SOPHIA COLLEGE (AUTONOMOUS)

Affiliated to

University of Mumbai

Program: Life Sciences

Program Code: SMSLSC

M.Sc.

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

Programme Outline: M.Sc. Life Sciences 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 Evolutionary Perspective	**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**	

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 to enhance their ability to think logically, analyze the information and help in problem solving skills in research work.

PROGRAMME OBJECTIVES

PO 1	**To provide students with detailed understanding of the major life sciences domains.**
PO 2	**To develop the research skills with critical thinking and problem solving abilities.**
PO 3	**To allow students to specialize in Neuroscience with real-world application through lectures, workshops, and interactive labs.**

PROGRAMME SPECIFIC OUTCOMES

PSO 1	**Learners will demonstrate a deep understanding of the principles, theories and methodologies in neuroscience, ecomapsing molecular, cellular, systems and behavioral neuroscience.**
PSO 2	**The learners will critically evaluate scientific literature, assess the validity of research findings, and contribute to the advancement of knowledge in life sciences through innovative research.**
PSO 3	**Learners will be able to effectively communicate scientific ideas and research findings through oral presentation, scientific writing and publication adhering to disciplinary conventions and standards.**

NAME OF THE COURSE	**Cellular Organization of the Nervous System**	
CLASS	M.Sc. Sem III	
COURSE CODE	SMSLSC301	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	30	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

Course Objectives:

CO 1	To introduce students to neuroscience by giving them a historical perspective and dawn of neuroscience
CO 2	Introduction to primitive nervous system and basic plan of vertebrate nervous system
CO 3	Introduction to the structural and functional features of Neuron and Glia
CO 4	Introduction to types of synapses, neurotransmitters and their functional localization and introduction to different electrophysiological techniques and computational neuroscience

Course Learning Outcomes :
Students will be able to

CLO 1	Differentiate between Mind and brain, between the primitive nervous system and Cephalization in Molluscs
CLO 2	Categorize between types of neurons, types of glia and their function in addition they will

	also learn about electrical properties of the neuron
CLO 3	Compare between the different types of synapse and neurotransmitters
CLO 4	Differentiate between electrophysiological techniques like Patch clamp and Voltage clamp

UNIT 1	**History of Neuroscience Nervous system: Overview and Evolutionary Perspective. (15 Lectures)**
1.	**History of Neuroscience Nervous system: Overview and Evolutionary Perspective** A. History of Neuroscience Major issues that have shaped neuroscience studies – Mind vs. Brain debate, Localism vs. Holism debate, Nature of neural communication and plasticity of the 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 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.
UNIT 2	**Neurons and Glia: Structural and Functional features. (15 Lectures)**
	A. Neurons and Glia: Structure and function 1. Structural and functional diversity of neurons - Types of neurons based on their structure and function 2. Neurons - General morphology of a typical neuron stressing on features relevant to their function – membrane receptors, ion channels, ion pumps, Significance of axon initial segment 3. Cytoskeletal elements and 'molecular motors' and role in axonal transport 4. Types of glia based on their structure and function – Astrocytes, Oligodendrocytes,
UNIT 3	**Synaptic Transmission and Neurotransmitters. (15 Lectures)**
	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 vesicle recycling. 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 functional localization** 5. Neurotransmitters: Structure, distribution, metabolism, types of receptors, agonist and antagonists, molecular mechanisms of action Acetylcholine, biogenic amines, catecholamines, serotonin, amino acids, Neuroactive peptides as transmitters.
UNIT 4	**Electrophysiological techniques and Computational Neuroscience (15 Lectures)**
	A. Electrical properties of the neuron–signal generation and propagation 1. Ionic concentrations, Donnan's equilibrium, equilibrium potential, 2. Nernst equation, Goldman-Hodgkin-Katz equation, Resting membrane potential, Depolarization and hyperpolarization. 3. Electrophysiological techniques to understand the electrical properties of the neuron – Patch-clamp and Voltage- clamp. 4. Perforated whole-cell patch clamp 5. Immunopanning techniques for astrocytes. **B. Computational Neurosciences** 1. Introduction, historical perspective and goals: Origin and scope of the field 2. Computational Neurosciences, Modeling the neuron components - variables and parameters, use of differential equations and matrices, components of membrane, electric circuits, Concept of Realistic and simplified brain models 3. Application of biological principles to artificial circuits: Hodgkin-Huxley model and GHK equation

