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 (2013-2015)

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*

Semester-I	EE	IA (Marks)
NS/101- Cell Biology and Neuron Organization	85	15
NS/102- Biochemistry	85	15
NS/103- Genetics and Molecular Biology	85	15
NS/104- Laboratory Tools and Techniques	85	15
NS/105- Laboratory Course-I: Cell Biology	100	
NS/106- Laboratory Course-II: Genetics, Biochemistry and Molecular Biology	100	
Semester-II		
NS/201-Neuroanatomy	85	15
NS/202-Immunology	85	15
NS/203-Developmental Neurobiology	85	15
NS/204-Cellular Neurophysiology and Biophysics	85	15
NS/205- Laboratory Course-III: Neuroanatomy	100	
NS/206- Laboratory Course-IV: Neurophysiology	100	
Semester-III		
NS/301- Neurochemistry	85	15
NS/302- Systems Neuroscience-I: Sensory and Motor Systems	85	15
NS/303- Systems Neuroscience-II: Regulatory System	85	15
NS/304-Behaviour and Cognitive Neuroscience	85	15
NS/305- Laboratory Course-V: Neuropathology	100	
NS/306- Laboratory Course-VI: Behavior biology	100	
Semester-IV		
NS/401-Clinical Neurochemistry and Neuropathology	85	15
NS/402- Nanotechnology and Bioinformatics for Neuroscience	85	15
NS/403- Laboratory course-VII: Research Methods, Biostatistics and Computer Applications	100	
NS/404- Dissertation	200*	
NS/405- Viva-voce related to the Dissertation	100*	

*= Evaluated both by the internal and external examiners at the time of presentation.
EE= External evaluation; IA= Internal assessment.

Detailed Syllabus (2013-2015)

Semester-I

NS/101: *CELL BIOLOGY AND NEURON ORGANIZATION*

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 sub-cellular 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

Membrane Structure and Function

Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Endo- and exocytosis; Membrane carbohydrates and their significance in cellular recognition; Cellular junctions and adhesions.

UNIT II

Organelles

Nucleus – Structure and function of nuclear envelope, lamina and nucleolus; Macromolecular trafficking; Chromatin organization and packaging; Cell cycle and control mechanisms; Mitochondria – Structure; Organization of respiratory chain complexes; ATP synthase; Structure-function relationship; Mitochondrial DNA and male sterility.

UNIT III

Endo-membrane System and Cellular Motility

Structure and function of microbodies, Golgi apparatus, lysosomes and endoplasmic reticulum; Organization and role of microtubules and microfilaments; Cell shape and motility; Actin-binding proteins and their significance; Muscle organization and function; Molecular motors; Intermediate filaments; Extracellular matrix in animals.

UNIT IV

An overview of the nervous system

Neurons: Introduction to neurons, The Neuron Doctrine, The Nissl and Golgi stains, Components of neurons, Classification and types of neurons, Cytology of neurons, Dendrites structure and function, Axons structure and functional aspects, ultrastructure, myelination and synapses.

UNIT V

Glial cells: Structure and function of glial cells, Different types of glial cells: astrocytes, oligodendrocytes and Schwann cells, Types of astrocytes – type I & II astrocytes, fibrous and protoplasmic astrocytes, Importance of astrocytes in glutamate metabolism and blood brain barrier, Functions of other glial cells: oligodendrocyte and microglial cells, Microglial phenotypes, Overview of glial and neuronal relationship in the CNS, Glial –neuronal interplay in the CNS.

