SOPHIA COLLEGE

(AUTONOMOUS)

Affiliated to the University of Mumbai

Syllabus for Semesters III to IV

Program: M.Sc.

Course: Life Sciences

(Choice Based Credit System with effect from the year 2021-2022)

PREAMBLE

The syllabus for the second year of M.Sc has been designed as a specialization in Neurobiology that introduces the students to the subject beginning from the basics, through structural and functional aspects and building up to understanding brain and behavior.

Each paper has a unit that describes relevant techniques applied in Neurobiology, in diagnosis and therapy.

The course also elaborates on the development and the complex functioning and behavior of the nervous system in health and disease.

This course would also enable the students enhance their ability to think logically, analyze the information and help in problem solving skills in research work.

M.Sc. Part II Life Sciences Syllabus

Choice based Credit and Grading System
Academic year 2021 - 22

SEMESTER III

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	LECTURES
Paper I	**Cellular Organization of the Nervous System**			
SMSLSC301	**1**	History of Neuroscience Nervous system: Overview and EvolutionaryPerspective	**4**	**15**
	2	Neuron and Glia: Structure, Functional features and electrical properties.		**15**
	3	Synaptic Transmission.		**15**
	4	Electrophysiological techniques and Computational Neuroscience		**15**
SMSLSCP301	Practical		**2**	
Paper II	**Organization and functional modification of the nervous system**			
SMSLSC302	**1**	Nerve and Muscle physiology	**4**	**15**
	2	Neuroimmunology		**15**
	3	Gut microbiome and nervous system		**15**
	4	Advanced Neurogenetics, imaging techniques Advanced Biostatistics		**15**
SMSLSCP302	Practical		**2**	
Paper III	**Systems approach to Neurosciences I**			
SMSLSC303	**1**	Anatomical and Functional organization of the CNS	**4**	**15**
	2	Anatomical and functional organization of the PNS		**15**
	3	Autonomic/ Enteric Nervous system Implications of pathogenic diseases		**15**
	4	Neuroimaging Technique		**15**
SMSLSCP303	Practical		**2**	
Paper IV	**Systems approach to Neurosciences II**			
SMSLSC304	**1**	Sensory system I	**4**	**15**
	2	Sensory system II		**15**
	3	Motor System		**15**
	4	IPR & Neuroethics		**15**
SMSLSCP304	Practical		**2**	

SEMESTER IV

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	LECTURES
Paper I	**Developmental Neurobiology**			
SMSLSC401	1	Developmental Neurobiology	**4**	**15**
	2	Axon Guidance and Synapse formation		**15**
	3	The Altered Brain		**15**
	4	Developmental disorders and genetic diseases		**15**
SMSLSCP401	Practical		**2**	
Paper II	**Behavioral Neurobiology I**			
SMSLSC402	1	Brain and Behaviour	**4**	**15**
	2	Cognitive development and Behavioral Disorders		**15**
	3	Emotion		**15**
	4	Sleep and Dreams, Consciousness		**15**
SMSLSCP402	Practical		**2**	
Paper III	**Behavioral Neurobiology II**			
SMSLSC403	1	Learning and Memory- I	**4**	**15**
	2	Learning and Memory- II		**15**
	3	Language and speech		**15**
	4	Neuroeconomics and Neuromarketing		**15**
SMSLSCP403	Practical		**2**	
Paper IV	**Molecular Neurobiology and Disease pathology**			
SMSLSC404	1	Neurotoxicology and Neuropharmacology	**4**	**15**
	2	Neurodegenerative diseases		**15**
	3	Recent Techniques in Experimental Neurosciences		**15**
	4	Bioinformatics: Drug Discovery		**15**
SMSLSCP404	Practical		**2**	

SEMESTER III

COURSE CODE: SMSLSC301

PAPER –I CELLULAR ORGANIZATION OF THE NERVOUS SYSTEM

Course Objectives:

CO1: To introduce students to neuroscience by giving them a historical perspective and dawn of neuroscience

CO2: Introduction to primitive nervous system and basic plan of vertebrate nervous system

CO3: Introduction to the structural and functional features of Neuron and Glia

CO4: Introduction to types of synapses, neurotransmitters and their functional localization and introduction to different electrophysiological techniques and computational neuroscience

Learning outcomes:

The student will be able to

LO1: differentiate between Mind and brain, between the primitive nervous system and Cephalization in Molluscs

LO2: catagorize between types of neurons, types of glia and their function in addition they will also learn about electrical properties of the neuron

LO3: compare between the different types of synapse and neurotransmitters

LO4: differentiate between electrophysiological techniques like Patch clamp and Voltage clamp