NAME OF THE COURSE	**Practicals**
CLASS	M.Sc. Sem III
COURSE CODE	SMSLSCP301

NUMBER OF CREDITS	2
NUMBER OF LECTURES PER WEEK	4
TOTAL NUMBER OF LECTURES PER SEMESTER	60
EVALUATION METHOD TOTAL MARKS PASSING MARKS	SEMESTER END EXAMINATION 50 20

Course code	**Practical title**
SMSLSCP301	1. Study of cells of the nervous system using electron micrographs 2. Study of permanent slides of histology of nervous system 3. Silver staining of neuronal cell / tissue using a suitable source eg. sensillae of Drosophila. 4. Whole mount of neurons of invertebrates using a suitable source. 5. Whole mount of vertebrate medullary fibers using a suitable source. a) Preparation of permanent slides and submission of two slides: a) Forebrain, b) midbrain, c) hindbrain, d) invertebrate brain. 6. Temporary mount of vertebrate muscle 7. Study of The Invertebrate Nervous System (Prawn/Crab)

NAME OF THE COURSE	**ORGORGANIZATION AND FUNCTIONAL MODIFICATION OF THE NERVOUS SYSTEM**
CLASS	M.Sc. Sem III
COURSE CODE	SMSLSC302
NUMBER OF CREDITS	4

NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	30	
EVALUATION METHOD TOTAL MARKS PASSING MARKS	INTERNAL ASSESSMENT 50 20	SEMESTER END EXAMINATION 50 20

Course Objectives:

CO 1	To introduce the basics of nerve and muscle physiology
CO 2	To introduce the basics of Neural – Immune interactions and Clinical implications of neural – immune signaling
CO 3	To introduce the basics of gut microbiome and nervous system
CO 4	To introduce the fundamentals of the tools related advanced neurogenetics and imaging techniques

Course Learning Outcomes :
Students will be able to

CLO 1	Interpret the mechanism of signal transmission at the neuromuscular junction and muscle contraction
CLO 2	Understand the correlation between nervous and immune system, its effect on behavior & clinical implication
CLO 3	comprehend the effect of the gut microbiome on the nervous system and neurodegenerative diseases
CLO 4	learn the fundamentals of advanced techniques in Neurogenetics and Imaging

UNIT 1	**Nerve and Muscle**	**(15 Lectures)**

	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
UNIT 2	**Neuroimmunology** **(15 Lectures)**
	A. Maternal immune system and Neural 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 signaling** 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
UNIT 3	**Gut microbiome and nervous system**. **(15 Lectures)**
	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 disorders 6. Role of microbiome in neurodegenerative disorders 7. Factors that affect / alter the microbiome
UNIT 4	**Advanced Neurogenetics, imaging Techniques and Advanced Biostatistics (15 Lectures)**

	A. Advanced Neurogenetics and imaging techniques 1. Brainbow technique 2. Connectomics 3. Brain machine interface 4. Blue brain project **B. Advanced Biostatistics** Non parametric tests: 1. Median and Interquartile range 2. Spearman Rank Correlation 3. Mann Whitney U test 4. Wilcoxon signed rank test 5. Kruskal Wallis H test 6. Concept of logistic regression & ROC curves.

NAME OF THE COURSE	**Practicals**
CLASS	M.Sc. Sem III
COURSE CODE	SMSLSCP302
NUMBER OF CREDITS	2
NUMBER OF LECTURES PER WEEK	4
TOTAL NUMBER OF LECTURES PER SEMESTER	60
EVALUATION METHOD TOTAL MARKS PASSING MARKS	SEMESTER END EXAMINATION 50 20

Course code	**Practical title**
SMSLSCP302	1. NEURON Coding Exercises for Resting Membrane Potential, Action

	Potential, Propagation of Impulse, Synaptic transmission 2. Functional physiology using Biopac – EEG (Electroencephalogram) 3. Functional physiology using Biopac –GSR (Galvanic skin response) 4. Functional physiology using Biopac –ECG (Electrocardiogram), 5. Functional physiology using Biopac –EOG (Electro- occulogram) 6. Demonstration of EMG measurement using BioPac 7. Biostatistics: Manual calculation and use of software for Non parametric tests: Median and interquartile range Spearman Rank Correlation Mann Whitney U test Wilcoxon signed rank test Kruskal Wallis H test Concept of logistic regression & ROC curves. (Analyze the given data using statistical tests that seem appropriate with the help of software and justify the reason for using each test).

