



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

## SEMESTER IV

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

### SEMESTER III

#### COURSE CODE: SMSLSC301

#### PAPER –I CELLULAR ORGANIZATION OF THE NERVOUS SYSTEM

##### Learning Objectives:

To enable the understanding of:

Historical perspective and dawn of neuroscience, cells of the nervous system with references to structure, function and transmission and also incorporates associated techniques.

Course code	Unit	Topic headings	Credits	Lectures	
SMSLSCP301	1	<b>History of Neuroscience Nervous system: Overview and Evolutionary Perspective</b>	4	15	
		<b>A. History of Neuroscience</b> Major issues that have shaped neuroscience studies – Mind vs. Brain debate, Localism vs. Holism debate, Nature of neural communication and plasticity of adult brain.			5
		<b>B. An overview of the nervous system with an evolutionary perspective</b> 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.			3 7
SMSLSCP301	2	<b>Neurons and Glia: Structural and Functional features</b>	4	15	
		<b>A. Neurons and Glia: Structure and function</b>			2
		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
		3. Cytoskeletal elements and ‘molecular motors’ and role in axonal transport			2
4. Types of glia based on their structure and function – Astrocytes, Oligodendrocytes,	2				

		<p>Microglia and Schwann cells and their functions</p> <p><b>B. Electrical properties of the neuron: Signal generation and Propagation.</b></p> <ol style="list-style-type: none"> <li>1. Ion distribution and Resting membrane potential. Nernst and Goldman equation.</li> <li>2. Ionic permeability changes and Action potential and its propagation along the axon</li> <li>3. Structure and function of ion channel – sodium, potassium, calcium, chloride.</li> </ol>		<p>2</p> <p>2</p> <p>2</p>
<b>SMSLSCP301</b>	<b>3</b>	<p><b>Synaptic Transmission and Neurotransmitters.</b></p> <p><b>A. Types of synapses – electrical &amp; chemical</b></p> <ol style="list-style-type: none"> <li>1. Electrical synapse – Structure and properties</li> <li>2. Chemical Synapse: Neurotransmitter release from presynaptic terminal: Depolarization of presynaptic terminal, calcium influx, Neurotransmitter discharge by vesicle, exocytosis, and synaptic vesicle recycling.</li> <li>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.</li> <li>4. Synaptic integration in the CNS- Excitatory and Inhibitory synapses</li> </ol> <p><b>B. Neurotransmitters: Biochemistry and functional localization</b></p> <ol style="list-style-type: none"> <li>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.</li> </ol>	<b>4</b>	<b>15</b>
				<p>1</p> <p>2</p> <p>3</p> <p>1</p> <p>5</p>

SMSLSCP301	4	<p><b>Electrophysiological techniques and Computational Neuroscience</b></p> <p><b>A. Electrical properties of the neuron–signal generation and propagation</b></p> <ol style="list-style-type: none"> <li>1. Ionic concentrations, Donnan’s equilibrium, equilibrium potential, 1</li> <li>2. Nernst equation, Goldman-Hodgkin-Katz equation, Resting membrane potential, Depolarization and hyperpolarization. 2</li> <li>3. Electrophysiological techniques to understand the electrical properties of the neuron – Patch-clamp and Voltage-clamp. 2</li> <li>4. Perforated whole-cell patch clamp 1</li> <li>5. Immunopanning techniques for astrocytes. 1</li> </ol> <p><b>B. Computational Neurosciences</b></p> <ol style="list-style-type: none"> <li>1. Introduction, historical perspective and goals: Origin and scope of the field 2</li> <li>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 4</li> <li>3. Application of biological principles to artificial circuits: Hodgkin-Huxley model and GHK equation 2</li> </ol>	4	15
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**COURSE CODE: SMSLSC302**

**PAPER –II ORGANISATION AND FUNCTIONAL MODIFICATION OF THE NERVOUS SYSTEM**

**Learning Objectives:**

To enable understanding of:

1. Transmission at the neuromuscular junction and muscle contraction
2. Communication between nervous and immune system, its effect on behavior & clinical implication
3. The effect of the gut microbiome on the nervous system and neurodegenerative diseases
4. Advanced techniques in Neurogenetics, Imaging and Biostatistics

