## Curriculum (2015-17)

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JIWAJI UNIVERSITY, GWALIOR  
MASTER OF SCIENCE (M.Sc.) IN NEUROSCIENCE

**Goal and Objectives:**
The major goal of introducing a M.Sc. Neuroscience course is for development of trained manpower having a broad overview of the different aspects of neuroscience. It is planned to teach this course at the postgraduate level, imparting the broad perspective of the different disciplines, which comprise neuroscience over a two-year period.

**The Training:**
It is hoped that the M.Sc. Neuroscience programme would offer training in neuroscience to graduates who would then be well equipped to take up their Ph.D. work in specific areas of brain research. The students with a M.Sc. in Neuroscience Degree would have acquired the basic knowledge in major disciplines of neuroscience, such as neuroanatomy, neurophysiology, neurochemistry, molecular neurobiology, neurogenetics, cognitive neuroscience and the knowledge of working of motor, sensory and regulatory systems. The development and regeneration of the brain as well as the knowledge in basics of clinical neuroscience in terms of diseases and diagnostic tools would also be provided. The students would also acquire practical knowledge in the above aspects as well as in research methodology and computational skills.

**SYLLABUS (2015-2017)**

Master of Science in Neuroscience course shall comprise of four semesters of six months duration each. The following is a summary of the course, which is followed by detailed descriptions:

**M.Sc. Neuroscience: Theory and Practical Courses**

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### Detailed Syllabus (2015-2017)

#### Semester-I (Credits 24)

**NS/101: CELL BIOLOGY AND NEURON ORGANIZATION**

_Credits: 3_

**Note:** Neurons contain the same intracellular components, as do other cells. Understanding of brain function would absolutely need a clear understanding of the cellular and molecular organization of neurons and glia as units. Thus in this paper the student is expected to learn in greater details the subcellular and molecular organization of neurons and glia. The paper to be taught in about 40 lectures each of 90 minutes duration. In view of the explosion of knowledge in Cell Biology we have tried to detail out the important aspects in each topic to easily confine to a limit in teaching.

**Unit-I**

1. Membrane Structure and Function, structural models; Composition and dynamics
2. Transport of ions and macromolecules; Pumps, carriers and channels
3. Endo- and exocytosis; Membrane carbohydrates and their significance in cellular recognition; Cellular junctions and adhesions
4. Nucleus – Structure and function of nuclear envelope, lamina and nucleolus; Macromolecular trafficking; Chromatin organization and packaging

**Unit-II**

5. Cell cycle and control mechanisms
6. Mitochondria — Structure; Organization of respiratory chain complexes; ATP synthase; Structure-function relationship; Mitochondrial DNA and male sterility
7. Structure and function of Golgi apparatus, lysosomes and endoplasmic reticulum
8. Organization and role of microtubules and microfilaments; Cell shape and motility
9. Actin-binding proteins and their significance; Muscle organization and function; Molecular motors; Intermediate filaments; Extracellular matrix in animals

**Unit-III**

10. An overview of the nervous system
12. Classification and types of neurons, Cytology of neurons
13. Dendrites structure and function, Axons structure and functional aspects, myelination and synapses

**Unit-IV**

15. Types of astrocytes – type I & II astrocytes, fibrous and protoplasmic astrocytes, importance of astrocytes in glutamate metabolism and blood brain barrier
16. Functions of other glial cells: oligodendrocyte and microglial cells, Microglial phenotypes,
17. Overview of glial and neuronal relationship in the CNS
18. Glial–neuronal interplay in the CNS

**Suggested Books:**


**NS/102: NEUROANATOMY**

_Credits: 3_

**Note:** It is expected that a student of M. Sc. Neuroscience should have basic understanding of the anatomical organization of the nervous system during the 1st semester so that he/she is able to correlate the functional aspects in subsequent stages of learning.

**Unit-I**

1. Gross anatomy of the adult brain; organization of the nervous system
2. Subdivisions of the nervous system; Concept of CNS, ANS & PNS
3. The scalp, skull and meninges
4. Cerebrospinal fluid
5. Constitutions of CNS: Overview; Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of axons

**Unit-II**

6. Peripheral nervous system; General organization: nerves, roots and ganglia; sensory endings
7. Spinal cord; Gross anatomy, internal structure, tracts of the ascending and descending fibers, spinal reflexes;
8. Brainstem: Medulla oblongata, pons, fourth ventricle, Midbrain, nuclei and tracts, reticular formation
9. Cranial nerves: Functional aspects, classification of cranial and spinal nerve components