Course code	Unit	Topic headings	Credits	Lectures
SMSLSCP301	**1**	**History of Neuroscience Nervous system: Overview and Evolutionary Perspective** **A. History ofNeuroscience** Major issues that have shaped neuroscience studies – Mind vs. Brain debate, Localism vs. Holism debate, Nature of neural communication and plasticity of adult brain. **B. An overview of the nervous system with an evolutionary perspective** 1. Primitive Nervous systems-Nerve net of hydra, segmental ganglia of worms, segmental networks of lamprey 2. Cephalization in molluscs and lateralization in arthropods – Early brain structural areas in (proto, deutero and trito cerebrum) and segmental ganglionated nerve cords citing suitable examples. Basic plan of the vertebrate nervous system.	**4**	**15** 5 3 7
SMSLSCP301	**2**	**Neurons and Glia: Structural and Functional features** **A. Neurons and Glia: Structure andfunction** 1. Structural and functional diversity of neurons - Types ofneuronsbased on their structure andfunction 2. Neurons - General morphology of a typical neuron stressing on features relevant to their function – membrane receptors, ion channels, ion pumps, Significance of axon initialsegment 3. Cytoskeletal elements and 'molecular motors' and role in axonaltransport 4. Types of glia based on their structure and function – Astrocytes,Oligodendrocytes,	**4**	**15** 2 3 2 2

		Microglia and Schwann cells and their functions **B. Electrical properties of the neuron: Signal generation and Propagation.** 1. Ion distribution and Resting membrane potential. Nernst and Goldmanequation. 2. Ionic permeability changes and Action potential and its propagation along the axon 3. Structure and function of ion channel – sodium, potassium, calcium,chloride.		 2 2 2
SMSLSCP301	**3**	**Synaptic Transmission and Neurotransmitters.** A. **Types of synapses** – electrical &chemical 1. Electrical synapse – Structure and properties 2. Chemical Synapse: Neurotransmitter release from presynaptic terminal: Depolarization of presynaptic terminal, calcium influx, Neurotransmitter discharge by vesicle, exocytosis, and synaptic vesiclerecycling. 3. Post Synaptic receptors: General structure and mechanism of action of Ionotropic and G-protein coupled receptors. Common motif (seven transmembrane molecules) in receptors of different sensory systems, signal transduction and second messenger systems. 4. Synaptic integration in the CNS-Excitatory and Inhibitory synapses **B. Neurotransmitters:Biochemistry and functionallocalization** 5. Neurotransmitters: Structure, distribution, metabolism, typesof receptors, agonist and antagonists, molecular mechanisms of action Acetylcholine, biogenic amines, catecholamines, serotonin, amino acids, Neuroactive peptides as transmitters.	**4**	**15** 1 2 3 1 5

SMSLSCP301	**4**	**Electrophysiological techniques and ComputationalNeuroscience** **A. Electrical properties of the neuron–signal generation andpropagation** 1. Ionic concentrations, Donnan's equilibrium, equilibriumpotential, 2. Nernst equation, Goldman-Hodgkin-Katz equation, Resting membrane potential, Depolarization and hyperpolarization. 3. Electrophysiological techniques to understandtheelectricalpropertiesofthe neuron – Patch-clamp and Voltage-clamp. 4. Perforated whole-cell patch clamp recording. Single cell electrophysiological recordings Calcium imaging, Two-photon microscopy for imaging neurons. 5. Immunopanning techniques for astrocytes. **B. Computational Neurosciences** 1. Introduction, historical perspective and goals: Origin and scope of thefield 2. Computational Neurosciences,Modeling the neuron components - variables and parameters, use of differential equations and matrices, components of membrane, electric circuits, Concept of Realisticand simplified brain models 3. Application of biological principles to artificial circuits: Hodgkin-Huxley model and GHKequation	**4**	**15** 1 2 2 1 1 2 4 2

COURSE CODE: SMSLSC302

PAPER –II ORGANISATION AND FUNCTIONAL MODIFICATION OF THENERVOUS SYSTEM

Course Objectives:

CO1: To introduce the basics of nerve and muscle physiology

CO2: To introduce the basics of Neural – Immune interactions and Clinical implications of neural – immune signaling

CO3: To introduce the basics of gut microbiome and nervous system.

CO4: To introduce the fundamentals of the tools related advanced neurogenetics and imaging techniques

Learning outcomes:

The students will be able to

LO1: interpret the mechanism of signal transmission at the neuromuscular junction and muscle contraction

LO2: understand the correlation between nervous and immune system, its effect on behavior & clinical implication

LO3: comprehend the effect of the gut microbiome on the nervous system and neurodegenerative diseases

LO4: learn the fundamentals of advanced techniques in Neurogenetics and Imaging

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC302	**1**	**Nerve and Muscle** **A. Nerve and muscle:** 1. Types of muscles 2. Muscle -structure and physiology of contraction. 3. Chemical transmission at the neuromuscular junction 4. Blocking by Neurotoxins e.g. Tetanus **B. Diseases of nerve and muscle:** 1. Muscular dystrophies 2. Myasthenia gravis. **C. Repair and Regeneration of the Damaged Brain** 1. Axon degeneration and its effects 2. Differential regenerative capacity of CNS and PNS 3. Therapeutic interventions to promote regeneration of CNS axons 4. Role of neural stem cells in regeneration	**4**	**15** 1 1 2 1 1 1 2 2 2 2
SMSLSC302	**2**	**Neuroimmunology** **A. Maternal immune system andNeural development** **B. Neural – Immune interactions** 1. Result of local tissue barriers – blood brain barrier 2. Result of immunosuppressive microenvironment –cytokines 3. Neural communication to the Immune system and influence of neuroendocrine hormones 4. Immune system communication with the nervous system **C. Clinical implications of neural – immune signalling** 1. Immunodeficiency disease –HIV 2. Autoimmune disease – Multiple Sclerosis and Guillain – Barre Syndrome **D. Behavioural Neuroimmunology** 1. Stress and Immunity 2. Mechanisms and moderators of stress-immune link		 2 2 2 2 1 2 2 2