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC302	1	<b>Nerve and Muscle</b> <b>A. Nerve and muscle:</b> 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>B. Diseases of nerve and muscle:</b> 1. Muscular dystrophies 2. Myasthenia gravis. <b>C. Repair and Regeneration of the Damaged Brain</b> 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	<b>Neuroimmunology</b> <b>A. Maternal immune system and Neural development</b> <b>B. Neural – Immune interactions</b> 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 <b>C. Clinical implications of neural – immune signalling</b> 1. Immunodeficiency disease – HIV 2. Autoimmune disease – Multiple Sclerosis and Guillain – Barre Syndrome		2 2 2 2 1 2



		<b>D. Behavioural Neuroimmunology</b>  1. Stress and Immunity 2. Mechanisms and moderators of stress-immune link		2  2
SMSLSC302	3	<b>Gut microbiome and nervous system.</b> 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	4	<b>15</b> 1 2 3  2  2  3  2
SMSLSC302	4	<b>Advanced Neurogenetics, imaging Techniques and Advanced Biostatistics</b>  <b>A. Advanced Neurogenetics and imaging techniques</b> 1. Brainbow technique 2. Connectomics 3. Brain machine interface 4. Blue brain project  <b>B. Advanced Biostatistics</b> 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.	4	<b>15</b>   1 1 1 1  1 2 2 2 2 2

**COURSE CODE: SMSLSC303**

**PAPER –III SYSTEMS APPROACH TO NEUROSCIENCES I**

**Learning Objectives:**

To enable the understanding of:

- Anatomical and functional organization of the nervous system, comprehensive information about the structure, organizations and functional connectivity of the CNS and PNS.
- Autonomic and enteric nervous system and deals with the integration of autonomic and endocrine functions with behavior.
- Further the implications of pathogenic diseases along with the neuroimaging techniques.

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC303	1	<b>Anatomical and Functional Organization of the CNS:</b>	4	<b>15</b>
		1. Major divisions of Nervous System–Spinal cord, Medulla, Pons and Brain stem, Midbrain, Cerebellum, Diencephalon, Cerebral Hemispheres.		3
		2. Orientation of the above components in the CNS with respect to three axes.		2
		3. Gross anatomy of the brain with reference to functional organization -major nuclei and functional pathways.		3
		4. Cranial nerves, their origin and innervations		3
5. The ventricular system in the brain - CSF, its flow and the blood brain barrier.	4			
SMSLSC303	2	<b>Anatomical and functional organization of the PNS:</b>	4	<b>15</b>
		1. Gross anatomy of the spinal cord: Ascending, descending and propriospinal functional pathways.		4
		2. Cervical, thoracic, lumbar and sacral regions of the spinal cord.		4
		3. Dorsal root ganglion and spinal nerve roots and their distribution, spinal effector mechanism.		3
		4. Spinal muscular dystrophy.		2
5. Heritable spinocerebellar ataxia.	2			

SMSLSC303	3	<p><b>Autonomic/ Enteric Nervous system</b></p> <ol style="list-style-type: none"> <li>1. Sympathetic pathways and thoracolumbar outputs</li> <li>2. Parasympathetic pathways and outputs from the brainstem nuclei and sacral spinal cord.</li> <li>3. Enteric nervous system.</li> <li>4. Integration of autonomic and endocrine functions with behaviour. Role of hypothalamus. Brain stem anatomy</li> <li>5. Implications of pathogenic diseases. For e.g.: Diabetes and autonomic neuropathy</li> </ol>	4	15
SMSLSC303	4	<p><b>Neuroimaging Technique:</b></p> <p><b>A. Study of functional anatomy: Recording and Imaging techniques and trends</b></p> <ol style="list-style-type: none"> <li>1. Single cell recording Electroencephalic Recording, Event-Related potential, MEG</li> <li>2. Dynamic Brain Imaging: PET, MRI, fMRI X-ray Imaging: Computerized Axial Tomography, Diffusion-Tensor MR Imaging and Tractography: Exploring Brain Microstructure and Connectivity</li> </ol> <p><b>B. Advanced techniques applied to Neuroscience</b> Visualizing Nervous system structure and function: Introduction to FRET, FRAP and Optogenetics, Chemogenetics.</p>	4	15