Unit-III
10. Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of Thalamus: Scheme of thalamic organization, nuclei of the thalamus;
11. Functional aspects, classification of cranial and spinal nerve components
12. Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of Basal ganglia: Corpus striatum, subthalamic nucleus, substantia nigra
13. Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of Cerebellum: Gross anatomy, cerebellar cortex, central nuclei, cerebellar peduncles, Functional anatomy of cerebellum

Unit-IV
15. Ascending sensory pathways, Descending motor pathways
16. Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of Auditory system
17. Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of Visual system
18. Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of olfactory system and Limbic system

Suggested Books:
3. Susan Standring (Editor-in-Chief), Gray’s Neuroanatomy: The Anatomical Basis of Clinical Practice (39th Edition), Elsevier, 2005

NS/103: GENETICS AND MOLECULAR BIOLOGY

Credits=3
Note: Current advances in molecular neurobiology and genetics have encouraged the neurobiologists to make strides in revealing more about gene expression in nervous system, elucidating nervous system development and understanding the genetic basis of diseases affecting human behaviour. With the belief that there is a molecular basis for memory, behaviour and mental abilities, in about 40 lectures the basics of genetics and molecular biology shall be taught to the students in this paper.

Unit-I
1. Introduction to genetics; Role of genetics in medicine; Mendel's laws of inheritance; Linkage, crossing over and chromosome mapping
2. Mutations; Oncogenes and Tumor suppressor genes; Nonsense, missense and point mutations; Intragenic and intergenic suppression; Frame shift mutations; Physical, Chemical and biological mutagens
3. Transposition - Transposable genetic elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutation
4. Viral and cellular oncogenes; Tumor suppressor genes from humans; Structure, function and mechanism of action of p53 and p53 tumor suppressor proteins
5. Activation of oncogenes and dominant negative effect; Suppression of tumor suppressor genes; Oncogenes as transcriptional activators

Unit-II
6. Organization of bacterial genome; DNA as genetic material; Structure of DNA; Structure of eucaryotic chromosomes
7. Role of nuclear matrix in chromosome organization and function; Matrix binding proteins; Heterochromatin and Euchromatin
8. DNA re-association kinetics (Col curve analysis); Repetitive and unique sequences; Kinetics and sequence complexities; Satellite DNA; DNA melting and buoyant density; Packing and organization of chromatin; Nucleosome phasing; DNase I hypersensitive regions; DNA methylation & Imprinting
9. DNA Replication; Repair & Recombination: Concepts of replication initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins involved in DNA replication; Fidelity in replication; Replication of single stranded circular DNA
10. Gene stability and DNA repair; DNA repair enzymes; Photoreactivation; Nucleotide excision repair; Mismatch correction; SOS repair

Unit-III
11. Recombination: Homologous and non-homologous recombination; Site specific recombination; Holliday structure; Resolution; Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLPe/FRT and Cre/Lox recombination RecA and other recombinases
12. Prokaryotic Transcription & Regulation; Promoters; Regulatory elements; Transcription unit; Constitutive and Inducible promoter; Operators; Initiation; Attenuation; Termination; Rhodependent and Independent termination; Anti-termination; Transcriptional regulation; Positive and negative regulation
13. Operon concept; Regulation of transcription of lac, trp, ara, his, and gal operons; Transcriptional control in lambda phage; Transcript processing; Processing of tRNA and rRNA
14. Eukaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Activators and repressors;

Unit-IV
15. Transcription initiation, elongation and termination; Activation and repression; Transcriptional and post-transcriptional gene silencing; Expression and processing of heterogeneous nuclear RNA, rRNA, tRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA.
16. Translation & Transport: Translation machinery; Mechanism of initiation, elongation and termination, Ribosome; Composition and assembly of Protein synthesis
17. Co-and post-translational modifications; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation.
18. Universal genetic code; Degeneracy of codons; Termination codons; Isoaccepting tRNA; Wobble hypothesis; Genetic code in mitochondria;

Suggested Books:
2. Stickberger, Genetics (3rd Edition), PHP Press, 2004
5. Griffiths & Miller, Introduction to Genetic Analysis (7th Edition), Freeman, 2005
7. Smith, Elements of Molecular Neurobiology, Wiley, 2002

NS/104: LABORATORY TOOLS AND TECHNIQUES
Credits=3
Note: The prime objective of the course is to develop trained manpower that would take up the challenges of neuroscience research. In view of this selectivity methods in neurobiology research have been included in this paper so that the student will have a feel of the contemporary techniques and the methods employed in neurobiology research. They will be taught about the principles and applications of such methods. However, extensive details with wide range of examples shall be avoided.