SMSLSC302	**3**	**Gut microbiome and nervous system**. 1. Introduction to the (gut)microbiome 2. Studying the microbiome 3. Communication between the gut microbiome and brain 4. Microbiome in neurodevelopment 5. Role of microbiome in neuropsychological ldisorders 6. Role of microbiome in neurodegenerative disorders 7. Factors that affect / alter the microbiome	**4**	**15** 1 2 3 2 2 3 2
SMSLSC302	**4**	**Advanced Neurogenetics, imaging Techniques and AdvancedBiostatistics** **A. Advanced Neurogenetics and imaging techniques** 1. Brainbowtechnique 2. Connectomics 3. Brain machineinterface 4. Blue brain project **B. AdvancedBiostatistics** Non parametric tests: 1. Median and Interquartile range 2. Spearman Rank Correlation 3. Mann Whitney Utest 4. Wilcoxon signed rank test 5. Kruskal Wallis Htest 6. Concept of logistic regression &ROC curves.	**4**	**15** 1 1 1 1 1 2 2 2 2 2

COURSE CODE: SMSLSC303

PAPER –III SYSTEMS APPROACH TO NEUROSCIENCES I

Course Objectives:

CO 1 To enable the understanding of anatomical and functional organization of the nervous system

CO 2 To demonstrate the comprehensive information about the structure, organizations and functional connectivity of the CNS and PNS.

Learning outcomes:

The student will be able to

LO 1 categorize the autonomic and enteric nervous system and also with the integration of autonomic and endocrine functions with behavior.

LO 2 further the implications of pathogenic diseases along with the neuroimaging techniques.

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC303	**1**	**Anatomical and Functional Organization of the CNS:** 1. Major divisions of Nervous System–Spinal cord, Medulla, Pons and Brain stem, Midbrain, Cerebellum, Diencephalon, Cerebral Hemispheres. 2. Orientation of the above components in the CNS with respect to three axes. 3. Gross anatomy of the brain with reference to functional organization -major nuclei and functional pathways. 4. Cranial nerves, their origin and innervations 5. Theventricularsysteminthebrain-CSF,its flow and the blood brainbarrier.	**4**	**15** 3 2 3 3 4
SMSLSC303	**2**	**Anatomical and functional organization of the PNS:** 1. Gross anatomy of the spinal cord: Ascending, descending and propriospinal functional pathways. 2. Cervical, thoracic, lumbar and sacral regions of the spinal cord. 3. Dorsal root ganglion and spinal nerve roots and their distribution, spinal effector mechanism. 4. Spinal muscular dystrophy. 5. Heritable spinocerebellar ataxia.	**4**	**15** 4 4 3 2 2
SMSLSC303	**3**	**Autonomic/ Enteric Nervous system** 1. Sympathetic pathways and thoracolumbar outputs 2. Parasympathetic pathways and outputs from the brainstem nuclei and sacral spinalcord. 3. Enteric nervous system. 4. Integration of autonomic and endocrine functions with behaviour. Role of hypothalamus. Brain stemanatomy 5. Implications of pathogenic diseases. For e.g.: Diabetes and autonomicneuropathy	**4**	**15** 4 2 2 4 3

SMSLSC303	**4**	**Neuroimaging Technique:** **A. Study of functional anatomy: Recording and Imaging techniques andtrends** 1. Single cell recording Electroencephalic Recording, Event-Related potential,MEG 2. Dynamic Brain Imaging: PET, MRI, fMRI X-ray Imaging: Computerized Axial Tomography, Diffusion-Tensor MR Imaging and Tractography: Exploring Brain Microstructure and Connectivity **B. Advanced techniques applied to Neuroscience** Visualizing Nervous system structure and function: Introduction to FRET, FRAP and Optogenetics, Chemogenetics.	**4**	**15** 5 5 5

COURSE CODE: SMSLSC304

PAPER –IV SYSTEMS APPROACH TO NEUROSCIENCES II

Course Objectives:

CO1: To introduce the students to process behind Sensory detection and encoding of neural signaling.

CO2: To introduce the conscious perception and awareness with respect to neural signaling processing

CO3: Understand Ethical, legal, social impact of imaging techniques and use of cognitive enhancers.

Learning outcomes:

The student will be able to

LO1: delineate the process and mode of transduction of sensory stimulus, their detection, and encoding of neural signaling pathway.

LO2: explain structural features of muscle, transmission of nerve signal leading to muscle contraction, displacement and movement.