NAME OF THE COURSE	**SYSTEMS APPROACH TO NEUROSCIENCES I**	
CLASS	M.Sc. Sem III	
COURSE CODE	SMSLSC303	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	30	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

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.

Course Learning Outcomes :
Students will be able to

CLO 1	Categorize the autonomic and enteric nervous system and also with the integration of autonomic and endocrine functions with behavior.
CLO 2	Further the implications of pathogenic diseases along with the neuroimaging techniques

UNIT 1	**Anatomical and Functional Organization of the CNS: (15 Lectures)**
	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) The ventricular system in the brain - CSF, its flow and the blood brain barrier.
UNIT 2	**Anatomical and functional organization of the PNS: (15 Lectures)**
	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.
UNIT 3	**Autonomic/ Enteric Nervous system (15 Lectures)**
	1. Sympathetic pathways and thoracolumbar outputs 2. Parasympathetic pathways and outputs from the brainstem nuclei and sacral spinal cord. 3. Enteric nervous system. 4. Integration of autonomic and endocrine functions with behaviour. Role of hypothalamus. Brain stem anatomy 5. Implications of pathogenic diseases. For e.g.: Diabetes and autonomic neuropathy

UNIT 4	**Neuroimaging Technique: (15 LECTURES)**
	A. Study of functional anatomy: Recording and Imaging techniques and trends 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.

NAME OF THE COURSE	**Practicals**
CLASS	M.Sc. Sem III
COURSE CODE	SMSLSCP304
NUMBER OF CREDITS	2
NUMBER OF LECTURES PER WEEK	4
TOTAL NUMBER OF LECTURES PER SEMESTER	60
EVALUATION METHOD	SEMESTER END EXAMINATION
TOTAL MARKS	50
PASSING MARKS	20

Course code	**Practical title**
SMSLSCP303	1. Haematoxylin and eosin staining of neuronal / glial cultured cells. 2. Biochemical estimations / Histochemical localizations in brain tissue: I. Na+/K+ -ATPase

	II. AChE III. NOS 1. TLC to separate brain phospholipids using day 3, day 6 and adult chick brain. 2. To prepare a smear of retinal neurons from the Avian eye and to observe retinal morphology of developing eyes. 3. One day visit to a Neuropathology teaching Center Interpretation of FMRI/FRET /FRAP images

NAME OF THE COURSE	**SYSTEMS APPROACH TO NEUROSCIENCES II**	
CLASS	M.Sc. Sem III	
COURSE CODE	SMSLSC304	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	30	
EVALUATION METHOD TOTAL MARKS PASSING MARKS	INTERNAL ASSESSMENT 50 20	SEMESTER END EXAMINATION 50 20

Course Objectives:

CO 1	To introduce the students to the process behind Sensory detection and encoding of neural signaling.
CO 2	To introduce the conscious perception and awareness with respect to neural signaling processing

CO 2	Understand Ethical, legal, social impact of imaging techniques and use of cognitive enhancers
CO 4	To make students aware of the neuroethics and IPR related with neuroscience

Course Learning Outcomes :
Students will be able to

CLO 1	Delineate the process and mode of transduction of sensory stimulus, their detection, and encoding of neural signaling pathway
CLO 2	Explain structural features of muscle, transmission of nerve signal leading to muscle contraction, displacement and movement.
CLO 3	Inculcate the ethical, legal, social impact of imaging techniques and use of cognitive enhancers
CLO 3	Aware of neuroethics .
CLO 3	Gauge the importance of IPR in context to neuroscience.

