University of Tehran
College of Science
School of Biology

Animal Biology Curriculum
Animal Physiology Ph.D. Program Syllabuses

Table 1. List of required/elective courses

Course		Credits			Hours			Pre-requisite/Co-requisite
		Theory	Practice	Total	Theory	Practice	Total	
1	Neurophysiology	2	0	2	32	0	32	None
2	Reproductive Neuroendocrinology	2	0	2	32	0	32	None
3	Neurotransmitters and their Mechanisms	2	0	2	32	0	32	None
4	Cell Receptors, Signaling and Transduction	2	0	2	32	0	32	None
5	Special Topics in Reproduction	2	0	2	32	0	32	None
6	Cardiovascular Physiology	2	0	2	32	0	32	None
7	Comparative Neurophysiology	2	0	2	32	0	32	None
8	Cellular and Molecular Mechanisms of Cancer	2	0	2	32	0	32	None
9	Bioinformatics	2	0	2	32	0	32	None
10	Pharmacology	2	0	2	32	0	32	None
11	Physiological Adaptation to the Environment	2	0	2	32	0	32	None
12	Electrophysiology	2	0	2	32	0	32	None
13	Physiology of Animal Microorganisms	2	0	2	32	0	32	None
14	Neuroanatomy	2	0	2	32	0	32	None
15	Seminar	2	0	2	32	0	32	None
Total		12	0	12	192	0	192	-

A student requires 14 credits shown in Table 1.

Prerequisites for Animal Biology - Animal Physiology Ph.D. Program
The student's supervisor may ask to study up to 6 credits from Master of Science (M.Sc.) program syllabuses.

Animal Biology Curriculum
Animal Physiology Ph.D. Program Syllabuses

Course: Neurophysiology
Number of credits: 2
Hours: 32
Type of credit: Theory
Type of course: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course Objective

To study higher brain functions with focus on cognition (learning and memory) as well as unconscious and autonomic actions focusing on spinal reflexes.

Course syllabus

1) A general review of neuroanatomophysiology in the central nervous system (CNS)
2) A review of synaptic functions, excitatory and inhibitory neurotransmitters, neuromodulators and their receptor mechanisms
3) Brain circulation and metabolism, effects of hypoxia and hypoglycemia on brain function
4) Somatosensory system, sensory receptors and pathways, the centers of touch, pain and thermoregulation
5) Special senses, receptors, pathways and centers, sensory agnosia types and their causes
6) Higher brain functions, self-consciousness and the role of cerebral cortex and brainstem reticular formation
7) The relationship between language and thought, aphasia types and their causes
8) Learning and memory processes, amnesia, types of memory and theories of memory formation, synaptic plasticity
9) Physiology of emotions, limbic system and its function in emotional behaviours
10) Autonomic nervous system, the neurotransmitters and the receptors
11) Brain motor systems and their physiological dysfunctions
12) Seminar on current research topics in neurophysiology

Evaluation

Continuous Evaluation (Quiz)	Mid-Term Exam	Final Exam - Writing	Seminar
10%	-	70%	20%

References for additional reading

Kandel, E., Schwartz, J., Jessell, T., 2013. Principles of Neural Science, the 5th edition. McGraw-Hill Medical.
Purves, D., 2001. Neuroscience, 2end edition, Mass.sinauer Associates.
Thompson, R.F., 2000. The brain: a neuroscience primer, The 3rd edition, Worth Publishers.
Bloom, F.E., Nelson, C.A. 2001. Brain, Mind and behavior. The 3rd edition, Worth Publishers.

Course: Reproductive Neuroendocrinology
Number of credits: 2
Hours: 32
Type of credit: Theory
Type of course: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course objective

Version 1: Reproduction is one of the main biological process in living organisms that is complex. Advances in neuroscience, endocrinology and cellular and molecular biology provided us with valuable knowledge to better understand regulation of reproduction. Students get familiar with physiology of reproduction, one of the major biological process in the living os.
Version 2: Reproduction by which new individual organisms are produced from their parents is a complex biological process. Various neuroendocrine and endocrine neurotransmitters/hormones/peptides regulate sex differentiation, gonadal development, maturation of gametes and fertilization. This course undertakes molecular and cellular exploration of reproduction with emphasize on vertebrates.