LO3: inculcate the ethical, legal, social impact of imaging techniques and use of cognitive enhancers

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC304	**1**	**Sensory system I:** 1. Introduction - sensory systems, and mediation of 4 attributes of a stimulus a) Modality, b) Location, c)Intensity, d) Timing. 2. Common plan of sensory system. General idea of a receptor and transduction of specific types of energy into electrical signals. **B. Visual system:** 1. Vertebrate eye and retina. Morphology and arrangement of photoreceptors. 2. Electrical response to light. Concept of receptive fields. 3. Color vision 4. Visual pathway, lateral geniculate nucleus and visual cortex 5. Visual perception as a creative process. 6. Perception of motion, depth, form and color. 7. Visual attention and conscious awareness.	**4**	**15** 2 3 3 1 1 2 1 1 1
SMSLSC304	**2**	**Sensory system II:** **A. Auditory system:** 1. Functional anatomy of ear and cochlea. 2. Cochlear hair cells and perception of stimulus (frequency and intensity). 3. Mechano-electrical transduction hair cells. 4. Adaptation to sustained stimuli 5. Role of brainstem nuclei, processing of auditory information in the cerebral cortex. 6. Vestibular system and perception of posture and movement. **B. Olfactory system:** 1. Structure of olfactory epithelium and odorant receptors. 2. Role of nasal olfactory neuron in odour detection 3. Olfactory signal transduction. 4. Spatial encoding of odorant information in the olfactory bulb. Processing of olfactory information in the cerebral cortex. **C. Gustatory system:**	**4**	**15** 1 1 1 1 1 1 1 1 1 1 1 1

		1. Taste buds and their localization in various types of papillae found in human tongue. 2. Taste cell: transduction of 4 basic stimuli into electrical signal Pathways to the CNS. **D. Somatosensory system:** 1. Touch and mediation by mechanoreceptors in skin. 2. Warmth and cold mediation by thermal receptors. Pain mediation by nociceptors. Role of spinal cord and cerebral cortexin somatosensation.		1 1 1
SMSLSC304	**3**	**Motor System:** 1. General introduction to motor system. 2. Reflex and contractions. Rhythmic movements produced by stereotype muscle. Voluntary movements 3. Motor circuits in spinal cord, brain stern, and forebrain 4. Influence of basal ganglia and cerebellum on cortical and brain motor mechanisms. 5. Motor function of the brain stem, vestibular apparatus and equilibrium 6. Motor functions of the spinal cord-reflexes 7. Diseases of the Nervous System – Parkinson's Disease	**4**	**15** 1 3 2 2 2 2 3
SMSLSC304	**4**	**Bioethics** 1. Bioethics: Definition – moral, values, ethics and ethics in biology; Role and importance of ethics in biology; 2. Basic Approaches to Ethics; Post humanism and Anti-Post humanism; 3. Bioethics in healthcare, agriculture, modern biology, biotechnology, animal welfare & right / animals in research, wildlife conservation and management, commercialism in scientific research 4. Bioethics and cross-cultural bioethics – Autonomy, Rights, Beneficence, Do No Harm, Justice, Confidentiality, Animal Rights, Environmental ethics, Mixed Perception of Benefit & Risk, 5. Reasoning behind Acceptance or Rejection of Genetic Manipulation, Concerns about Consuming products of GMOsPast and Present 'Bioethical Conflicts' in Biotechnology-Interference with Nature, Fear of unknown, Regulatory concerns, Human misuse 6. Introduction to IPR; Types of Intellectual property – Patents, Trademarks, Copyrights and related rights.	**4**	**15** 2 1 3 3 3 3

SEMESTER III

PRACTICAL

Course Code: SMSLSCP301

1. Study of cells of the nervous system using electronmicrographs
2. Study of permanent slides of histology of nervoussystem
3. Silver staining of neuronal cell / tissue using a suitablesource eg. sensillae of Drosophila.
4. Whole mount of neurons of invertebrates using a suitable source.
5. Whole mount of vertebrate medullary fibres using a suitablesource.
6. Preparation of permanent slides and submission of two slides: a) Forebrain, b) midbrain, c) hindbrain, d) invertebratebrain.
7. Temporary mount of vertebratemuscle
8. Study of The Invertebrate Nervous System (Earthworm/crab)

Course Code: SMSLSCP302

9. NEURON Coding Exercises for Resting Membrane Potential, Action Potential, Propagation of Impulse, Synaptictransmission
10. Functional physiology using Biopac – EEG(Electroencephalogram)
11. Functional physiology using Biopac –GSR (Galvanic skinresponse)
12. Functional physiology using Biopac –ECG(Electrocardiogram),
13. Functional physiology using Biopac –EOG (Electro-occulogram)
14. Demonstration of EMG measurement usingBioPac

Course Code: SMSLSCP303

15. Haematoxylin and eosin staining of neuronal / glial culturedcells.
16. Biochemical estimations / Histochemical localizations in braintissue:
    i. Na^+/K^+-ATPase
    ii. AChE
    iii. NOS
17. TLC to separate brain phospholipids using day 3, day 6 and adult chickbrain.
18. To prepare a smear of retinal neurons from Avian eye and to observe retinal morphology of developingeye.
19. One day visit to a Neuropathology teachingCentre
20. Interpretation of FMRI/FRET /FRAPimages