**COURSE CODE: SMSLSC304**

**PAPER –IV SYSTEMS APPROACH TO NEUROSCIENCES II**

**Learning Objectives:**

To enable understanding of:

- To understand the processing and mode of transduction of visual, auditory, olfactory, gustatory and tactile stimuli their detection and encoding of neural signal processing.
- To understand conscious perception and awareness with respect to visual stimuli.
- To understand the structural features of muscle, transmission of nerve signal leading to muscle contraction, displacement and movement.
- To understand role of motor neurons and vestibular system in posture maintenance during ongoing movement and role of basal ganglia and neurotransmitters during voluntary movement.
- Human brain research and development of nootropic drugs, Use of combination drugs and its efficacy during therapy.
- Understanding the ethical, legal, social impact of imaging techniques and use of cognitive enhancers.

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC304	1	<b>Sensory system I:</b>	4	<b>15</b>
		1. Introduction - sensory systems, and mediation of 4 attributes of a stimulus a) Modality, b) Location, c) Intensity, d) Timing.		2
		2. Common plan of sensory system. General idea of a receptor and transduction of specific types of energy into electrical signals.		3
		<b>B. Visual system:</b>		3
		1. Vertebrate eye and retina. Morphology and arrangement of photo receptors.		1
		2. Electrical response to light. Concept of receptive fields.		1
		3. Color vision		2
4. Visual pathway, lateral geniculate nucleus and visual cortex	1			
5. Visual perception as a creative process.	1			
6. Perception of motion, depth, form and color.	1			
7. Visual attention and conscious awareness.	1			

SMSLSC304	2	<p><b>Sensory system II:</b></p> <p><b>A. Auditory system:</b></p> <ol style="list-style-type: none"> <li>1. Functional anatomy of ear and cochlea.</li> <li>2. Cochlear hair cells and perception of stimulus (frequency and intensity).</li> <li>3. Mechano-electrical transduction hair cells.</li> <li>4. Adaptation to sustained stimuli</li> <li>5. Role of brainstem nuclei, processing of auditory information in the cerebral cortex.</li> <li>6. Vestibular system and perception of posture and movement.</li> </ol> <p><b>B. Olfactory system:</b></p> <ol style="list-style-type: none"> <li>1. Structure of olfactory epithelium and odorant receptors.</li> <li>2. Role of nasal olfactory neuron in odour detection</li> <li>3. Olfactory signal transduction.</li> <li>4. Spatial encoding of odorant information in the olfactory bulb. Processing of olfactory information in the cerebral cortex.</li> </ol> <p><b>C. Gustatory system:</b></p> <ol style="list-style-type: none"> <li>1. Taste buds and their localization in various types of papillae found in human tongue.</li> <li>2. Taste cell: transduction of 4 basic stimuli into electrical signal Pathways to the CNS.</li> </ol> <p><b>D. Somatosensory system:</b></p> <ol style="list-style-type: none"> <li>1. Touch and mediation by mechanoreceptors in skin.</li> <li>2. Warmth and cold mediation by thermal receptors. Pain mediation by nociceptors.</li> </ol> <p>Role of spinal cord and cerebral cortex in somatosensation.</p>	4	15
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<b>SMSLSC304</b>	<b>3</b>	<b>Motor System:</b> <ol style="list-style-type: none"> <li>1. General introduction to motor system.</li> <li>2. Reflex and contractions. Rhythmic movements produced by stereotype muscle. Voluntary movements</li> <li>3. Motor circuits in spinal cord, brain stem, and fore brain</li> <li>4. Influence of basal ganglia and cerebellum on cortical and brain motor mechanisms.</li> <li>5. Motor function of the brain stem, vestibular apparatus and equilibrium</li> <li>6. Motor functions of the spinal cord-reflexes</li> <li>7. Diseases of the Nervous System – Parkinson’s Disease</li> </ol>	<b>4</b>	<b>15</b> 1 3 2 2 2 2 3
<b>SMSLSC304</b>	<b>4</b>	<b>IPR &amp; Neuroethics</b> <ol style="list-style-type: none"> <li><b>A. IPR patents related to neuroscience</b> <ol style="list-style-type: none"> <li>1. Example : Piracetam, Levitracetum (a GABA derivative).</li> <li>2. Levodopa and therapeutic applications.</li> <li>3. Gabapentin and Neuropathic pain.</li> <li>4. Ethical usage of drugs for multiple indications: Carbamazepine /Valproate.</li> <li>5. Personalised drug : Thiopurine.</li> <li>6. Life style drugs, Assessment Neuro-technologies, Intervention Neuro-technologies.</li> </ol> </li> <li><b>B. Neuroethics:</b> <ol style="list-style-type: none"> <li>1. An introduction to Neuroethics</li> <li>2. Reading the brain-state of consumers</li> <li>3. Neurodisability and criminal justice system</li> <li>4. Brain imaging and criminal justice system</li> <li>5. Use of Neurotechnology for litigation</li> <li>6. Pharmaceutical brain enhancement</li> <li>7. Use of amphetamine in Military environment</li> </ol> </li> </ol>	<b>4</b>	<b>15</b> 1 1 1 2 1 2 1 1 1 1 1 1