Course syllabus

1) Pituitary growth and development and syndromes associated with pituitary disorders
2) Hypothalamus growth and development, GnRH system, hypophyseal portal system
3) Morphology of pituitary cells, hypothalamic organization, and GnRH-neuron distribution
4) Secretory functions of pituitary cells
5) The *hypothalamo-neurohypophysial system* (HNS), Oxytocin and Vasopressin, Methods to identify secretory neurons that produce oxytocin and vasopressin in paraventricular nucleus (PVN) and supraventricular nucleus (supraoptic nucleus), (SON)
6) Oxytocin and vasopressin membrane receptors, oxytocinergic and vasopressinergic neurons and their electrical properties
7) The relation between electrical activity and secretion/synchronization of oxytocinergic neurons **(**Synchronous Bursting of Oxytocin Neuronal)
8) The regulation of biosynthesis and secretion of pituitary gonadotropins, Biosynthesis of gonadotropines, Regulatory factors of LH, FSH and GnRH biosyntheses and secretions
9) The gonadal steroids, Intracellular signaling in regulation of biosynthesis and secretion of gonadotropins
10) The pulsatile secretion of gonadotropins, prolactin, growth hormone, and growth factor, Regualtion of pulsatile secretion of LH, Regulation of paired GnRH/LH secretion
11) The endogenous opioids and their receptors, Physiological functions of opioids
12) **Pituitary adenylate cyclase-activating polypeptide (**PACAP): Biosynthesis and secretion in supraoptic (SON) and paraventricular (PVN) nuclei
13) Growth hormone, Adrenomedullin, Neurophysins, Central nervous system and peripheral regulation of prolactin

Evaluation

Continuous Evaluation (Quiz)	Mid-Term Exam	Final Exam - Writing	Seminar
10%	-	70%	20%

References for additional reading

Strauss, J., Barbieri, R., 2004. Yen and Jaffe's Reproductive Endocrinology: Physiology, Pathophysiology and Clinical Management, 5th edition.

Course: Neurotransmitters and their Mechanisms
Number of credits: 2
Number of Hours: 32
Type of credit: Theory
Course Type: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course objective

To study metabolism, function and signaling of different brain neurotransmitters, their signaling and anatomophysiological pathways

Course syllabus

1) Acetylcholine: synthesis, storage, release and termination of action; different cholinergic receptors and their signaling pathways; cholinergic systems (anatomy, physiology and behavior)
2) Dopamine: synthesis, storage, release and termination of action; different dopaminergic receptors and their signaling pathways; dopaminergic systems (anatomy, physiology and behavior)
3) Noradrenalin (Norepinephrine): synthesis, storage, release and termination of action; different adrenergic receptors and their signaling pathways; noradrenergic systems (anatomy, physiology and behavior)
4) Serotonin: synthesis, storage, release and termination of action; different serotonergic receptors and their signaling pathways; serotonergic systems (anatomy, physiology and behavior)
5) Glutamate: synthesis, storage, release and termination of action; different glutamatergic receptors and their signaling pathways; glutamatergic systems (anatomy, physiology and behavior)
6) GABA: synthesis, storage, release and termination of action; different GABAergic receptors and their signaling pathways; GABAergic systems (anatomy, physiology and behavior)
7) Histamine: synthesis, storage, release and termination of action; different histaminergic receptors and their signaling; histaminergic systems (anatomy, physiology and behavior)
8) Neuropeptides: synthesis, storage, release and termination of action; different neuropeptide receptors and their signaling pathways; Neuropeptide systems (anatomy, physiology and behavior)
9) Other neurotransmitter systems such as nitric oxide, purines, eicosanoids: synthesis, storage, release and action termination; different receptors and their signaling pathways

Evaluation

Continuous Evaluation (Quiz)	Mid-Term Exam	Final Exam - Writing	Seminar
10%	-	70%	20%

References for additional reading

Bohlen und Halbach, O.V., Dermietzel, R., 2006. Neurotransmitters and Neuromodulators: Handbook of Receptors and Biological Effects. Wiley
Wang, Z., 2008. Molecular Mechanisms of Neurotransmitter Release. Humana Press.
Webster, R., 2001. Neurotransmitters, Drugs and Brain Function. Wiley
Kandel, E., Schwartz, J., Jessell, T., Siegelbaum, S., Hudspeth, A.J., 2012. Principles of Neural Science, Fifth Edition. McGraw Hill Professional

Course: Cell Receptors, Signaling and Transduction
Number of credits: 2
Hours: 32
Type of credit: Theory
Type of course: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course Objective

Advances in basic concepts of the cell receptors which direct cellular organization, coordination and function, provided students with valuable knowledge to better understand cellular mechanisms and regulations.