Unit-I
1. Principles of fixation and staining of nervous tissue; Methods of tissue processing for microscopy, cryotomy and vibratome.
2. Golgi and other impregnation methods
3. Immunocytochemistry: Principles and applications
4. Basic concepts of microscopy, stereology and image analysis; Principles and applications of confocal microscopy
5. Principles and applications of fluorescence microscopy, scanning and transmission electron microscopy

Unit-II
6. Tools in electrophysiological studies of the brain in animals
7. Different types of mazes and their application in studies on behavior, learning and memory and cognitive aspects of animals; Animal activity monitoring, Rotarod, grip strength meter; Pain sensitivity testing with the help of tail-flick instrument and paw test
8. Spectroscopy Techniques: UV, Visible Spectroscopy; Fluorescence; MS, NMR
9. Chromatography Techniques: Chromatographic methods for macromolecule separation- TLC and Paper chromatography; Gel permeation, ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and FPLC
10. Electrophoretic techniques: Theory and application of Polycrylamide and Agarose gel electrophoresis and brief idea about other types of electrophoresis

Unit-III
11. Centrifugation; Principle and types of centrifuges and their applications
12. Recombinant DNA technology; Preparation of recombinant DNA (Gene cloning)
13. Preparation of genomic and c-DNA libraries, General idea of expression library; screening of gene libraries
14. Methods in gene analysis: Hybridization techniques; Southern, Northern, Western, Dot and slot blots and in situ hybridization
15. General idea of DNA sequencing, chromosome walking, foot printing, RT-PCR and finger printing

Unit-IV
16. Imaging techniques: MRI, PET, SPECT, MRT/FLMRT
17. Principle of experimental design; Collection of data, sampling and presentation of data Statistical tables, charts and graphs

Jiwaji University, Gwalior
18. Centering constants and their measurements: Mean, median and mode; Measurement of
   variability; like deviation, standard deviation, standard error, etc.
19. Tests of significance: Student t-test, Chi-square test; ANOVA: one way and two-way;
   Coefficient of correlation and regression

Suggested Text Books
4. Bancroft, Theory and Practice of Histological Techniques (Edition),
   Churchill Livingstone,
5. Wadhwa & Dinda, Stereology, Image Processing and Quantitative, Image Analysis in
   Biomedical Research

NS105: PRACTICAL- CELL BIOLOGY AND GENETICS

1. Microscopy/Cryotomy/Vibratome
2. Histology: General methods: Hematoxylin & Eosin staining, Cresyl violet (Nissl) staining
3. Histochemical demonstration of the following in brain tissue:
   a) Lipids
   b) Proteins
   c) Carbohydrates
   d) Enzymes and
   e) Nucleic acids
4. Golgi technique for nerve fibers
5. Study of permanent slides and electron micrographs
6. Study of mitotic chromosomes from rat bone marrow
7. Study of polyethylene chromosomes in Chironomus/Blow Fly larvae etc.

NS/106: PRACTICAL-NEUROANATOMY

1. Dissection of nervous system in invertebrates and vertebrates
2. Dissection of nervous system of rat as experimental model
3. Procedure for removal of various parts of brain in rat and other experimental animals
   for further study
4. Perfusion techniques
5. Processing and handling of tissue for microanatomy of brain
6. Study of gross anatomy and pre-dissected human brain
7. Immunocytochemistry: Tissue processing, Immunoenzymatic and immunofluorescence
   methods
8. Fluorescence microscropy and immunofluorescence

NS/107 ASSIGNMENT/PERSONALITY AND SKILL DEVELOPMENT

NS/108 SEMINAR-1

NS/109 COMPREHENSIVE VIVA-VOCE EXAM
Semester-II (Credits=24)

NS/201: BIOCHEMISTRY  
Credits=3

Note: Here we aim to let the students learn the language of biochemistry, get a balanced understanding of
the physical, chemical and biological properties of biomolecules, their reactivity and pathways in which
they operate, get exposed to the themes related to evolution, dynamics, regulation and the biochemical
relationship between the structure and function. The topics to be taught in a manner that the opportunity
in identifying gaps in our knowledge which can challenge the future generation of neuroscientists in better
understanding of the biochemical aspects in relation to brain function and disorders.

Unit-I
1. Chemical basis of life; Composition of living matter; Water – properties, pH, ionization and
   hydrophobicity; Biomolecular hierarchy;
2. Macromolecules; Molecular assemblies; Structure-function relationships
3. Amino acids – structure and functional group properties; Peptides and covalent structure of
   proteins
4. Elucidation of primary and higher order structures; Evolution of protein structure
5. Structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin,
   chymotrypsin etc.