Suggested Books:

1. Siegel, Basic Neurochemistry (7th Edition) Academic Press, 2006
2. Albertes, Molecular Biology of the Cell (5th Edition) Garland Science, 2008
3. Kendel, Principles of Neural Science (5th edition), McGraw Hill, 2013
4. Verkhratsky, Glial Neurobiology, A Text Book, Wiley, 2007

NS/102: *BIOCHEMISTRY*

Note: Here we aim to let the students learn the language of biochemistry, get a balance understanding of the physical, chemical and biological properties of biomolecules, their reactivities 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

Chemical basis of life; Composition of living matter; Water – properties, pH, ionization and hydrophobicity; Biomolecular hierarchy; Macromolecules; Molecular assemblies; Structure-function relationships

Amino acids – structure and functional group properties; Peptides and covalent structure of proteins; Elucidation of primary and higher order structures; Evolution of protein structure; Structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc.

UNIT II

Enzyme catalysis – general principles of catalysis; Quantitation of enzyme activity and efficiency; Enzyme characterization and Michaelis-Menten kinetics; Relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes

UNIT III

Sugars - mono, di, and polysaccharides; suitability in the context of their different functions-cellular structure, energy storage, signaling; Glycosylation of other biomolecules - glycoproteins and glycolipids;

Lipids - structure and properties of important members of storage and membrane lipids; lipoproteins

UNIT IV

Biomembrane organization - sidedness and function; Membrane bound proteins - structure, properties and function; transport phenomena Nucleosides, nucleotides, nucleic acids - structure, diversity and function; sequencing; Brief overview of central dogma

UNIT V

Bioenergetics-basic principles; Equilibria and concept of free energy; Coupled processes; Glycolytic pathway; Kreb's cycle; Oxidative phosphorylation; Elucidation of metabolic pathways; Logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; Regulatory steps; Signals and second messengers.

Suggested Books:

1. Nelson & Cox, Principles of Biochemistry (4th Edition), Freeman, 2005
2. Voet & Voet, Biochemistry (4th edition), Wiley Press, 2006
3. Stryer, Biochemistry (6th Edition), W.H. Freeman, 2007

NS/103: *GENETICS AND MOLECULAR BIOLOGY*

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

Introduction to genetics

Role of genetics in medicine; Mendel's laws of inheritance; Linkage, crossing over and chromosome mapping;

Mutations; Oncogenes and Tumor suppressor genes

Nonsense, missense and point mutations; Intragenic and Intergenic suppression; Frame shift mutations; Physical, chemical and biological mutagens; Transposition - Transposable genetic elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutation; Viral and cellular oncogenes; Tumor suppressor genes from humans; Structure, function and mechanism of action of pRB and p53 tumor suppressor proteins; Activation of oncogenes and dominant negative effect; Suppression of tumor suppressor genes; Oncogenes as transcriptional activators.

UNIT II

Genome organization

Organization of bacterial genome; DNA as genetic material; Structure of DNA; Structure of eucaryotic chromosomes; Role of nuclear matrix in chromosome organization and function; Matrix binding proteins; Heterochromatin and Euchromatin; Molecular components; DNA re-association kinetics (Cot 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

UNIT III

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; Gene stability and DNA repair; DNA repair enzymes; Photoreactivation; Nucleotide excision repair; Mismatch correction; SOS repair. Recombination: Homologous and non-homologous recombination; Site specific recombination; Holliday structure; Resolution; Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLP/FRT and Cre/Lox recombination RecA and other recombinases.

UNIT IV

Prokaryotic & Eukaryotic Transcription

Prokaryotic Transcription & Regulation; Promoters; Regulatory elements; Transcription unit; Constitutive and Inducible promoter; Operators; Initiation; Attenuation; Termination; Rho-dependent and independent termination; Anti-termination; Transcriptional regulation; Positive and negative regulation; 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

Eucaryotic 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; Transcription initiation, elongation and termination; Activation and repression; Transcriptional and post-transcriptional gene silencing; Expression and processing of heterogeneous nuclear RNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA.

UNIT V

Translation & Transport

Translation machinery; Ribosome; Composition and assembly; Universal genetic code; Degeneracy of codons; Termination codons; Isoaccepting tRNA; Wobble hypothesis; Mechanism of initiation, elongation and termination; Co- and post-translational modifications; Genetic code in mitochondria; Protein synthesis; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation.