Course syllabus

1) General functions of signaling pathways- Pathway structure- Main mechanisms of cell to cell communications- Signal reception through receptors- Signal transduction components- Extracellular signaling molecules- Chemical nature of hormones- Hormone analogues and antagonists- Endocrine, paracrine and autocrine signaling through hormone receptors- Changes in the receptor and cellular responses of the target cell- Signal reinforcement
2) Regulation of signaling within and between cells- Function of lipid anchors- sSignaling via nuclear receptors- Modifications of the hormones in the target tissue- Nuclear receptors and their classification- Steroid hormone receptors and their binding sites- Suppression of transcription via steroid receptors
3) Signalling of retinoids, vitamins and T3 hormone- - signal transduction through G-protein-coupled receptors (GPR)-Intracellular activity of the receptors- Structure of transmembrane receptors (external, intramembrane and cytosolic parts)- Regulation of G-protein-coupled receptors Activity and desensitization of GPR receptors- GTPases and their family- Subfamily of Gγ- G-protein regulation- Phosphomyosin and RGS proteins- Gγ effector molecules- Adenylate cyclase structure- Phospholipase C, Cβ , Cγ
4) Intracellular messengers and their functions- Activation of cAMP,cGMP,inositol,calcium,DAG, iP3 and Ras pathways - Calcium as a second messenger molecule and its role in muscle contraction and vision- cell proliferation and the role of calmodulin and other calcium receptors in this process
5) NO as a signaling molecule- NO synthesis and function- Protein kinases and their classification- Protein kinase regulation- Calcium/calmodulin-dependent kinases
6) Signal transduction through tyrosine kinase receptors- Structure and function of tyrosine kinase receptors- Classification, activation, ligand structure, receptor oligomerizationand heterodimer formation of tyrosine kinase receptors.
7) Study of apoptosis in nematode C. elegans- Apoptosis components in mammals- Caspases and their activating cofactors- Bcl2 family- - Intracellular regulation of apoptosis via shock- Cytochrome c/Apaf pathway- Apoptosis and other signaling pathways

Evaluation

Continuous Evaluation (Quiz)	Mid-Term Exam	Final Exam-Writing	Seminar
10%	-	70%	20%

References for additional reading

Kraucss G., 2012. Biochemistry of signal transduction and regulation, 4th edition 2012, Wiley Co.
Lodish, H., et al., 2012. Biology of the cell, 7th edition, 2012, W.H. Freeman Co.
Becker Wayne, H., 2009. The world of the cell, 7th edition.

Course: Special Topics in Reproduction
Number of credits: 2
Hours: 32
Type of credit: Theory
Type of course: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course objective

To review and discuss recent highlighted studies or discoveries in reproductive biology which have not been though in the other animal physiology curriculum under undergraduate (B.Sc.) and postgraduate program (M.Sc.).

Course syllabus

1) GnRH functions in pituitary and peripheral tissues, GnRH isoforms, Identification and localization of GnRH receptors in peripheral reproductive tissues; Identification of GnRH receptors in the healthy and cancerous ovary, placenta, cancerous prostate and breast cells
2) GnRH1 and GnRH2 functions in cancerous cells: Effects on growth, angiogenesis, and metastasis
3) Intracellular GnRH signaling in pituitary cells, ovary, prostate, uterus, and breast cells with cancer
4) Steroid hormones, and sex steroid feedback regulation of GnRH release
5) Morphological sex differences in the central nervous system (CNS), Brain (Neural) mechanisms controlling sexual behavior
6) The effect of endogenous opioids, neuropeptide Y, oxytocin, inhibin, follistatin, somatostatin, and galanin on the hypothalamic–pituitary–gonadal axis
7) The effect of pituitary adenylate cyclase activating peptide (PACAP), neurophysin, prolaction and angiotensin II, indomethacin, endothelin, and Nitric oxide (NO) on hypothalamic–pituitary–gonadal axis
8) Prolactin and its physiological functions
9) Pineal gland, Structure and function of melatonin, The effects of melatonin on reproductive cycle