Course Code: SMSLSCP304

21. Anatomy of the chick brain –display of ventral and dorsal view
22. Gross anatomy of the mammalian brain using brain atlas – goat /sheep
23. Localization of grey and white matter of mammalian brain using Mulligan'sstaining
24. Human brain anatomy using virtual anatomy software
25. Human Spinal cord and PNS anatomy using virtual anatomy software
26. Protocol using a mouse model system brain to observe hippocampus
27. Case study on Neuroethics
28. Molecular basis of taste detection/ receptor mechanism

SEMESTER IV

COURSE CODE: SMSLSC401

PAPER –I DEVELOPMENT NEUROBIOLOGY

Course Objectives:

CO1: To enable understanding of the various processes involved in development of a functional nervous system

CO2: Introduction to disorders and genetic diseases associated with the developing brain

CO3: Understand Sexual Differentiation of the Nervous System

CO4: Introduction to Aging of the brain and its associated diseases

Learning objectives

The student will be able to

LO1: gain insights into Axis formation and Neural Induction

LO2: learn about Axon guidance and synapse formation

LO3: know the details of the developmental disorders and genetic diseases associated to the brain

LO4: gain knowledge about role of genes and hormones in determination of physical differences and generation of sexually dimorphic behavior

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC401	**1**	**Developmental Neurobiology** **A. Early Development and Patterning of CNS** 1. Axis formation (anterior-posterior and dorso-ventral axis) – role of Hoxgenes, 2. Neural Induction – neural tube regionalization **B. Cellular Determination and Differentiation** 1. Neuronal progenitors – proneural and neural genes 2. Generation of neurons and glia (asymmetric divisions) 3. Neuronal migration and organization of cerebral cortex – role of Radial Glial cells 4. Target selection, survival of neurons and their regulation by neurotrophic factors 5. Role of apoptosis in development	**4**	**15** 2 2 2 2 2 2 3
SMSLSC401	**2**	**Axon Guidance and Synapse formation** **A. Growth cones and axonal path finding** 1. Differences between early development of axons and dendrites. Growth cone structure and formation 2. Guidance cues in axonal path finding **B. Formation and Elimination of Synapses** 1. Principles of synaptic differentiation(with neuromuscular junction as an example) 2. Synapse formation in the CNS 3. Refinement & elimination of synaptic connections **C. Early Experience and Critical Periods** 1. Effect of visual experience on refinement of cortical connections, Critical periods of brain Development 2. Effect of early social deprivation on brain and behaviour	**4**	**15** 2 2 2 2 1 3 3

SMSLSC401	**3**	**Developmental disorders and genetic diseases:** 1. Autism spectrum disorders(Asperger's Syndrome) 2. Attention Deficit Hyperactivity Disorder (ADHD), Microcephaly, Hydrocephaly 3. Down'ssyndrome 4. Fragile Xsyndrome 5. Spinabifida	**4**	**15** 3 6 2 2 2
SMSLSC401	**4**	**The Altered Brain** **A. Sexual Differentiation of the Nervous System** a. Role of genes and hormones in determination of physical differences Generation of sexually dimorphic behavior b. Role of environmental cues in sexually dimorphic behavior **B. The Ageing Brain** a. Changes in structure and function of brain with age Cognitive decline in diseases – Dementia and Alzheimer's	**4**	**15** 5 3 3 4

COURSE CODE: SMSLSC402

PAPER –II BEHAVIOURAL NEUROBIOLOGY

Course Objectives:

CO1: Introduce to brain and behavior

CO2: Familiarize the students with Cognitive development and associated Behavioral Disorders

CO3: Familiarize the students with terms related to emotions, sleep and dreams, and Consciousness

Learning objectives

The student will be able to

LO1: develop the knowledge about the Brain and behavior, connections established between the physiology and functions of the brain to the activities.

LO2: inculcate the insight about the cognitive and emotional aspects of the brain.

LO3: learn about the diseases associated with the behavioral disorders and neurological correlates of sleep**.**

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC402	**1**	**Brain and Behavior:** **A. Introduction to behavior** 1. Types of behavior 2. Behavior in nature and under laboratory conditions. 3. Development of behavioral paradigms - Invertebrate and vertebrate model system. **B. Evolution of brain and behaviour** 1. Brain- like function in unicellular organisms. 2. Nerve nets, invertebrate nervous system and types of behaviour. **C. Evolution of social behaviour**-language (FOXP2 gene), mirror neurons their role and association with brain throughout evolution.	**4**	**15** 1 2 3 2 3 4
SMSLSC402	**2**	**Cognitive development and Behavioral Disorders** **A. Cognitive development:** 1. Approaches to development of Cognition-Behavioral-basic mechanisms of learning Psychometric – Developmental and intelligence testing Piagetian stages of development 2. Cognitive Neuroscienc eapproach 3. Perspectives on adult development: 4. Beyond Piaget- the shift to post formal thought. 5. Life span model of cognitive development 6. Emotional intelligence 7. Moral Development – Kohlberg's theory. Gender and moral development **B. Behavioral disorders and therapies** Disorders of thought and volition: Schizophrenia- diagnosis, genetic and	**4**	**15** 2 1 1 1 1 1 4
		non-genetic risk factors, neuro anatomic abnormalities, therapy 2. Disorders of mood and anxiety- diagnosis, genetic and non-genetic risk factors, neuro anatomic abnormalities, psychotherapy Personality disorders- diagnostic features of personality disorders.		4