UNIT 1	**Sensory system I: (15 Lecture)**
	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 photo receptors. 2. Electrical response to light. Concept of receptive fields. 3. Color vision Visual pathway, lateral geniculate nucleus and visual cortex 4. Visual perception as a creative process. 5. Perception of motion, depth, form and color. 6. Visual attention and conscious awareness.
UNIT 2	**Sensory system II: (15 Lectures)**
	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:** 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 cortex in somatosensation.
UNIT 3	**Motor System: (15 Lecture)**
	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 fore brain 4. Influence of basal ganglia and cerebellum on cortical and brain motor mechanisms. 5. Motor function of the brain stem, vestibular apparatus and equilibrium Motor functions of the spinal cord-reflexes 6. Diseases of the Nervous System– Parkinson's Disease
UNIT 4	**IPR & Neuroethics (15 Lecture)**
	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. Personalized drug : Thiopurine. 6. Lifestyle 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

NAME OF THE COURSE	**Practicals**
CLASS	M.Sc. Sem III
COURSE CODE	SMSLSCP304
NUMBER OF CREDITS	2
NUMBER OF LECTURES PER WEEK	4
TOTAL NUMBER OF LECTURES PER SEMESTER	60
EVALUATION METHOD TOTAL MARKS PASSING MARKS	SEMESTER END EXAMINATION 50 20

Course code	**Practical title**
SMSLSCP304	1. Anatomy of the chick brain –display of ventral and dorsal view 2. Gross anatomy of the mammalian brain using brain atlas – goat / sheep 3. Localization of grey and white matter of mammalian brain using Mulligan's staining 4. Human brain anatomy using virtual anatomy software 5. Human Spinal cord and PNS anatomy using virtual anatomy software 6. Protocol using a mouse model system brain to observe hippocampus 7. Case study on Neuroethics 8. Molecular basis of taste detection/ receptor mechanism

SEMESTER IV

NAME OF THE COURSE	**DEVELOPMENT NEUROBIOLOGY**	
CLASS	M.Sc. Sem IV	
COURSE CODE	SMSLSC401	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	30	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

CO 1	To enable understanding of the various processes involved in development of a functional nervous system
CO 2	Introduction to disorders and genetic diseases associated with the developing brain
CO 3	Understand Sexual Differentiation of the Nervous System
CO 4	Introduction to Aging of the brain and its associated diseases

Course Learning Outcomes :
Students will be able to

CLO 1	Interpret the mechanism of signal transmission at the neuromuscular junction and muscle contraction
CLO 2	Understand the correlation between nervous and immune system, its effect on behavior & clinical implication
CLO 3	comprehend the effect of the gut microbiome on the nervous system and neurodegenerative diseases

CLO 4	learn the fundamentals of advanced techniques in Neurogenetics and Imaging

UNIT 1	**Developmental Neurobiology (15 Lectures)**
	A. Early Development and Patterning of CNS 1. Axis formation (anterior-posterior and dorso-ventral axis) – role of Hox genes, 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
UNIT 2	**Axon Guidance and Synapse formation (15 Lectures)**
	A. Growth cones and axonal pathfinding 1. Differences between early development of axons and dendrites Growth cone structure and formation 2. Guidance cues in axonal pathfinding **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 behavior
UNIT 3	**Developmental disorders and genetic diseases: (15 Lectures)**
	1. Autism spectrum disorders (Asperger's Syndrome) 2. Attention Deficit Hyperactivity Disorder (ADHD), Microcephaly, Hydrocephaly 3. Down's syndrome 4. Fragile X syndrome 5. Spina bifida
UNIT 4	**The Altered Brain (15 Lectures)**

	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 b. Cognitive decline in diseases – Dementia and Alzheimer's

NAME OF THE COURSE	**Practicals**
CLASS	M.Sc. Sem IV
COURSE CODE	SMSLSCP401
NUMBER OF CREDITS	2
NUMBER OF LECTURES PER WEEK	4
TOTAL NUMBER OF LECTURES PER SEMESTER	60
EVALUATION METHOD TOTAL MARKS PASSING MARKS	SEMESTER END EXAMINATION 50 20

Course code	**Practical title**
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

NAME OF THE COURSE	**DEVELOPMENT NEUROBIOLOGY**	
CLASS	M.Sc. Sem IV	
COURSE CODE	SMSLSC402	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	30	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

Course Objectives:

CO 1	Introduce to brain and behavior
CO 2	Familiarize the students with Cognitive development and associated Behavioral Disorders
CO 3	Familiarize the students with terms related to emotions, sleep and dreams, and Consciousness

Course Learning Outcomes :
Students will be able to

CLO 1	Develop the knowledge about the Brain and behavior, connections established between the physiology and functions of the brain to the activities
CLO 2	Inculcate the insight about the cognitive and emotional aspects of the brain.
CLO 3	learn about the diseases associated with the behavioral disorders and neurological correlates of sleep.