Unit-II
6. Enzyme catalysis – general principles of catalysis; Quantitation of enzyme activity and
   efficiency
7. Enzyme characterization and Michaelis-Menten kinetics; Relevance of enzymes in metabolic
   regulation; Activation, inhibition and covalent modification; single substrate enzymes
8. Sugars – monos, dis, and polysaccharides; suitability in the context of their different functions;
   cellular structure, energy storage, signaling;
9. Glycosylation of other biomolecules - glycoproteins and glycolipids

Unit-III
10. Lipids - structure and properties of important members of storage and membrane lipids;
    lipoproteins
11. Biomembrane organization - sidedness and function
12. Membrane bound proteins - structure, properties and function; transport phenomena
13. Nucleosides, nucleotides, nucleic acids - structure, diversity and function; sequencing; Brief
    overview of central dogma

Unit-IV
14. Bioenergetics-basic principles; Equilibria and concept of free energy; Coupled processes;
15. Glycolytic pathway; Krebs’s cycle; Oxidative phosphorylation;
16. Elucidation of metabolic pathways; Logic and integration of central metabolism;
17. Entry/ exit of various biomolecules from central pathways
18. Principles of metabolic regulation; Regulatory steps; Signals and second messengers.

Suggested Books:
5. P.S. Bisen & Anjana Sharma, Introduction to Instrumentation in Life Sciences, CRC 2013

NS/202: NEUROCHEMISTRY

Credits=3

Note: The topics included in neurochemistry are in line with the neurochemistry curriculum developed by a
group of Neurochemists at a conference organized for the purpose and subsequently updated with every
new edition of Basic Neurochemistry by Siegel. This paper is appropriate for postgraduate students in
neuroscience expected to take up research in modern areas of neuroscience to be covered in about 40
classes of 90 minutes duration. It is expected that the students would learn the basics of neurochemistry.

Unit-I
1. Synaptic transmission and cellular signaling: An overview
2. Acetylcholine: Chemistry, synthesis, storage and release; Nicotinic and muscarinic receptors
3. Catecholamines: Biosynthesis, storage and release; Dopamine, adrenergic receptors
4. Serotonin: Synthesis, action and distribution; Role of serotonin receptors in behavior
5. Excitatory amino acid transmitters: Synthesis, metabolism, distribution and receptor subtypes

Unit-II
6. Histamine: Dynamics, molecular sites and action in the CNS
7. GABA, glycine: Synthesis, uptake and release; Receptors of GABA and glycine
8. Neuropeptide neurotransmitters: Biosynthesis, function regulation and receptors
9. Opioid peptide and opioid receptors: Synthesis, metabolism, distribution and receptor subtypes
Unit-III
10. CSF: Microcirculation and blood brain and CSF barriers
11. Intracellular signalling: G proteins and second messengers
12. Metabolism: Energy metabolism of the brain; Hypoxic-ischemic brain injury and oxidative stress
13. Metabolic encephalopathies

Unit-IV
14. Eicosanoids, docosanoids, platelet-activating factor and inflammation
15. Mechanism of action of drugs
16. Drug addiction, drug abuse and adverse drug reaction
17. Neuroendocrinology of behaviour
18. Apoptosis and necrosis

Text Books
2. Frielder, Pracatical Biochemistry

NS/203: DEVELOPMENTAL NEUROBIOLOGY
Credits=3

Note: The aim of this paper is to provide a contemporary overview of neural development to the postgraduate students who by now shall have some background in the fields of modern biology in general and neurobiology in particular. The topics are so included to understand the construction of brain in an integrated series of events beginning with the decision of few early embryonic cells to act as progenitors of the nervous system, i.e., from the formation of the neural plate to built up of complicated neuronal circuitry during embryogenesis and postnatal life. The teaching shall range from basics of embryonic development to developmental genetics.