SMSLSC402	**3**	**Emotions** **A. Neuroscience of Emotions** 1. An overview of theories of Emotions. Dimensions of Emotion 2. Emotional Arousal and Memory 3. Anatomy of an Emotional memory 4. Amygdala and Emotional experiences 5. Emotional Regulation/Self-regulation. **B. The Nucleus of Accumbens** 6. An integration centre for cognitive and behavioural functions. 7. Neuropathological Mechanisms underlying Drug addiction (Glutamate signaltransduction) 8. Pharmacological Inhibition of Drug seeking behaviour.(Manipulation of glutamate systems)	**4**	**15** 1 1 1 1 1 3 3 4
SMSLSC402	**4**	**Sleep and Dreams, Consciousness** **A. Sleep and Dreaming:** 1. Circadian rhythms in the animal world 2. Neurological correlates of sleep- EEG, EOG and EMG, Rapid eye movement – REM sleep. Normal sleep cycle. Differences between REM and non-REM Evolution /need of REM in mammals 3. Hypothalamic control of sleep cycle **B. Neuroscience of Consciousness** 1. Consciousness in other species, Arousal &consciousness, 2. Neural correlates of perception and consciousness; freewill 3. Contemporary model for consciousness	**4**	**15** 2 4 2 3 2 2

COURSE CODE: SMSLSC403

PAPER –III BEHAVIOURAL NEUROSCIENCES II

Course Objectives:

CO 1 To classify types of learning, the processes, including information encoding, storing, and retrieval.

CO 2 To define learning and memory processes at cellular and molecular level.

CO 3 To demonstrate the manner of complex language processing.

Learning objectives

The student will be able to

LO 1 analyze the neural pathways leading to the ability of encoding ideas into signals.

LO 2 enable the learner to understand the theory of human decision making as the course includes an interdisciplinary topic of economics, psychology and neuroscience

LO 3 able to apply neuroscience to marketing, use of imaging technology and to understand consumer behavior.

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC403	**1**	**Learning and Memory-I** 1. Definition and types / classification of learning and memory. 2. Neural systems involved in memory medial temporal lobe, Pre-frontal, association areas of cortex. Neural mechanisms for explicit and implicit memory –overview. 3. Cellular / molecular mechanisms of implicit memory 4. Synaptic transmission & its modification. Aplysia as a model. Molecular basis of habituation, sensitization and classical conditioning.	**4**	**15** 2 10 3
SMSLSC403	**2**	**Learning and Memory- II** 1. Cellular / molecular mechanisms of Explicit memory storage. 2. Long term potentiation and long-term depression. 3. Synaptic plasticity in the adult brain and epigenetic modulation, Hebbian plasticity in Hippocampalneurons 4. Neural pathways in mammals with special reference to fear Learning induced changes and biological basis of individuality A. **Attention**: 1. Definition and varieties of attention, Attention and neural responses, Filtering of unwanted stimuli 2. Roleof Prefrontal Cortex(PFC):Anatomy and Organization of PFC, 3. Theories of PFC function, Neurophysiology ofPFC **B. Thought and working memory**	**4**	**15** 2 2 2 3 1 2 2 1
SMSLSC403	**3**	**Language and speech** **Language** 1. Communication in other animals. (eg. Bird song) 2. Human language and in attributes (phonemes) morphonemes, words and Cortical regionsinvolved in language processing. 3. Model for neural basis oflanguage. 4. Aphasias, functional MRT and current	**4**	**15** 2 3 3 2

		understanding of languageprocessing. 5. Language acquisition and its universality. Role of language in other cognitive function.		2 3

SMSLSC403	**4**	**Neuroeconomics and Neuromarketing** **A. Neuroeconomics:** 1. Introduction and scope of Neuro economics 2. Basics of economics 3. Neuroanatomy, Neurophysiology, and Neuroimaging: Tools of Neuroeconomics 4. Introducing Brain Models of Decision-Making and Choice 5. Neural Representation of Subjective Value 6. Affective Mechanisms of Decision-Making 7. Dual Process Theory of Decision-Making: Toward a Neuroeconomics Perspective 8. Decision-Making under Risk: Toward a Neuroeconomics Mechanism 9. The Social Brain: Games in the Brain 10. Evolutionary Perspective of Decision-Making **B. Neural Marketing** 1. What is Neuromarketing? 2. Role of Attention & Consciousness and Learning &Memory 3. Sensory Neuromarketing 4. Emotions & Feelings, Wanting &Liking 5. Neuroethics and Consumer Aberrations	**4**	**15** 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1

COURSE CODE: SMSLSC404

PAPER –IV MOLECULAR NEUROBIOLOGY AND DISEASE PATHOLOGY

Course Objectives:

CO1: To familiarize students with the aspects of neuro toxicology and neuro pharmacology.

CO2: To understand the processes behind neurodegenerative diseases of nervous system.

CO3: To Introduce students with recent techniques in experimental neuroscience

CO4: To make students aware of the neuroethics and IPR related with neuroscience

Learning objectives

The student will be able to

LO1: understand details of neurotoxicology and neuropharmacology

LO2: interpret pathophysiology of degenerative disease of nervous system.