Evaluation

Continuous Evaluation (Quiz)	Mid-Term Exam	Final Exam - Writing	Seminar
10%	-	70%	20%

References for additional reading

Recent articles published in pee-reviewed journals

Course: Cardiovascular Physiology
Number of credits: 2
Hours: 32
Type of credit: Theory
Type of course: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course Objective

To study anatomy and physiology of heart and vasculature with focus on application of electrocardiography in heart diseases

Course syllabus

1) A review on invertebrate and vertebrate circulation and their difference
2) Comparing nodal tissue and ordinary myocardium regarding bioelectrical and biomechanical events, their ionic basis and membrane channels
3) Conduction and velocity of action potential in cardiac tissue
4) Electrocardiography and its basic applications
5) Physical properties of blood and comparing blood in different animals
6) Factors that stablish and change blood pressure, factors that change vessel diameter, comparing these factors in systemic and pulmonary circulations
7) Atherosclerosis and its physiologic and pathologic basis
8) Angiogenesis and factors that affect it
9) Capillary circulation, lymph formation and circulation and its return to blood
10) Cardiovascular shocks and their causes
11) Differences between pulmonary and systemic circulations
12) Fetus circulation and changes after birth
13) Seminar about new researches in cardiovascular physiology

Evaluation

Continuous Evaluation (Quiz)	Mid-Term Exam	Final Exam - Writing	Seminar
10%	-	70%	20%

References for additional reading

Moyes, C.D., Schulte, P.M., 2008. Principles of Animal Physiology, 2nd edition. Pearson/Benjamin Cummings
Vaz, M., Tony Raj, T., Anura, K., 2016. Guyton & Hall Textbook of Medical Physiology, 2nd edition. Elsevier India.
Mohrman, D.E., Heller, L.J., 2005. Cardiovascular physiology. Lange Medical Books/McGraw hill

Course: Comparative Neurophysiology
Number of credits: 2
Number of Hours: 32
Type of credit: Theory
Course Type: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course Objective

To study comparative anatomy and physiology of nervous systems including physiology of sensing in various animal classes ranging from invertebrates to vertebrates

Course syllabus

1) General properties of sensory systems and classification of the sensory receptors in animals
2) Encoding and processing of different stimuli in sensory systems
3) Neurophysiology of chemical senses in invertebrates and vertebrates (olfactory and gustatory systems)
4) Neurophysiology of mechanical senses in invertebrates and vertebrates (mechanoreception; i.e., touch, balance, hearing)
5) Neurophysiology of animal visual systems; eye anatomy and function in animals
6) Neurophysiology of the other senses (thermoception and magnetoreception) and cooperation with sensory systems in inducing circadian rhythms
7) Organization and evolution of the animal nervous systems
8) Comparative neuroanatomophysiology of the brain in invertebrates and vertebrates (size, structure and function)
9) Coordinated functions of the nervous system in animals
10) Comparative learning and memory processes in invertebrates and vertebrates

Evaluation

Continuous Evaluation (Quiz)	Mid-Term Exam	Final Exam - Writing	Seminar
10%	-	70%	20%

References for additional reading

Moyes, C.D., Schulte, P.M., 2008. Principles of Animal Physiology, 2nd edition. Pearson/Benjamin Cummings.
Butler, A.B., Hodos, W., 2005. Comparative Vertebrate Neuroanatomy: Evolution and Adaptation. John Wiley and Sons.
Kandel, E., Schwartz, J., Jessell, T., Siegelbaum, S., Hudspeth, A.J., 2012. Principles of Neural Science, 5th edition. McGraw Hill Professional.