Unit-I
1. Early embryology of metazoans: cleavage, formation of blastula and gastrula
2. Derivation of neural tissue and early neural morphogenesis in vertebrates and invertebrates
4. Patterning, polarity and segmentation of the nervous system: Regional identity of the nervous system. The anterior-posterior axis and Hox genes
5. Signaling molecules that pattern the anterior-posterior axis in vertebrates: heads or tails

Unit-II
6. Organizing centers in the developing brain. Forebrain development, prosomeres and Pax genes
8. Genesis and migration of neurons; cellular and molecular mechanisms describing the generation of appropriate number of neurons and glia from neuronal precursors
9. Generation of neurons and glia and control of neuronal and glial cell population
10. Histo genesis of cerebral cortex and cerebellar cortex. Molecular mechanisms of neuronal migration in PNS and CNS

Unit-III
11. Neurogenesis in post-embryonic and adult age
13. Asymmetric cell division and asymmetric fate. Specification and differentiation of vertebrate neural crests
15. Neurotrophic factors: Neurotrophins and their receptors. Intracellular-signaling pathways that mediate survival

Unit-IV
16. Axon growth, path finding and nerve patterns: Growth Cone, Dynamic cytoskeleton, axonal navigation and axon elongation. Directional information to growth cones: cell adhesion molecules, repulsive guidance, chemotaxis gradients and other guidance molecules: Target recognition and Target selection
17. Synapse formation and elimination: Initiation of synaptic contacts, structure and function of newly formed synapses. Presynaptic and postsynaptic elements, synapse elimination
18. Experience and Refinement of synaptic connections. Rearrangement of developing neuronal connections: Synaptic rearrangement in different parts of the nervous system
19. Denervation and regeneration of synaptic connections; Effects of Denervation on the postsynaptic cell; Denervation super-sensitivity, susceptibility to innervation, and axonal sprouting;
20. Repairing the damaged brain; Regeneration of central and peripheral axons in mammalian nervous system.

**Suggested Books:**

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**NS/204: CELLULAR NEUROPHYSIOLOGY AND BIOPHYSICS**  [Credits=3]

**Note:** This paper is expected to present both the established background and the important developments in brain research. The topics to be covered are in a concise enough manner so that the fundamentals be absorbed by a non-specialized student coming from a non-biology or biology background with in the limited term of 90 days teaching, assuming that the student has no prior knowledge of neuroanatomy or neurophysiology. The teaching to be carried out in a manner that the students understand the solid facts and have an effective brain storming to stimulate ideas in brain research on problems still unsolved.

**Unit-I**
1. Electrical properties of excitable membranes: Basic electricity and electric circuits,
2. Neurons as conductors of electricity, equivalent circuit representation
3. Electrical properties of excitable membranes: Membrane conductance, linear and nonlinear membrane, ionic conductance, current-voltage relations
4. Ion movement in excitable cells: Physical laws, Nernst-Planck Equation, active transport of ions, movement of ions across biological membranes
5. Membrane potential and role of sodium and potassium pumps

**Unit-II**
6. Neural Signals: Overview of Neurons, Synapses and Networks
7. Stimulus → Sensory Perception → Motor Action / Higher Brain Function
8. Chemical and Electrical Signaling Within a Circuit; Methods to Record Electrical Activity of a Neuron
9. Action potential, non-gated ion channels and generation of action potential

**Unit-III**
10. Electrical properties of neurons, quantitative models of simulations, Hodgkin & Huxley's analysis of squid giant axon; Voltage-clamp experiments;
11. Voltage gated channels; Biophysical, biochemical and molecular properties of voltage gated channels.
12. Synaptic vesicles; Principles of synaptic transmission: Electrical and chemical synapses
13. Calcium hypothesis: Control of transmitter release

**Unit-IV**
15. Synaptic transmission at nerve-muscle synapses
16. Synaptic transmission at central synapses
17. Ligand gated channels
18. Second messengers and synaptic transmission

**Suggested books:**

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Jiwaji University, Gwalior
NS/205: PRACTICAL-BIOCHEMISTRY AND MOLECULAR BIOLOGY
1. Handling of tissue for biochemical analysis
2. Detailed methods for preparation of buffers and solutions with special attention to normality, molarity, etc.
3. Quantitative estimation of proteins and carbohydrates in brain tissues
4. Electrophoresis/SDS PAGE
5. Demonstration and analysis of biomolecules using TLC/Paper chromatography
6. Isolation and purification of DNA and/or RNA and estimation of their concentration and purity check using UV-spectrophotometer
7. Restriction Digestion
8. Plasmid preparation
9. Ligation
10. Preparation of competent cells
11. Gene cloning methods

NS/206: PRACTICAL-NEUROPHYSIOLOGY
1. Acquisition of data for various physiological parameters using Biopac Electrophysiological recording setup:
   a) EEG
   b) ECG
   c) EMG, EOG
   d) Heart rate, respiration, pulse rate, heart sound, etc.
2. To determine pain sensitivity in rat/mice using Tail-Flick Analgesia meter and Paw test apparatus
3. To learn the use of Stereotoxic instrument for neuroscience research
4. Demonstration of basal metabolic rate
5. Effect of various neurotransmitters on fish melanophores
6. Pharmacological experiments on melanophores
7. Study of Physiology models related to neurophysiology