LO3: able to understand the recent techniques in experimental neuroscience.

LO4: aware conscious about neuroethics .

LO5: guage the importance of IPR in context to neuroscience.

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC404	**1**	**Neurotoxicology and Neuropharmacology** **A. Neurotoxicology:** 1. General principles of toxicology and neurotoxicology 2. Effect of injurious chemicals/ agents/ environmental factors on the nervoussystem and their mechanisms of action. Neurotoxicity of metals and cellular mechanisms. 3. Model systems and methods used to study neurotoxicology Effects of toxins on neurodevelopment. **B. Nanoparticles:** 1. Cell – nanoparticleinterface. 2. Other applications of nanoparticles in neuroscience – Imaging, Drug / Genedelivery (across Blood brain barrier)	**4**	**15** 2 4 4 2 3
SMSLSC404	**2**	**Neurodegenerative diseases** **A. Molecular basis of neurodegenerative diseases** **Infectious Diseases** 1. Leprosy 2. PrionsDisease **B. Degenerative diseases of the Nervoussystem** 1. Genetic mechanisms – Huntington's Disease, Duchenne Muscular Dystrophy Myopathies andNeuropathies 2. Malnutrition Diseases – Kwashiorkor and Marasmus 3. Tumours of the CNS –neuroblastomas, medulloblastomas andgliomas	**4**	**15** 4 4 3 4

SMSLSC404	**3**	**Recent Techniques in Experimental Neurosciences** **A. Molecular screens and Making and Using Transgenic organisms:** 1. cDNA libraries 2. RNA interference(RNAi) and RNAi screens 3. Nextgen sequencing. 4. Disrupting gene products and direct gene targeting: Knockouts, knockins, conditional knockouts (Cre/lox, FLP/FRT, CRIPR-Cas9, ZFNs, TALENs) morpholinos, dominant negatives 5. Binary transgenic systems: Gal4/UAS, Cre/lox, Flp/Frt, Tet-off/Tet-on	**4**	**15** 2 3 3 4 3
SMSLSC404	**4**	**IPR & Neuroethics** **A. IPR patents related to neuroscience** 1. Example : Piracetam, Levitracetum (a GABA derivative). 2. Levodopa and therapeutic applications. 3. Gabapentin and Neuropathic pain. 4. Ethical usage of drugs for multiple indications: Carbamazepine /Valproate. 5. Personalised drug : Thiopurine. 6. Life style drugs**,** Assessment Neuro technologies, Intervention Neuro technologies. **B. Neuroethics:** 1. An introduction to Neuroethics 2. Reading the brain-state of consumers 3. Neurodisability and criminal justice system 4. Brain imaging and criminal justice system 5. Use of Neurotechnology for litigation 6. Pharmaceutical brain enhancement 7. Use of amphetamine in Military environment	**4**	**15** 1 1 1 2 1 2 1 1 1 1 1 1 1

SEMESTER IV

PRACTICAL

Course Code: SMSLSCP401

1. Morphometric study in developing chick / zebrafish brain
2. LDH pattern of developingbrain
3. Histochemical localization of cytochrome oxidase using chick embryo / zebrafish
4. Developmental studies in invertebrates – mounting of imaginal discs from *Drosophila*
5. Measurement of some serum cytokine/cortisol levels usingELISA

Course Code: SMSLSCP402

6. To study behavior of fish using zebrafish (*Danio rerio*)as a model organism.
7. Behavioral assay using *C. elegans* /snail/earthworm
8. Cognitive tasks: Stroop test (Klein 1964) and visualSearch
9. Intelligence tests, Personality tests, Projective tests, any other psychologicaltools
10. Case Study of abnormal / differently abled / aging subject
11. Toxicity testing of any chemical /metal / environmental factor using *Daphnia/ C. elegans*/ zebrafish/ Any other modelsystem.
12. Study of histopathological correlates of neurotoxicity using permanent slides/ photographs.
13. Preparation of any nanoparticle and itscharacterization
14. In vivo/ in vitro effect of any nanoparticle.(Demonstration)

Course Code: SMSLSCP403

Thesis containing Literature Review, Project work, Poster presentation in any conference (MANDATORY)

Good Laboratory Practices

Course Code: SMSLSCP404

15. Extraction of DNA from brain / neural cellculture
16. Extraction of RNA from brain / neural cellculture
17. PCR of gene from neural tissue and demonstration of PCR product usingAGE
18. RFLP analysis of PCRproduct
19. Real time PCR/Western Blot (Demonstration)
20. Bioinformatics:
    i. Protein structure classification: CATH andSCOP
    ii. Secondary Structure: InterProScan/Prosite/JPRED
    iii. Tertiary structure: PDB, Rasmol
    iv. Homology Modelling–SWISS-MODEL, Introduction to docking (protein - protein)
    v. Immunoinformatics: - Epitope mapping
    vi. Detection of post translational modification eg. phosphorylation (in neuroproteins)
    vii. Functional proteomics: -Protein-protein interactions:STRING
    viii. Use of advanced databases: Pubchem, Comparative Toxicogenomics Database