Suggested Books:

1. Simmons, Principles of Genetics (7th Edition), Wiley, 2011
2. Strickberger, Genetics (3rd Edition), PHP Press, 2004
3. Albertes, Molecular Biology of the Cell (5th Edition) Garland Science, 2008
4. Lewin, Genes X, Jones & Bartlett, 2009
5. Griffiths & Miller, Introduction to Genetic Analysis (7th Edition), Freeman, 2005
6. Lodish, Molecular Cell Biology (4th Edition), Freeman, 2004
7. Smith, Elements of Molecular Neurobiology, Wiley, 2002

NS/104: *LABORATORY TOOLS AND TECHNIQUES*

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 selective 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

Microscopy

Principles of fixation and staining of nervous tissue; Methods of tissue processing for microtomy, cryotomy and vibratomy; Golgi and other impregnation methods; Immunocyto(histo)chemistry: Principles and applications; Principles and applications of fluorescence, confocal, scanning and transmission electron microscopy; Basic concepts of stereology and image analysis.

Unit-II

Neurophysiology, Behavior

Tools in electrophysiological studies of the brain in animals; animal activity monitoring; Different types of mazes and their application in studies on behavior, learning and memory and cognitive aspects of animals; Rotarod; grip strength meter; Pain sensitivity testing with the help of tail-flick instrument and paw test.

Unit- III

Spectroscopy Techniques

UV, Visible Spectroscopy; Fluorescence; MS, NMR

Chromatography Techniques

Chromatographic methods for macromolecule separation- TLC and Paper chromatography; Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and FPLC;

Electrophoretic techniques

Theory and application of Polyacrylamide and Agarose gel electrophoresis; Types of electrophoresis.

Centrifugation:

Principle and types of centrifuges and their applications.

Imaging

MRI, PET, SPECT/FMRI

Unit-IV

Recombinant DNA technology

Preparation of recombinant DNA (Gene cloning); Preparation of genomic and c-DNA libraries, General idea of expression library; screening of gene libraries; Methods in gene analysis: Hybridization techniques (Southern, Northern, Western, dot and slot blots and *in situ* hybridization; General idea of DNA sequencing, chromosome walking, foot printing, RFIP and finger printing

UNIT V

Experimental design and data analysis

Principle of experimental design; Collection of data, sampling and presentation of data: Statistical tables, charts and graphs; Centering constants and their measurements: Mean, median and mode; Measurement of variabilities like deviation, standard deviation, standard error, etc.; Tests of significance: Student t-test and Chi-square test; ANOVA- one way and two-way; Coefficient of correlation and regression

Suggested Text Books

1. Williams & Walker, Practical Biochemistry (5th Edition), Cambridge, 2000
2. Plummer, Practical Biochemistry (3rd Edition), Tata-McGraw Hill, 2004
3. Freifelder, Physical Biochemistry (2nd Edition), Freeman, 1982
4. Bancroft, Theory and Practice of Histological Techniques (Edition), Churchill Livingstone,

5. Wadhwa & Dinda, Stereology, Image Processing and Quantitative Image Analysis in Biomedical Research
6. Cohen & Wilkin, Neural Cell Culture, OUP, 1996
7. Kothari, Research Methodology (2nd Edition), New Age, 2005
8. Mahajan, Biostatistics (6th Edition), Jaypee, 2006
9. Rubens, Science & Technical Writing (2nd Edition) Routledge, 2001
10. Renshaw, Immunohistochemistry Scicon, 2006

LABORATORY COURSE-I: NS105: CELL BIOLOGY

1. Microtomy/Cryotomy/Vibratomy
2. Histology and histochemistry: general methods
3. Histological demonstrations of
   a) Lipids
   b) Proteins
   c) Carbohydrates
   d) Enzymes and
   e) Nucleic acids
4. Immunocytochemistry: Tissue processing, SABC and fluorochrome methods
5. Fluorescence microscopy and immunofluorescence
6. Study of permanent slides and electron micrographs