NS/207 ASSIGNMENT/PERSOANLITY AND SKILL DEVELOPMENT

NS/208 SEMINAR-II

NS/209 COMPREHENSIVE VIVA-VOCE EXAM
NS/301: IMMUNOLOGY  
Credits=3  
Note: This paper has been designed to provide an exposure to fundamental concepts of immunology from anatomy to clinical aspects. The student is expected to have an understanding of the subject to extend to be able to comprehend the bases of immunological disorders in general and the brain in particular.  
Unit-I  
1. Immunology- fundamental concepts  
2. Innate and acquired immunity, components of innate and acquired immunity  
3. Antibody structure, antigen-antibody interactions  
4. Cells and organs of the immune system and regulation of immune response  
5. Cellular basis of adaptive immunity, B-cell and antibodies  
Unit-II  
6. Generation of antibody diversity  
7. T cells, Helper T cells and lymphocytic activation  
8. MHC proteins  
9. Immunity to infection Bacterial, viral, fungal and parasitic infections (with examples from each group).  
Unit-III  
10. Overview of multiple sclerosis and autoimmune disease  
11. Mechanisms of neuroinflammation; Role of astrocytes, Schwann cells and microglia  
12. Hypersensitivity,  
13. Autoimmunity,  
Unit-IV  
14. Transplantation  
15. Tumor immunology and Immunodeficiency  
16. Neuro-AIDS  
17. Immunotechnology; Hybridoma technology, Monoclonal antibodies, Vaccines, DNA vaccines  
18. Immunochemical techniques antigen-antibody interactions and various cellular techniques  
Suggested Books:  

NS/302: SENSORY AND MOTOR SYSTEMS  
Credits=3  
Note: The basic senses-somatic sensations, olfaction, vision, audition, etc. all vary from one another. However, a few fundamental rules are followed by the brain in handling each of these diverse modalities. The central circuitry for sensory processing has well-organized maps which further determine interactions within and among the major categories of sensation. In this paper the students are expected to gain basic knowledge on neurobiology of sensation with the importance of structure-function relationships. Every conscious or unconscious behaviour is regulated by the brain and the spinal cord based on a set of muscular contractions. Thus understanding of the spinal circuitry that makes elementary reflex movements possible and the way the brain governs successful performance of complex motor acts is essential. The students shall be provided basic overviews on sensory and motor systems.  
Unit-I  
1. Sensation and perception, Organizational principles and coding mechanisms of sensory systems, Sensory Receptors, Parallel processing, Central processing, Common anatomical plan,  
2. Structure, function & connections of sensory cortex  
3. Somatosensory System: Peripheral mechanisms of somatic sensation, Spinal and Brainstem components of somatosensory system,  
4. Thalamic ventrobasal complex, somatosensory areas of cerebral cortex.  
5. Sensory transduction: Phototransduction, olfactory transduction, taste, mechanoreception  
Unit-II  
6. Touch: Active and passive touch, Properties and functional features of mechanoreceptors,  
7. Primary somatosensory cortex and information processing on touch, representation of body surfaces in the brain, cortical responses to stimuli.  
8. Pain: Nociceptors, Flow of nociceptive signals from nociceptors to neurons in the spinal cord, peripheral and central hyperalgesia, nociceptive pathways to thalamus, control of pain, opioid peptides and endogenous pain control  
9. Taste: Taste receptors and taste buds, turnover & replacement, Innervation by cranial nerves, Flow of gustatory afferent information, Extraction of sensory information, Tuning of peripheral taste fibers
10. **Olfaction:** Odor stimuli, Olfactory receptor cells, Molecular receptive ranges of olfactory cells, Convergence of olfactory projections, Information processing and the role of dendrodendritic synapses in the olfactory bulb, Olfactory cortex, Vomeronasal system and pheromones detection in Accessory Olfactory Bulb

**Unit-III**

11. **Vision:** Fundamental concepts in visual physiology, Eye and retina, Retinal ganglion cells, Basic retinal circuit, Lateral geniculate nucleus, Visual perception and geniculostriate pathway, Visual cortex
12. **Audition:** Amplitude and frequency ranges of hearing, External & Middle ear, The Cochlea, The auditory nerve, Descending systems to the periphery, Central Nervous System
13. **Fundamentals of Motor Systems:** Spinal cord as central pattern generator; Reflexes and locomotion, Brain projections to spinal cord; Posture and voluntary movement, Basal nuclei and cerebellum; Focusing and coordinating movement
14. **Muscle, Motor Neurons and Motor neuron pools:** Skeletal muscle, Motor Units, Motor neuron pools, Muscle afferents
15. **Spinal Motor control, Reflexes and locomotion:** Basic Principles, Reflexes, Interneurons associated with movements, Locomotion