UNIT 1	**Brain and Behavior**	**(15 Lecture)**

	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
UNIT 2	**Cognitive development and Behavioral Disorders (15 Lecture)**
	A. Cognitive development: 1. Approaches to development of Cognition-Behavioral-basic mechanisms of learningPsychometric – Developmental and intelligence testing Piagetian stages of development 2. Cognitive Neuroscience approach 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** 1. Disorders of thought and volition: Schizophrenia- diagnosis, genetic and non-genetic risk factors, neuroanatomic abnormalities, therapy 2. Disorders of mood and anxiety- diagnosis, genetic and non-genetic risk factors, neuroanatomic abnormalities, psychotherapy Personality disorders- diagnostic features of personality disorders.
UNIT 3	**Emotions (15 Lectures)**
	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** 1. An integration centre for cognitive and behavioural functions. 2. Neuropathological Mechanisms underlying Drug addiction (Glutamate signal transduction) 3. Pharmacological Inhibition of Drug seeking behaviour.(Manupulation

	of glutamate systems)
UNIT 4	**Sleep and Dreams, Consciousness (15 Lectures)**
	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; free will 3. Contemporary model for consciousness

NAME OF THE COURSE	**Practicals**
CLASS	M.Sc. Sem IV
COURSE CODE	SMSLSCP402
NUMBER OF CREDITS	2
NUMBER OF LECTURES PER WEEK	4
TOTAL NUMBER OF LECTURES PER SEMESTER	60
EVALUATION METHOD TOTAL MARKS PASSING MARKS	SEMESTER END EXAMINATION 50 20

Course code	Practical title
SMSLSCP402	1. To study the behavior of fish using zebrafish (Danio rerio)as a model organism. 2. Behavioral assay using C. elegans /snail/earthworm 3. Cognitive tasks: Stroop test (Klein 1964) and visualSearch 4. Intelligence tests, Personality tests, Projective tests, any other psychologicaltools. 5. Case Study of abnormal / differently abled / aging subject 6. Toxicity testing of any chemical /metal / environmental factor using Daphnia/ C. elegans/ zebrafish/ Any other model system. 7. Study of histopathological correlates of neurotoxicity using permanent slides/ photographs. 8. Preparation of any nanoparticle and its characterization 9. In vivo/ in vitro effect of any nanoparticle.(Demonstration)

NAME OF THE COURSE	**BEHAVIOURAL NEUROSCIENCES II**	
CLASS	M.Sc. Sem IV	
COURSE CODE	SMSLSC403	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	30	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

UNIT 1	**Learning and Memory-I** **(15 Lecture)**

	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. 5. Aplysia as a model. Molecular basis of habituation, sensitization and classical conditioning.
UNIT 2	**Learning and Memory-II (15 Lecture)**
	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 Hippocampal neurons 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. Role of Prefrontal Cortex (PFC): Anatomy and Organization of PFC, 3. Theories of PFC function, Neurophysiology of PFC B. Thought and working memory
UNIT 3	**Language and speech (15 Lecture)**
	Language 1. Communication in other animals. (eg. Bird song) 2. Humanlanguage and in attributes (phonemes) morphonemes, words and Cortical regions involved in language processing. 3. Model for neural basis of language. 4. Aphasias, functional MRT and current understanding of language processing. 5. Language acquisition and its universality. 6. Role of language in other cognitive functions.
UNIT 4	**Neuroeconomics and Neuromarketing (15 Lecture)**
	A. Neuroeconomics: 1. Introduction and scope of Neuroeconomics 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 A. 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

NAME OF THE COURSE	Practicals
CLASS	M.Sc. Sem IV
COURSE CODE	SMSLSCP403
NUMBER OF CREDITS	2
NUMBER OF LECTURES PER WEEK	4
TOTAL NUMBER OF LECTURES PER SEMESTER	60
EVALUATION METHOD TOTAL MARKS PASSING MARKS	SEMESTER END EXAMINATION 50 20

Course code	**Practical title**
SMSLSCP403	Thesis containing Literature Review, Project work, Poster presentation in any conference

	(MANDATORY) Good Laboratory Practices.