## **SEMESTER III**

### **PRACTICAL**

#### **Course Code: 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 fibres using a suitable source.
6. Preparation of permanent slides and submission of two slides: a) Forebrain, b) midbrain, c) hindbrain, d) invertebrate brain.
7. Temporary mount of vertebrate muscle
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, Synaptic transmission
10. Functional physiology using Biopac – EEG (Electroencephalogram)
11. Functional physiology using Biopac –GSR (Galvanic skin response)
12. Functional physiology using Biopac –ECG (Electrocardiogram),
13. Functional physiology using Biopac –EOG (Electro- oculogram)
14. Demonstration of EMG measurement using BioPac
15. 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).

#### **Course Code: SMSLSCP303**

16. Haematoxylin and eosin staining of neuronal / glial cultured cells.
17. Biochemical estimations / Histochemical localizations in brain tissue:
  - i.  $\text{Na}^+/\text{K}^+$  -ATPase
  - ii. AChE
  - iii. NOS
18. TLC to separate brain phospholipids using day 3, day 6 and adult chick brain.
19. To prepare a smear of retinal neurons from Avian eye and to observe retinal morphology of developing eye.
20. One day visit to a Neuropathology teaching Centre
21. Interpretation of FMRI/FRET /FRAP images

**Course Code: SMSLSCP304**

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



## SEMESTER IV

### COURSE CODE: SMSLSC401

#### PAPER –I DEVELOPMENT NEUROBIOLOGY

#### Learning Objectives:

To enable understanding of:

- The various processes involved in development of a functional nervous system
- Disorders and genetic diseases associated with the developing brain
- Sexual Differentiation of the Nervous System
- Ageing of the brain and its associated diseases

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC401	1	<b>Developmental Neurobiology</b>	4	15
		<b>A. Early Development and Patterning of CNS</b> 1. Axis formation (anterior-posterior and dorso-ventral axis) – role of Hox genes, 2. Neural Induction – neural tube regionalization  <b>B. Cellular Determination and Differentiation</b> 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		
SMSLSC401	2	<b>Axon Guidance and Synapse formation</b> <b>A. Growth cones and axonal pathfinding</b> 1. Differences between early development of axons and dendrites Growth cone structure and formation 2. Guidance cues in axonal pathfinding <b>B. Formation and Elimination of Synapses</b> 1. Principles of synaptic differentiation (with neuromuscular junction as an example) 2. Synapse formation in the CNS 3. Refinement & elimination of synaptic connections <b>C. Early Experience and Critical Periods</b> 1. Effect of visual experience on refinement of cortical connections, Critical periods of brain development	4	15