Course: Cellular and Molecular Mechanisms of Cancer
Number of credits: 2
Hours: 32
Type of credit: Theory
Type of course: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course Objective

To study molecules and cells that are involved in cancer with the focus on major proteins and genes

Course syllabus

1) An introduction to cell transformation and formation of cancer cells-, Characteristics of colorectal cancer as an example
2) Molecular mechanisms of cell transition from epithelial to mesenchymal (EMT)
3) Intercellular adhesions and their correlation with cancer
4) Deregulation of G1 to S phase transition during cancer
5) Deregulation of G2 to M phase transition during cancer
6) Senescence of cancer cells
7) Apoptosis (programmed cell death) and its deregulation in cancer
8) Oncogenes and their activation mechanisms in cancer cells
9) Tumor suppressor genes and their inactivation mechanisms in cancer cells
10) Major signal transduction pathways and their deregulation during human cancers
11) Genetic instability in human
12) Cellular and molecular mechanisms of angiogenesis in tumors
13) Cellular and molecular mechanisms of metastasis
14) New methods in treating cancer

Evaluation

Continuous Evaluation (Quiz)	Mid-Term Exam	Final Exam - Writing	Seminar
10%	-	70%	20%

References for additional reading

Volgelstein, B., Kinzler, K.W., 2002. The Genetic Basis of Human Cancer, 2nd edition. Mc Graw Hill.
Recent Research and Review Articles published in peer-reviewed journals (Nature Reviews, Cancer, etc).

Course: Bioinformatics
Number of credits: 2
Hours: 32
Type of credit: Theory
Type of course: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course objective

To study and investigate bioinformatic methods

Course syllabus

1) Introduction: History and significance of bioinformatics
2) Databases including bibliographic databases, primary databases for protein sequence and nucleotide sequence, secondary databases such as Blocks and Prosite
3) Pairwise sequence alignment including scoring matrices
4) Global and local alignment
5) Multiple sequence alignment including scoring, and progressive and iterative alignment
6) Phylogenetic trees including space and maximum probability methods
7) Predicting secondary structure of RNA
8) Genomic analyses including gene prediction in prokaryotes and eukaryotes
9) Tumor prediction
10) Classifications of proteins, Prediction of spatial structures of proteins

Evaluation

Continuous Evaluation (Quiz)	Mid-Term Exam	Final Exam – Writing	Seminar
10%	-	70%	20%

References for additional reading

Mount, D.W., 2004. Bioinformatics. Cold Springer Harbor Laboratory Press.
Durbin, R., 1999. Biological Sequence Analysis. Cambridge University Press.
Attwood, T.K., 1999. Introduction to Bioinformatics. Longman.
Gu J., 2009. Structural Bioinformatics. Wiley-Blackwell.
Ignacimuthu, S., 2013. Basic Bioinformatics. Alpha Science International Limited.
Higgs, P.G., 2005. Bioinformatics and Molecular Evolution. Blackwell Publishing.
Lesk, A.M., 2014. Introduction to Bioinformatics. Cambridge University Press.

Course: Pharmacology
Number of credits: 2
Number of Hours: 32
Type of credit: Theory
Course Type: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course Objective

Pharmacology of drugs and signaling pathways in neuromuscular, cardiac and endocrine systems

Course syllabus

1) Introduction to pharmacology
2) Principles of pharmacokinetics
3) Principles of pharmacodynamics
4) Mechanisms of drug action and intracellular signaling pathways
5) Effective drugs on smooth muscle functions (1. histamine, serotonin)
6) Effective drugs on smooth muscle functions (2. nitric oxide, prostaglandins)
7) Pharmacology of autonomic nervous system (1. cholinergic and anticholinergic agents)
8) Pharmacology of autonomic nervous system (2. sympathomimetic agents and sympathetic antagonists)
9) Effective drugs on cardiovascular systems (1. blood pressure, arrhythmia)
10) Effective drugs on cardiovascular system (2. congestive heart failure, angina pectoris)
11) Pharmacology of drugs that interfere with sodium channels (muscle relaxants, local anesthetics)
12) Pharmacology of somniferous and sedative drugs
13) Pharmacology of opioidergic drugs with analgesic effects
14) Pharmacology of antidepressant and antipsychotic drugs
15) Pharmacology of anticonvulsive drugs
16) Pharmacology of hypothalamus and pituitary hormones
17) Pharmacology of adrenal cortex hormones

Evaluation

Continuous Evaluation (Quiz)	Mid-Term Exam	Final Exam - Writing	Seminar
10%	-	70%	20%

References for additional reading

Katzung, B.G., 2012. Basic and Clinical Pharmacology. 12th edition.