RECOMMENDED TEXTBOOKS

1. Kandel J., Schwartz T., Jessell S., Siegelbaum A., Hudspeth E. Principles of Neuroscience, 2013, 5th Edition, *Mc Graw HillMedical*.
2. Squire L.(Ed.) The History of Neuroscience in Autobiography, 2012 (Vol 7), *Oxford UniversityPress.*
3. Ramachandran V.S. (Ed in chief). Encyclopedia of Human Brain, 2002, *Academic Press Volumes I to4.*
4. Squire. L. (Ed.). Fundamental Neuroscience. 2013, 4th Edition. *ElsevierInc.*
5. Sanes D. (Ed.) Development of Nervous system, 2011, 3rd Edition, *ElsevierInc.*
6. WatsonC.,MathewK.,PaxinosG.Brain:Anintroductiontofunctionalneuroanatomy, 2010, *London AcademicPress.*
7. BaerM.,ConnorsB.,ParadiscoM.NeuroscienceExploringthebrain,2006,3rdEdition, *Lippincott Williams and Wilkins.*
8. NichollsJ.,MartinR.,WallaceB.,FuchsP.FromNeurontobrain,2001,4thEdition, *Sinauer Asso. Inc.*
9. Purves D., Augustine G., Fitzpatrick D., et al. Neuroscience, 2011,5th Edition, *Sinauer AssociateInc.*
10. Carter M., Shieh J. Guide to research techniques in Neuroscience, 2010,*Elsevier*.
11. Brady S., (Ed.), Siegel G, (Ed.), et al. Basic Neurochemistry: Molecular, Cellular and Medical Aspects, 2005, 7th Edition, *AcademicPress.*
12. Martin J. B. Molecular Neurobiology, 1998, *ScientificAmerican*.
13. Crossman A.R., Neary D. Neuroanatomy: An Illustrated coloured text, 2015, 5thEdition, *Churchill Livingstone -Elsevier*
14. Pandey M. (Ed.) Biostatistics – Basic and Advanced, 2015, *M VLearning.*
15. Giulia E. GUT: The inside story of our most under rated organ, 2015,*Scribe.*
16. Genco S.J., Pohlmann A.P., Steidl P, Neuromarketing for Dummies, 2013, *John Wiley and Sons.*
17. RoseS.TheFutureoftheBrain–ThePromiseandPerilsofTomorrow'sNeuroscience, 2005, *Oxford UniversityPress*.
18. Baars B., Gage G. Cognition, Brain and Consciousness, 2010, 2nd Edition,*Elseiver*.
19. BermudezJ.CognitiveScience:AnintroductiontothescienceofMind,2010, *Cambridge University Press.*
20. Kalat J. Biological Psychology, 2009 10th Edition, *Wadsworth CengageLearning*.
21. Eichenbaum H. (Ed.) The cognitive Neuroscience of Memory: An introduction, 2012, 2nd Edition, *Oxford UniversityPress*.
22. Harvey RA. Pharmacology (Lippincott's Illustrated Reviews), 2011, 5th Edition, *Pub Volters Kluwer (India) PvtLtd.*
23. Richard H., Whitbourne S. Abnormal Psychology – Clinical Perspectives on Psychological Disorders, 2010, 6th Edition, *Tata McGraw Hill Education Pvt.Ltd.*
24. PurvesD.,BrannonE.,CabezaR.,etal.PrinciplesofCognitiveNeuroscience,20081stEditio n, *SinauerAssociates*.
25. Mangun G.R. (Ed.) Neuroscience of Attention: Attentional Control and Selection, 2012, *Oxford UniversityPress*.
26. Printz J.J. (Ed.) The Conscious Brain, 2012, *Oxford UniversityPress.*

27. Bostock H. et al (Ed.) The Neurobiology of Disease: Contribution from Neuroscience to Clinical Neurology, 2011, *Cambridge University Press*.
28. WalkerM.Whywesleep: The Newscience of sleep and DreamsEnder,2017,*Penguin.*
29. Doidge N. The Brain that changes itself. Stories of personal triumph from thefrontiers of Science, 2008, *Penguin.*
30. Gilbert P. Depression: The Evolution of Powerlessnes, 1992, *GuilfordPress*.
31. Martin R. The Opposable Mind, 2009, *Harvard Business Review Press*.
32. Andrews A. (Ed.) Neuropsychology from theory to practice, 2016, *Psychology Press Book*.
33. Claverie J.M., Notredame C., Bioinformatics for Dummies, 2003, *John Wiley &Sons*
34. Xiong J, Essential Bioinformatics, 2006, *Cambridge University Press*
35. Arthur Lesk. Introduction to Bioinformatics. 4th Ed, 2014, *Oxford University Press*

RECOMMENDED JOURNALS

1. Trends in Neurosciences
2. Current Opinions in Neurobiology
3. Annual Review on Neurosciences
4. Annual Review on Biochemistry
5. Science
6. Nature
7. Scientific American

RECOMMENDED COURSES

1. Introduction to Neuroeconomics: How the Brain Makes Decisions
   https://www.coursera.org/learn/neuroeconomics
2. An Introduction to Consumer Neuroscience & Neuromarketing
   https://www.coursera.org/learn/neuromarketing
3. Gut Check: Exploring your microbiome
   https://www.coursera.org/learn/microbiome/home