LABORATORY COURSE-II: NS/106: *GENETICS,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/ LPLC/ Paper chromatography
6. Study of mitotic chromosomes from rat bone marrow
7. Study of polytene chromosomes Chronomous/Blow Fly larval etc.
8. Isolation and purification of DNA and/or RNA and estimation of their concentration and purity check using UV-spectrophotometer
9. Restriction Digestion
10. Plasmid preparation
11. Ligation
12. Preparation of competent cells
13. Gene cloning methods

SEMESTER-II

NS/201: *NEUROANATOMY*

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

Gross anatomy of the adult brain; organization of the nervous system; Subdivisions of the nervous system; Concept of CNS, ANS & PNS; The scalp, skull and meninges; Cerebrospinal fluid

Unit- II

Constitutions of CNS: Overview
Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of: Peripheral nervous system: General organization; nerves, roots and ganglia; sensory endings; Spinal cord: Gross anatomy, internal structure, tracts of the ascending and descending fibers, spinal reflexes; Brainstem: Medulla oblongata, pons, fourth ventricle, midbrain, nuclei and tracts, reticular formation

Unit-III

Cranial nerves: Functional aspects, classification of cranial and spinal nerve components
Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of:
Thalamus: Scheme of thalamic organization, nuclei of the thalamus; Basal ganglia: Corpus striatum, subthalamic nucleus, substantia nigra; Ascending sensory pathways

Unit-IV

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; Cerebral cortex: Histology, general organization, functional localization; Descending motor pathways

Unit-V

Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of: Auditory system; Visual system; Olfactory and Limbic system; Autonomic system

Suggested Books:

1. John A. Kierrnan, Barr's the Human Nervous System (7th Edition), Lippincott-Raven, 1998
2. Richard S. Snell, Clinical Neuroanatomy for the Medical Students (5th Edition) Lippincott-Williams & Wilkins, 2001
3. Susan Standring (Editor-in-Chief), Gray's Neuroanatomy: The Anatomical Basis of Clinical Practice (39th Edition), Elsevier, 2005
4. M.J.T. Fitzgerald, Clinical Neuroanatomy & Related Neuroscience (4th Edition) CRC Press, 2000
5. Water, J. Hendelman, Atlas of Functional Neuroanatomy, CRC Press, 2000

NS/202: *IMMUNOLOGY*

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 an extend to be able to comprehend the bases of immunological disorders in general and the brain in particular.

UNIT I

Immunology- fundamental concepts
Innate and acquired immunity, components of innate and acquired immunity, antibody structure, antigen-antibody interactions; Cells and organs of the immune system and regulation of immune response

UNIT II

Cellular basis of immunity
Cellular basis of adaptive immunity, B-cell and antibodies; Generation of antibody diversity; T cells and MHC proteins; Helper T cells and lymphocytic activation

UNIT III

Immunity to infection
Bacterial, viral, fungal and parasitic infections (with examples from each group). Overview of multiple sclerosis and autoimmune disease.
Mechanisms of neuroinflammation; Role of astrocytes, Schwann cells and microglia.

UNIT IV

Clinical Immunology
Hypersensitivity, Autoimmunity, Transplantation, Tumor immunology and Immunodeficiency; Neuro-AIDS.

UNIT V

Immunotechnology
Hybridoma technology, Monoclonal antibodies, Immunochemical techniques antigen-antibody interactions and various cellular techniques; Vaccines, DNA vaccines

Suggested Books:

1. Goldsby, Kuby Immunology (6th Edition), W.H. Freeman, 2007
2. Banjamini, Immunology (5th edition), Wiley Liss, 2003
3. M. Roitt, Immunology (7th Edition), Mosby Publication, 2006
4. Janeway, Immunobiology (6th Edition), Churchill Livingstone, 2008
5. Verkhratsky, Glial Neurobiology, A Text Book, Wiley, 2007

NS/203: *DEVELOPMENTAL NEUROBIOLOGY*

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

Major events in early embryonic development: Role of nucleus and cytoplasm, cleavage, formation of blastula and gastrula; Embryonic origin of nervous system, early neural morphogenesis in vertebrates and invertebrates,

Neural Induction: The organizer concept, Molecular nature of the Neural inducer, Conservation of neural induction; Dorsal neural tube and neural crest; Neural crest cells and its derivatives.