NAME OF THE COURSE	**MOLECULAR NEUROBIOLOGY AND DISEASE PATHOLOGY**	
CLASS	M.Sc. Sem IV	
COURSE CODE	SMSLSC 404	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	30	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

Course Objectives:

CO 1	To familiarize students with the aspects of neuro toxicology and neuro pharmacology
CO 2	To understand the processes behind neurodegenerative diseases of nervous system
CO 3	To Introduce students with recent techniques in experimental neuroscience
CO 4	To give emphasis on Bioinformatics with of structural biology and neuropharmacology

Course Learning Outcomes :
Students will be able to

CLO 1	Understand details of neurotoxicology and neuropharmacology
CLO 2	Interpret pathophysiology of degenerative disease of nervous system.

CLO 3	Able to understand the recent techniques in experimental neuroscience
CLO 3	Students will be able to use Bioinformatics tools for various research problems.

UNIT 1	**Neurotoxicology and Neuropharmacology (15 Lectures)**
	A. Neurotoxicology: 1. General principles of toxicology and neurotoxicology 2. Effect of injurious chemicals / agents / environmental factors on the nervous system 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 – nanoparticle interface. 2. Other applications of nanoparticles in neuroscience – Imaging, Drug / Gene delivery (across Blood brain barrier)
UNIT 2	**Neurodegenerative diseases (15 Lectures)**
	A. Molecular basis of neurodegenerative diseases 1. Infectious Diseases 2. Leprosy 3. Prions Disease **B. Degenerative diseases of the Nervous system** 1. Genetic mechanisms – Huntington's Disease, Duchenne Muscular Dystrophy Myopathies and Neuropathies 2. Malnutrition Diseases – Kwashiorkor and Marasmus 3. Tumors of the CNS – neuroblastomas, medulloblastomas and gliomas
UNIT 3	**Recent Techniques in Experimental Neurosciences (15 Lecture)**
	A. Advances in molecular biology techniques in Neurosciences 1. Genomics: Impact of human genome project on neuroscience research Proteomics in Neuroscience 2. The connectome project **B. Molecular screens and Making and Using Transgenic organisms:** 1. cDNA microarray, RNAi screens, Nextgen sequencing. 2. Disrupting gene products and direct gene targeting: Knockouts, knockins, conditional knockouts (Cre/lox, FLP/FRT, CRIPR-Cas9, ZFNs, TALENs) RNA interference (RNAi), morpholinos, dominant negatives 3. Binary transgenic systems: Gal4/UAS, Cre/lox, Flp/Frt, Tet-off/Tet-on

UNIT 4	**Structural Bioinformatics and Drug Designing (15 Lectures)**
	A. Structural Bioinformatics: **1.** Prediction of protein secondary structure: PHD and PSI-PRED method. 2. Prediction of Protein Tertiary (3-D) Structure: Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) 3. Homology Modeling, fold recognition, threading approaches, and ab-initiostructure prediction methods. **B. Applications of Bioinformatics** 1. Drug designing: Drug targets, Lead Identification and Modification, Computer-Aided Drug Design. 2. Chemi-informatics: Introduction and History cheminformatics, Search types, data representation – SMILES, Virtual screening, Quantity Structure Activity Relationship, Applications of chemiinformatics 3. Immunoinformatics 4. Toxico-omics and predictive toxicology

NAME OF THE COURSE	**Practicals**
CLASS	M.Sc. Sem IV
COURSE CODE	SMSLSCP404
NUMBER OF CREDITS	2
NUMBER OF LECTURES PER WEEK	4
TOTAL NUMBER OF LECTURES PER SEMESTER	60
EVALUATION METHOD TOTAL MARKS PASSING MARKS	SEMESTER END EXAMINATION 50 20

Course code	Practical title
SMSLSCP404	1. Extraction of DNA from brain / neural cellculture 2. Extraction of RNA from brain / neural cellculture 3. PCR of gene from neural tissue and demonstration of PCR product usingAGE 4. RFLP analysis of PCRproduct 5. Real time PCR/Western Blot (Demonstration) 6. 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

ASSESSMENT DETAILS:

Internal assessment (50 marks)

Part 1: Test (25 marks) Students will be given a test from any of the units for 25 marks. The duration of the test will be 50 minutes. (Multiple choice questions- 10 marks, Answer in one word/sentence - 05 marks, Subjective questions - HWY, Justify, Differentiate between, Diagrammatically etc. - 10 marks).