		2. Effect of early social deprivation on brain and behaviour		3
<b>SMSLSC401</b>	<b>3</b>	<b>Developmental disorders and genetic diseases:</b> 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	<b>4</b>	<b>15</b> 3 6 2 2 2
<b>SMSLSC401</b>	<b>4</b>	<b>The Altered Brain</b> <b>A. Sexual Differentiation of the Nervous System</b> 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>B. The Ageing Brain</b> a. Changes in structure and function of brain with age Cognitive decline in diseases – Dementia and Alzheimer's	<b>4</b>	<b>15</b> 5 3 3 4

**COURSE CODE: SMSLSC402**

**PAPER –II BEHAVIOURAL NEUROBIOLOGY**

**Learning Objectives:**

To enable the understanding of:

- Brain and behavior, connections established between the physiology and functions of the brain to the activities.
- Cognitive and emotional aspects of the brain.
- Diseases associated with the behavioural disorders and neurological correlates of sleep.

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC402	1	<b>Brain and Behavior:</b> <b>A. Introduction to behavior</b> 1. Types of behavior 2. Behavior in nature and under laboratory conditions. 3. Development of behavioral paradigms - Invertebrate and vertebrate model system. <b>B. Evolution of brain and behaviour</b> 1. Brain- like function in unicellular organisms. 2. Nerve nets, invertebrate nervous system and types of behaviour. <b>C. Evolution of social behaviour-</b> language (FOXP2 gene), mirror neurons their role and association with brain throughout evolution.	4	15 1 2 3  2 3 4
SMSLSC402	2	<b>Cognitive development and Behavioral Disorders</b> <b>A. Cognitive development:</b> 1. Approaches to development of Cognition-Behavioral-basic mechanisms of learning Psychometric – 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>B. Behavioral disorders and therapies</b> Disorders of thought and volition: Schizophrenia- diagnosis, genetic and	4	15 2  1 1 1  1 1 4

		<p>non-genetic risk factors, neuroanatomic abnormalities, therapy</p> <p>2. Disorders of mood and anxiety-diagnosis, genetic and non-genetic risk factors, neuroanatomic abnormalities, psychotherapy</p> <p>Personality disorders- diagnostic features of personality disorders.</p>		4
<b>SMSLSC402</b>	<b>3</b>	<p><b>Emotions</b></p> <p><b>A. Neuroscience of Emotions</b></p> <p>1. An overview of theories of Emotions. Dimensions of Emotion</p> <p>2. Emotional Arousal and Memory</p> <p>3. Anatomy of an Emotional memory</p> <p>4. Amygdala and Emotional experiences</p> <p>5. Emotional Regulation/Self-regulation.</p> <p><b>B. The Nucleus of Accumbens</b></p> <p>6. An integration centre for cognitive and behavioural functions.</p> <p>7. Neuropathological Mechanisms underlying Drug addiction (Glutamate signal transduction)</p> <p>8. Pharmacological Inhibition of Drug seeking behaviour.(Manipulation of glutamate systems)</p>	<b>4</b>	<b>15</b>
<b>SMSLSC402</b>	<b>4</b>	<p><b>Sleep and Dreams, Consciousness</b></p> <p><b>A. Sleep and Dreaming:</b></p> <p>1. Circadian rhythms in the animal world</p> <p>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</p> <p>3. Hypothalamic control of sleep cycle</p> <p><b>B. Neuroscience of Consciousness</b></p> <p>1. Consciousness in other species, Arousal &amp; consciousness,</p> <p>2. Neural correlates of perception and consciousness; free will</p> <p>3. Contemporary model for consciousness</p>	<b>4</b>	<b>15</b>

**COURSE CODE: SMSLSC403**

**PAPER –III BEHAVIOURAL NEUROSCIENCES II**

**Learning Objectives:**

- Understand types of learning, the processes, including information encoding, storing, and retrieval.
- To study learning and memory processes at cellular and molecular level.
- Understanding the complex language processing, Neural pathways leading to the ability of encoding ideas into signals.
- An interdisciplinary topic of economics, psychology and neuroscience enabling the learner to understand theory of human decision making.
- Application of neuroscience to marketing, use of imaging technology to understand consumer behaviour.