Unit-II

Patterning, polarity and regionalization of the nervous system: The anterior-posterior axis and Hox genes; Organizing centers in the developing brain; forebrain development, prosomeres and Pax genes; Patterning, polarity and regionalization of the nervous system: Dorsal-ventral polarity in the neural tube; Neuronal determination and differentiation: Fate mapping of cell determination, differentiation of nerve cells and cell lineage, acquisition of neurotransmitter property and electrical excitability

Unit-III

Birth and migration of neurons, Mechanism of cell movement, migration of neurons in PNS and CNS, control of neuronal and glial cell population; Histogenesis of cerebral cortex and cerebellar cortex

Neurogenesis in post-embryonic and adult age

Neuronal death during development: Programmed cell death, target dependent and innervation dependent neuronal death

Neurotrophic factors: Nerve growth factor (NGF), biological system of NGF, agents analogous to NGF in functions, role of NGF as trophic agents, survival factors

Unit-IV

Axon growth, path finding and nerve patterns: Growth Cone, Axonal navigation and axon elongation, cell adhesion molecules, factors influencing axon guidance, target recognition; Synapse formation and elimination: Initiation of synaptic contacts, structure and function of newly formed synapses;- Presynaptic and postsynaptic elements, target selection and synapse elimination

Selective synaptic connections: Skeletal muscle, autonomic ganglia, spinal cord and CNS

Unit-V

Experience and the refinement of synaptic connections, maintenance of synapses;

Rearrangement of developing neuronal connections: Synaptic rearrangement in different parts of the nervous system.

Denervation and regeneration of synaptic connections; Effects of Denervation on the postsynaptic cell; Denervation super-sensitivity, susceptibility to innervation, and axonal sprouting; Repairing the damaged brain; Regeneration of central and peripheral axons in mammalian nervous system.

Suggested Books:

1. Sanes, Development of the Nervous System (3rd Edition), Academic Press, 2012
2. Squire, Fundamental Neuroscience (4th Edition), Elsevier, 2013
3. Kendel, Principles of Neural Science (5th edition), McGraw Hill, 2013
4. Gilbert, Developmental Biology (7th Edition) Sinnaur Publication, 2006

NS/204: *CELLULAR NEUROPHYSIOLOGY AND BIOPHYSICS*

Note: This paper is expected to present both the established background and the important developments in brain research. The topics to be covered 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

Electrical properties of excitable membranes: Basic electricity and electric circuits, neurons as conductors of electricity, equivalent circuit representation;
Electrical properties of excitable membranes: Membrane conductance, linear and nonlinear membrane, ionic conductance, current-voltage relations;
Ion movement in excitable cells: Physical laws, Nernst-Planck Equation, active transport of ions, movement of ions across biological membranes;
Membrane potential and role of sodium and potassium pumps

Unit-II

Neural Signals
Overview of Neurons, Synapses and Networks;
Stimulus → Sensory Perception → Motor Action / Higher Brain Function;
Chemical and Electrical Signaling Within a Circuit;
Methods to Record Electrical Activity of a Neuron.

Unit-III

Action potential, non-gated ion channels and generation of action potential;
Electrical properties of neurons, quantitative models of simulations, Hodgkin & Huxley's analysis of squid giant axon: Voltage-clamp experiments;
Voltage gated channels;
Biophysical, biochemical and molecular properties of voltage gated channels.