Course Name: Physiological Adaptation to the Environment
Number of credits: 2
Number of Hours: 32
Type of credit: Theory
Course Type: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course Objective

To study various homeostatic mechanisms in vertebrates and invertebrates

Course syllabus

1) Definition of adaptation, Adaptation in molecular and genomic scale, Comparative methods to detect adaptations
2) Protein evolution, Principles of similarity, Allometric and isometric measurements, Metabolism and adaptation, Body size and adaptation
3) Water properties and factors that affect fresh and salty water characteristics, The effects of atmosphere on water, sound in water, light in water, The effect of biological factors on water properties, The effects of physical factors on earth environment, sound in the air, light in the air.
4) Aquatic animals: Morphological properties, motion, respiratory organ and gas exchange, excretory organs and excreted substance, reproduction, weightlessness, balance
5) Terrestrial animals: Earth gravity and the problem of animal weight, body size (compared to marine animals), quadrupedalism, balance, mechanisms that prevent body water loss, causes of difference and similarity in form and movement
6) Various types of respiratory organs and gas exchange, excretory organ and excreted substance, reproduction, hibernation, aestivation
7) Endothermic and exothermic animals, energy and metabolism, keeping balance and controlling body temperature in marine and terrestrial animals
8) Extreme adaptation such as polar regions and deep ocean hot water springs
9) Digestion, Mechanisms of food intake and diversity, Adaptations in digestive tract, Digestive enzymes and food type
10) Nervous systems, cephalization, Brain evolution and behavior complexity
11) Internal and external life adaptations
12) Endocrine glands and environment adaptation ability
13) Seminar in the area of environmental adaptation

Evaluation

Continuous Evaluation	Mid-Term Exam	Final Exam - Writing	Seminar
10%	-	70%	20%

References for additional reading

Willer, P., Stone, G., Johnston, I., 2005. Environmental physiology of animals. Blackwell.
Nybakken, J.W., 2001.Marine biology, an ecological approach. Benjamin Cummings.
Louw, G.,1993. Physiological animal ecology. Longman Scientific and Technical publishing Co.

Course: Electrophysiology
Number of credits: 2
Number of Hours: 32
Unit Type: Theoretical
Course Type: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course Objective

To study different research methods in electrophysiology and evoked potentials as well as application of electrophysiology in different neuromuscular diseases

Course syllabus

1) Definition of electrophysiology and its history from experiments of Galvani to Volta and experimental studies of 20th century
2) Research methods in electrophysiology, excitation measurement techniques, recording and measurements, electrodes and microelectrodes, stimulators and biological sensors, oscilloscope fundamentals and applications
3) Resting potential and its establishment in excitable muscle and nerve cells, diffusion potential, equilibrium potential for one ion and multiple ions, voltage-gated membrane channels (i.e., sodium, potassium, calcium and chloride ions channels).
4) Action potential and excitation laws, the relation between stimulation intensity and duration, ion transmissions during action potential, delay time, wavelength, refractory period, all or none law
5) Electrophysiology of subthreshold stimuli, electrotonic potentials in excitable neuromuscular membranes
6) Excitatory and inhibitory postsynaptic potentials (IPSP and EPSP), synaptic convergence and divergence, bioelectric phenomena of excitatory and inhibitory chemical synapses and electrical synapses
7) Electrophysiology of compound action potentials, recording nerve potential and nerve potential propagation as well as its implication in characterizing nerve fibers
8) Electroencephalography (EEG) and electrocorticography, definitions, recording methods and interpretation of EEG rhythms
9) Application of EEG in studying consciousness level, sleep and wakefulness, REM and NREM sleep stages
10) Application off EEG in neural and mental diseases, drug-induced anesthesia and brain death
11) Evoked potentials and related techniques in neuroscience
12) Electrophysiology of smooth and striated muscle fibers, electromyography and its applications
13) Potential of motor-end plate, recording and applications, disruption of excitation transfer from nerve to muscle
14) Seminar on current research subjects and new trends in electrophysiology

