pumps and transporters, role and significance of intracellular stores, influencing enzymatic functions). The effect of intracellular Ca^{2+} on normal and pathological cellular function.

7. Specific ion channels
General characterization of the chemical structure of the voltage-dependent and related K^{+}, Ca^{2+} and Na^{+} ion channels. Describe the molecular background of activation and inactivation processes. The location and functions of these ion channels in the neuronal membrane.

8. Fast synaptic transmission in the central nervous system
Presentation of typical synaptic forms. The three main ionotropic receptors. Characterization of ligand-gated ion channels (cholinergic, glutamatergic, purinergic). Their molecular structure and presentation of their activation.

9. The role of metabotropic receptors in neuronal activation
Presentation of the structure of major metabotropic receptor families (e.g. rhodopsin-like, amino acid receptors). Characterization of the secondary messenger systems they activate, cAMP, cGMP, Ca^{2+}-dependent signaling pathways. Presentation of the role of protein kinases, phosphatases and proteases.

10. Motor system
Reflexes. The coordination of complex movements. The role of the cerebellum, basal ganglia and neocortex in the control of movement.

11. Sensory systems
General organization and functioning of perception. The relationship between sensory nerves and receptors in the spinal cord, the formation of ascending sensations. The brainstem, brainstem nuclei, the role of thalamus in perception, the location of sensory cortical areas.

12. Basic pharmacological and neurotoxicological knowledge
Dose-response curves, agonists and antagonists. The fate of drugs and foreign substances in the body.

13. An overview of neurological dysfunction and their therapeutic potential
Neurological and psychiatric disorders (e.g. epilepsy, depression, anxiety). Recognition of neurodegenerative disorders, nervous system effects, treatment options. The effect of neural injury on neuronal function. Pharmacological methods, stem cell therapy. Applicability and limitations.

14. Biological rhythms
The types of daily rhythms, their characteristics, the effect of light and temperature. Synchronization with ambient rhythms. Anatomy and physiology of the biological clock. The genetic background of the biological clock. Inputs and outputs of the biological clock.

15. Sleep and wake
The phenomenology of sleep. The neurophysiology of sleep-wake regulation. Waking and sleep centers. Homeostatic regulation of sleep. Sleep factors, sleep apnea. The function of sleep. Sleep disorders.

16. The brain reward system, emotions
Motivation as a driving force for behavior. Mesolimbic dopaminergic system and methods of its examination. Addiction. The limbic system. Structure of the amygdala. The fear responses its neuronal background.

17. Control of food intake
Peripheral and central systems. Hormonal and neuronal regulatory mechanisms. Neuropeptides and their role in regulating food intake.

18. Learning mechanisms
Short and long term elementary learning processes (e.g. facilitation, depression, LTP), homo- and heterosynaptic effects. Synaptic plasticity mechanisms, homeostatic plasticity. Associative learning forms.

19. In vitro neuroscience techniques
Use of isolated organ, cell and tissue cultures in neuroscience, their use in physiological and pharmacological studies. Benefits and limitations of each method, and their applicability.

20. Electrophysiological measurements
EEG, event-related potentials, single cell activity. Extra- and intracellular recording. Methods of signal processing.