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC403	1	<b>Learning and Memory-I</b> 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	<b>Learning and Memory- II</b> 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 <b>A. Attention:</b> 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>B. Thought and working memory</b>	4	15 2 2 2 3 1 2 2 1

SMSLSC403	3	<p><b>Language and speech</b></p> <p><b>Language</b></p> <ol style="list-style-type: none"> <li>1. Communication in other animals. (eg. Bird song) 2</li> <li>2. Human language and its attributes (phonemes) morphemes, words and Cortical regions involved in language processing. 3</li> <li>3. Model for neural basis of language. 3</li> <li>4. Aphasia, functional MRI and current understanding of language processing. 2</li> <li>5. Language acquisition and its universality. 2</li> </ol> <p>Role of language in other cognitive function. 3</p>	4	15
SMSLSC403	4	<p><b>Neuroeconomics and Neuromarketing</b></p> <p><b>A. Neuroeconomics:</b></p> <ol style="list-style-type: none"> <li>1. Introduction and scope of Neuroeconomics 1</li> <li>2. Basics of economics 1</li> <li>3. Neuroanatomy, Neurophysiology, and Neuroimaging: Tools of Neuroeconomics 2</li> <li>4. Introducing Brain Models of Decision-Making and Choice</li> <li>5. Neural Representation of Subjective Value 1</li> <li>6. Affective Mechanisms of Decision-Making 1</li> <li>7. Dual Process Theory of Decision-Making: Toward a Neuroeconomics Perspective 1</li> <li>8. Decision-Making under Risk: Toward a Neuroeconomics Mechanism 1</li> <li>9. The Social Brain: Games in the Brain 1</li> <li>10. Evolutionary Perspective of Decision-Making 1</li> </ol> <p><b>B. Neural Marketing</b></p> <ol style="list-style-type: none"> <li>1. What is Neuromarketing? 1</li> <li>2. Role of Attention &amp; Consciousness and Learning &amp; Memory 1</li> <li>3. Sensory Neuromarketing 1</li> <li>4. Emotions &amp; Feelings, Wanting &amp; Liking 1</li> <li>5. Neuroethics and Consumer Aberrations 1</li> </ol>	4	15

**COURSE CODE: SMSLSC404**

**PAPER –IV MOLECULAR NEUROBIOLOGY AND DISEASE PATHOLOGY**

**Learning Objectives:**

To enable the understanding of:

- Molecular basis of neurological disease, therapeutic implications, recent techniques
- Bioinformatics with emphasis on structural biology and neuropharmacology

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC404	1	<b>Neurotoxicology and Neuropharmacology</b>	4	<b>15</b>
		<b>A. Neurotoxicology:</b> 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>B. Nanoparticles:</b> 1. Cell – nanoparticle interface. 2. Other applications of nanoparticles in neuroscience – Imaging, Drug / Gene delivery (across Blood brain barrier)		2 4 4 2 3
SMSLSC404	2	<b>Neurodegenerative diseases</b>	4	<b>15</b>
		<b>A. Molecular basis of neurodegenerative diseases</b>		4
		<b>Infectious Diseases</b> 1. Leprosy 2. Prions Disease <b>B. Degenerative diseases of the Nervous system</b> 1. Genetic mechanisms – Huntington’s Disease, Duchenne Muscular Dystrophy Myopathies and Neuropathies 2. Malnutrition Diseases – Kwashiorkor and Marasmus 3. Tumours of the CNS – neuroblastomas, medulloblastomas and gliomas		4 3 4