Evaluation

Continuous Evaluation (Quiz)	Mid-Term Exam	Final Exam - Writing	Seminar
10%	-	70%	20%

References for additional reading

Steinberg, J.S., Mittal, S., 2010. Electrophysiology. Lippincott Williams & Wilkins.
Kandel, E., Schwartz, J., Jessell, T., Siegelbaum, S., Hudspeth, A.J., 2012. Principles of Neural Science, 5th Edition. McGraw Hill Professional

Cours: Physiology of Animal Microorganisms
Number of credits: 2
Number of Hours: 32
Type of credit: Theory
Course Type: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course objective

To study the physiological signaling in protozoan organisms, and biotechnology and genetic engineering in microorganisms

Course syllabus

1) General principles of structure and physiology of protozoa components
2) Membrane physiology in protozoa, Identification of signal molecules and signaling mechanisms in protozoa
3) Physiology of nutrition, Feeding (food absorption) and metabolic mechanisms, Identification of factors affecting nutrition such as temperature, humidity, light, environmental compounds, other creatures
4) Physiology of growth, Studying factors that affect and regulate growth
5) Physiology of reproduction in animal microorganisms, comparative physiology of sexual and asexual reproduction
6) Physiology of respiration, aerobic and anaerobic processes
7) Physiology of movement, mechanisms of movement processes
8) Physiology of adaptation, processes that cause adaptation and equilibrium in response to biotic and abiotic changes
9) Symbiosis in protozoa: Mutualism, parasitism, and amensalism, …
10) Relation between predator and prey in the world of protozoa
11) Protozoa as models to study higher animals
12) A glance to biotechnology and genetic engineering of protozoa

Evaluation

Continuous Evaluation (quiz)	Mid-Term Exam	Final Exam - Writing	Seminar
10%	-	70%	20%

References for additional reading

Laybourn-Parry, J., 2001. A functional Biology of Free-Living Protozoa Croom Helm, London, Sydney
Csaba, G., Müller, W.E.G., 2011. Signaling Mechanisms in Protozoa and Invertebrates
Calkins, G.N., 2007. Protozoa Morphology & Physiology. Springer

Course: Neuroanatomy
Number of credits: 2
Number of Hours: 32
Type of credit: Theory
Course Type: Required

Pre-requisite: No	Supplementary training: Yes	Educational Expedition: No
Workshop: No	Laboratory: No	Seminar: Yes

Course Objective

To study the anatomy of central and peripheral nervous systems, connections of different parts of brain with each other and their interactions

Course syllabus

1) An introduction to anatomy and anatomical techniques
2) Neuronal arrangement in the central and peripheral nervous systems
3) Sensory receptors and neuromuscular junctions
4) Internal anatomy of spinal cord and the spinal pathways
5) Description of brainstem (the medulla oblongata, the pons, nuclei of brainstem and the midbrain), connections of red nuclei, reticular formations of midbrain
6) Structure of the cerebellum, cerebellar divisions, cerebellar peduncles and structure of cerebellar cortex, connections and pathways of cerebellum with the other brain regions
7) Olfactory regions and the limbic system
8) Brain hemispheres, external and internal surface of brain hemispheres, functional areas of the cerebral cortex
9) Nuclei of cranial nerves, the somatic/visceral afferent and efferent nuclei, functional components of each cranial nerve
10) Diencephalon, the dorsal/ventral thalamus, its nuclei and connections with other brain regions, the hypothalamus, its nuclei and connections, the epithalamus
11) The basal ganglia and their connections
12) The internal capsule, brain commissures, brain ventricles
13) Autonomic nervous system

Evaluation

Continuous Evaluation (Quiz)	Mid-Term Exam	Final Exam - Writing	Seminar
10%	-	70%	20%

References for additional reading

Singh, I., 2006. Textbook of Human Neuroanatomy. Jaypee Brothers Publishers
Patestas, M.A., Gartner, L.P., 2011. A Textbook of Neuroanatomy. Blackwell publishing
Crossman, A.R., Neary, D., 2011. Neuroanatomy: An Illustrated Colour Text. Churchhill Livingstone