**Unit-IV**

16. **Supraspinal Descending Control:** The medial "Postural" System: Ablation and transection studies; Sensory information about head posture, Postural reflexes of the head and the body; The role of Brainstem in controlling coordinated postural reactions, Vestibular damage & disorders of the postural control
17. **Voluntary Descending Control:** Cortical pathways to Motor Neurons, Organization of the Motor cortex, Control of voluntary movements by the motor cortex
19. **Basal Ganglia:** Anatomy of the Basal Ganglia, Signalling in Basal Ganglia, Effect of damage in behaviour, Fundamental Principles of Basal Ganglia operation
20. **Cerebellum:** Anatomy and Phylogenetic Development of the cerebellum, Assessing Cerebellar Function

**Suggested Text Books**


**NS/303: REGULATORY SYSTEM**

**Credits=3**

**Note:** This paper is expected to provide an overview of central regulation of major systems and autonomic functions. By the end of the term the student is expected to have a basic understanding of the central control of breathing, cardiovascular activities, circadian timings, sleep, psychosexual development, etc.

**Unit-I**

1. **Chemical Control of Brain and Behaviour:** Organizational Principles of Adult Hypothalamus
   - Role of hypothalamus and pituitary hormones
2. The ANS in regulation of brain and behaviour
3. ANS Pharmacology - Transmitter and Receptor Coding
4. **Autonomic Controls of Homeostasis:** Hierarchically Organized CNS Circuits
5. The diffuse modulatory systems of the brain: Locus coeruleus, raphe nucleus, substantia nigra, etc.

**Unit-II**

6. **Neural Control of the Breathing:** Early Neuroscience and the Brainstem, Breathing & gas exchange, CNS & Breathing, Respiratory Rhythm Generation
7. Sensory inputs and Altered Breathing, Modulation of Respiratory Motor Output
8. Suprapontine structures and Breathing, Respiratory neurons and their discharge pattern
9. **Cardiovascular System:** Basics of Cardiovascular physiology, Sympathetic VasoMotor Tone
10. Neural Control of Heart, Cardiovascular Homeostasis, The Nervous System and the Long-term control of the Cardiovascular System

**Unit-III**

11. Anatomy and Physiology of the Brainstem regulatory Systems
12. **Circadian Timing:** Pinea l and Circadian Rhythms, The Suprachiasmatic Nucleus, Light as the Dominant Stimulus
13. Circadian timings and reproduction, Heritability of Circadian Timings
14. Sex and behaviour: Neuronal basis of sexual behaviour, Sex Hormones and Brain, The Accessory Olfactory Pathway
15. Sleep and Dreaming: The two states of sleep - slow wave and rapid eye movement

**Unit-IV**

16. Maternal Stimulation and Male Psychosexual Development. Why and how male and female brains differ?
Suggested Text Books

NS/304: BEHAVIOUR AND COGNITIVE NEUROSCIENCE
Credits=3

Note: It is expected that in this paper the students will be exposed to the basic understanding of evolution of human brain and behaviour, cellular and genetics aspects of behaviour, cognitive development, neural control of attention, language acquisition and language processing, learning and memory, and cognitive functions like thought and consciousness. While this is the front line of neuroscience research today the students will be given the basic elementary exposure to the subject to stimulate them to undertake further research in this challenging area, it is essential to repeat that only introductory aspects of the subject shall be dealt.

Unit-I
1. A brief history of cognitive neuroscience
2. Organization of central nervous system in relation to cognition
3. Evolutionary and comparative principles, mammalian evolution
4. Human Brain Evolution
5. Brain and cognitive development

Unit-II
6. Aging and cognition
7. Pathological processes in cognitive development and aging
8. Cognitive functions of the motor system
10. Spatial cognition: Neural system of spatial cognition- Parietal cortex, Frontal cortex, Hippocampus and adjacent cortex

Unit-III
11. Theories of learning and memory: Models and mechanisms of short-term and long-term memory
12. Learning and Memory: Basic Systems: Basic mechanisms of learning, key insights from invertebrate studies, Classical conditioning in vertebrates
13. Long-term potentiation and long-term depression
14. Learning and memory: Brain systems, Major memory systems in mammalian brain, Multiple memory systems and behavior