SMSLSC404	3	<p><b>Recent Techniques in Experimental Neurosciences</b></p> <p><b>A. Advances in molecular biology techniques in Neurosciences</b></p> <ol style="list-style-type: none"> <li>1. Genomics: Impact of human genome project on neuroscience research Proteomics in Neuroscience</li> <li>2. The connectome project</li> </ol> <p><b>B. Molecular screens and Making and Using Transgenic organisms:</b></p> <ol style="list-style-type: none"> <li>1. cDNA microarray, RNAi screens, Nextgen sequencing.</li> <li>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</li> <li>3. Binary transgenic systems: Gal4/UAS, Cre/lox, Flp/Frt, Tet-off/Tet-on</li> </ol>	4	<p><b>15</b></p> <p>2</p> <p>3</p> <p>3</p> <p>4</p> <p>3</p>
SMSLSC404	4	<p><b>Structural Bioinformatics and Drug Designing</b></p> <p><b>A. Structural Bioinformatics:</b></p> <ol style="list-style-type: none"> <li>1. Prediction of protein secondary structure: PHD and PSI-PRED method.</li> <li>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.)</li> <li>3. Homology Modeling, fold recognition, threading approaches, and ab-initio structure prediction methods.</li> </ol> <p><b>B. Applications of Bioinformatics</b></p> <ol style="list-style-type: none"> <li>1. <b>Drug designing:</b> Drug targets, Lead Identification and Modification, Computer-Aided Drug Design.</li> <li>2. <b>Chemi-informatics:</b> Introduction and History cheminformatics, Search types, data representation – SMILES, Virtual screening, Quantity Structure Activity Relationship, Applications of cheminformatics</li> <li>3. <b>Immunoinformatics</b></li> <li>4. <b>Toxico-omics and predictive toxicology</b></li> </ol>	4	<p><b>15</b></p> <p>2</p> <p>3</p> <p>3</p> <p>2</p> <p>3</p> <p>1</p> <p>1</p>



## **SEMESTER IV**

### **PRACTICAL**

#### **Course Code: SMSLSCP401**

1. Morphometric study in developing chick / zebrafish brain
2. LDH pattern of developing brain
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 using ELISA

#### **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 visual Search
9. Intelligence tests, Personality tests, Projective tests, any other psychological tools
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 model system.
12. Study of histopathological correlates of neurotoxicity using permanent slides/ photographs.
13. Preparation of any nanoparticle and its characterization
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 cell culture
16. Extraction of RNA from brain / neural cell culture
17. PCR of gene from neural tissue and demonstration of PCR product using AGE
18. RFLP analysis of PCR product
19. Real time PCR/Western Blot (Demonstration)
20. Bioinformatics:
  - i. Protein structure classification: CATH and SCOP
  - 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 neuro proteins)
  - 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, 5<sup>th</sup> 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, 4<sup>th</sup> Edition. *Elsevier Inc*.
5. Sanes D. (Ed.) Development of Nervous system, 2011, 3<sup>rd</sup> 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, 3<sup>rd</sup> Edition, *Lippincott Williams and Wilkins*.
8. Nicholls J., Martin R., Wallace B., Fuchs P. From Neuron to brain, 2001, 4<sup>th</sup> Edition, *Sinauer Asso. Inc*.
9. Purves D., Augustine G., Fitzpatrick D., et al. Neuroscience, 2011,5<sup>th</sup> 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, 7<sup>th</sup> Edition, *Academic Press*.
12. Martin J. B. Molecular Neurobiology, 1998, *Scientific American*.
13. Crossman A.R., Neary D. Neuroanatomy: An Illustrated coloured text, 2015, 5<sup>th</sup> 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, 2<sup>nd</sup> Edition, *Elseiver*.
19. Bermudez J. Cognitive Science: An introduction to the science of Mind, 2010, *Cambridge University Press*.
20. Kalat J. Biological Psychology, 2009 10<sup>th</sup> Edition, *Wadsworth Cengage Learning*.
21. Eichenbaum H. (Ed.) The cognitive Neuroscience of Memory: An introduction, 2012, 2<sup>nd</sup> Edition, *Oxford University Press*.
22. Harvey RA. Pharmacology (Lippincott's Illustrated Reviews), 2011, 5<sup>th</sup> Edition, *Pub Volters Kluwer (India) Pvt Ltd*.
23. Richard H., Whitbourne S. Abnormal Psychology – Clinical Perspectives on Psychological Disorders, 2010, 6<sup>th</sup> Edition, *Tata McGraw Hill Education Pvt. Ltd*.
24. Purves D., Brannon E., Cabeza R., et al. Principles of Cognitive Neuroscience, 2008 1<sup>st</sup> 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 the frontiers of Science*, 2008, *Penguin*.
30. Gilbert P. *Depression: The Evolution of Powerlessness*, 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*. 4<sup>th</sup> 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>