Part 2: An activity for 25 marks would be given in the form of a creative learning process. (Powerpoint presentation, Viva, Report and Viva, Preparation of study material and viva on the same, any other activity) .

Semester end examination (50 marks) :

- The duration of the paper will be two hours.
- There shall be five compulsory questions.
- Q1-4 shall correspond to the four units.
- Q1-4 shall contain an internal choice (Q1A or Q1A and Q1B or Q1B and so on).
- Q1-4 shall carry a maximum of 10 marks. Q5 shall be from Units 1 to 4.
- Q5 shall carry a maximum of 10 marks (attempt any 2 of 4)

Practical Assessment :

- The duration of the practical exam will be three days.
- There will be 50 marks practical per paper.
- To appear in the practical exam, students must bring a properly certified journal.

RECOMMENDED TEXTBOOKS

1. Kandel J., Schwartz T., Jessell S., Siegelbaum A., Hudspeth E. Principles of Neuroscience, 2013, 5th Edition, *Mc Graw Hill Medical*.
2. Squire L.(Ed.) The History of Neuroscience in Autobiography, 2012 (Vol 7), *Oxford University Press.*

3. Ramachandran V.S. (Ed in chief). Encyclopedia of Human Brain, 2002, *Academic Press Volumes I to 4.*
4. Squire. L. (Ed.). Fundamental Neuroscience. 2013, 4th Edition. *Elsevier Inc.*
5. Sanes D. (Ed.) Development of Nervous system, 2011, 3rd Edition, *Elsevier Inc.*
6. Watson C., Mathew K., Paxinos G. Brain: An introduction to functional neuroanatomy, 2010, *London Academic Press.*
7. Baer M., Connors B., Paradisco M. Neuroscience Exploring the brain, 2006, 3rd Edition, *Lippincott Williams and Wilkins.*
8. Nicholls J., Martin R., Wallace B., Fuchs P. From Neuron to brain, 2001, 4th Edition, *Sinauer Asso. Inc.*
9. Purves D., Augustine G., Fitzpatrick D., et al. Neuroscience, 2011,5th Edition, *Sinauer Associate Inc.*
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, *Academic Press.*
12. Martin J. B. Molecular Neurobiology, 1998, *Scientific American.*
13. Crossman A.R., Neary D. Neuroanatomy: An Illustrated coloured text, 2015, 5th Edition, *Churchill Livingstone - Elsevier*
14. Pandey M. (Ed.) Biostatistics – Basic and Advanced, 2015, *M V Learning.*
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. Rose S. The Future of the Brain – The Promise and Perils of Tomorrow's Neuroscience, 2005, *Oxford University Press*.
18. Baars B., Gage G. Cognition, Brain and Consciousness, 2010, 2nd Edition, *Elseiver.*
19. Bermudez J. Cognitive Science: An introduction to the science of Mind, 2010, *Cambridge University Press.*
20. Kalat J. Biological Psychology, 2009 10th Edition, *Wadsworth Cengage Learning*.
21. Eichenbaum H. (Ed.) The cognitive Neuroscience of Memory: An introduction, 2012, 2nd Edition, *Oxford University Press*.
22. Harvey RA. Pharmacology (Lippincott's Illustrated Reviews), 2011, 5th Edition, *Pub Volters Kluwer (India) Pvt Ltd.*
23. Richard H., Whitbourne S. Abnormal Psychology – Clinical Perspectives on Psychological Disorders, 2010, 6th Edition, *Tata McGraw Hill Education Pvt. Ltd.*
24. Purves D., Brannon E., Cabeza R., et al. Principles of Cognitive Neuroscience, 2008 1st Edition, *Sinauer Associates*.
25. Mangun G.R. (Ed.) Neuroscience of Attention: Attentional Control and Selection, 2012, *Oxford University Press*.
26. Printz J.J. (Ed.) The Conscious Brain, 2012, *Oxford University Press*.
27. Bostock H. et al (Ed.) The Neurobiology of Disease: Contribution from Neuroscience to Clinical Neurology, 2011, *Cambridge University Press*.
28. Walker M. Why we sleep: The New science of sleep and Dreams Ender, 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, *Guilford Press*.
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