Unit-IV
15. Attention: Verities of attention and Neglect syndrome, Visual system and attention
16. Language and communication: Animal communication, Human language, Neuronal organization for language
17. Executive brain functions: Role of prefrontal cortex, Neurophysiology of prefrontal cortex, Theories of prefrontal cortex function
18. Consciousness

Suggested Text Books

NS/305: PRACTICAL-NEUROPATHOLOGY
Credits=3

1. Neurotoxicological studies using animal models
2. Study of developing rat cerebellar cortex: Normative and under exposure to toxic agents
3. Study of human pathological tissue from different pathological conditions
4. Visits to neurology and neurosurgery clinics
5. Histopathological methods for analysis of pathological tissues
6. Study of neurodegenerative models:
   a. Nerve injury models: Sciatic nerve and facial nerve transection
   b. Intracerebroventricular infusion

NS/306: PRACTICAL-BEHAVIOUR BIOLOGY
Credits=3

1. Automated exploratory behaviour recording using activity monitor
2. Assessment of neuromuscular function/performance using Grip Strength Meter
3. Studies on locomotor behaviour in rats using Open Field test
4. Studies on spatial learning behaviour using T-maze with the help of Any Maze software
5. Studies on spatial learning behaviour using Y-maze with the help of Any Maze software
6. Elevated Plus maze for anxiety like behaviour with the help of Any Maze software
7. Morris water maze for learning and memory with the help of Any Maze software
8. Studies on locomotory development like: pivoting, traversing, homing, etc.
9. Maternal behaviour in rats and mice

NS/307 ASSIGNMENT/PERSOALITY AND SKILL DEVELOPMENT Credits=1
NS/308 SEMINAR-III Credits=1
NS/309 COMPREHENSIVE VIVA-VOCE EXAM Credits=4

Semester-IV (Credits=24)

NS/401: CLINICAL NEUROCHEMISTRY AND NEUROPATHOLOGY  
Credits=3

Note: Research in neuropathology/neurological disorders involves specific neurochemical changes. This paper will aim at introducing the students to the neurochemical bases of brain disorders and principles and applications of important diagnostic tools.

Unit-I
1. Neurochemical and molecular mechanisms of peripheral Neuropathy; Diseases involving myelin
2. Multiple sclerosis and other demyelinated disorders
3. Genetic disorders of Lipid, glycoprotein, and Mucopolysaccharide metabolism
4. Molecular and genetic aspects and diagnostic characteristics of Duchenne Muscular dystrophy
5. Nutritional and metabolic Diseases: Disorders of amino acid metabolism

Unit-II
6. Wernicke-Korsakoff syndrome; Pellagra; Alcoholic Cerebellar Degeneration
7. Metabolic Encephalopathies and Coma
8. Neurotransmitters and disorders of basal ganglia; Molecular targets of abused drugs
9. Ischemia and hypoxia
10. Epileptic seizures

Unit-III
11. Genetics and diagnosis of Huntington disease and other triplet repeat disorders
12. Alzheimer’s disease; Molecular, genetic, immunological aspects and diagnostics
13. Theories of aging; Neurobiology of aging: cellular and molecular aspects of neuronal aging
14. Aging and neurodegeneration
15. Parkinson’s disease

Unit-IV
16. Motor Neuron Diseases
17. Prion’s Disease
18. Biochemical aspects of the psychotic disorders
19. Biochemical basis of mental illness: Anxiety disorders; Mood disorders
20. Attention disorders; Schizophrenia

Suggested Books:
4. Duchene E. Haines, Fundamental Neuroscience for Basic & Clinical Applications (3rd Edition), Churchill
5. Livingstone, 2006

NS/402: RESEARCH METHODS, BIOSTATISTICS AND COMPUTER APPLICATIONS  
Credits=3

1. Collection of data for statistical analysis
2. Chi square test
3. Student ‘t’ test
4. ANOVA
5. Designing of an experiment for a hypothesis
6. Case studies at a neurology ward
7. Case studies of biological populations
8. Basics of animal handling and maintenance
9. Computer applications: Word, Excel and Power point
10. Image analysis
11. Stereology

NS/403: DISSERTATION  
Credits=12

The students are required to take up a study in an aspect of neuroscience. A dissertation/report has to be submitted at the time of examination. The work may be initiated at any point of time depending upon the capability of a student from earlier semesters as well. This is to provide a student real exposure to planning, execution and reporting of a research proposal.

NS/404: ASSIGNMENT/PERSONALITY AND SKILL DEVELOPMENT  
Credits=1

NS/405: SEMINAR-IV  
Credits=1

NS/406: COMPREHENSIVE VIVA-VOCE EXAM  
Credits=4