Unit-IV

Synaptic vesicles
Principles of synaptic transmission: Electrical and chemical synapses;
Calcium hypothesis: Control of transmitter release;
Synthesis and trafficking of neuronal proteins.

Unit-V

Synaptic transmission at nerve-muscle synapses;
Synaptic transmission at central synapses;
Ligand gated channels;
Second messengers and synaptic transmission.

Suggested books;

1. Squire, Fundamental Neuroscience (4th Edition), Elsevier, 2013
2. Kendel, Principles of Neural Science (5th edition), McGraw Hill, 2013
3. Duchene E. Haines, Fundamental Neuroscience for Basic & Clinical Applications (3rd Edition), Churchill Livingstone, 2006
4. Bear, Neuroscience-Exploring the Brain (3rd Edition), Lippincott, 2007

LABORATORY COURSE-III: NS/205: *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: Nissl/Silver techniques
6. Study of gross anatomy and pre-dissected human brain

LABORATORY COURSE- IV: NS /206: *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

SEMESTER-III

NS/301: *NEUROCHEMISTRY*

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

Synaptic transmission and cellular signaling: An overview
Acetylcholine: Chemistry, synthesis, storage and release; Nicotinic and muscarinic receptors; Catecholamine: Biosynthesis, storage and release; Dopamine, adrenergic receptors

Unit-II

Serotonin: Synthesis, action and distribution; Role of serotonin receptors in behavior;
Excitatory amino acid transmitters: Synthesis, metabolism, distribution and receptor subtypes;
Histamine: Dynamics, molecular sites and action in the CNS;
GABA, glycine: Synthesis, uptake and release; Receptors of GABA and glycine.

Unit- III

Neuropeptides neurotransmitters: Biosynthesis, function regulation and receptors;
Opioid peptide and opioid receptors: Synthesis, metabolism, distribution and receptor subtypes;
CSF; Micro circulation and blood brain and CSF barriers
Intracellular signaling; G Proteins and second messengers

Unit-IV

Metabolism: Energy metabolism of the brain; Hypoxic-Ischemic brain injury and oxidative stress; Metabolic encephalopathies; Eicosanoids, docosanoids, platelate-activating factor and inflammation

Unit-V

Mechanism of action of drugs; Drug addiction, drug abuse and adverse drug reaction; Neuroendocrinology of behaviour; Apoptosis and necrosis

Text Books

1. Siegel, Basic Neurochemistry (8th Edition) Academic Press, 2012
2. Friefelder: Practical Biochemistry
3. Kendel, Principles of Neural Science (5th edition), McGraw Hill, 2013
4. Squire, Fundamental Neuroscience (4th Edition), Elsevier, 2013

NS/302: *SENSORY AND MOTOR SYSTEMS*

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

Transduction and processing of sensory signals-Basic Principles: Sensation and perception, Receptors, Parallel processing, Central processing, Common anatomical plan,
Structure, function & connections of sensory cortex
Sensory Transduction: Phototransduction, olfactory transduction, taste, mechanoreception
Somatic sensation: Peripheral mechanisms of somatic sensation, Spinal and Brainstem components of somatosensory system, Thalamic ventrobasal complex, somatosensory areas of cerebral cortex.

Unit-II

Touch: Role of dorsal root ganglia cells in somatic sensory system, mechanoreceptors and other receptors,
Primary somato-sensory cortex and information processing on touch, representation of body surfaces in the brain, cortical responses to stimuli.
Pain: Nociceptors, hyperalgesia, control of pain, opioid peptides and pain
Taste: Taste receptors and taste buds, turnover & replacement, Innervation by cranial nerves, Flow of gustatory afferent information, Extraction of sensory information, Turning of peripheral taste fibers, Gustatory neuron types, Modulation of taste activity in the Medulla

Unit-III

Olfaction: Odor stimuli, Olfactory receptor cells, Vertebrate ORNs, Molecular receptive Ranges of olfactory cells, Convergence of olfactory projections, Information processing in the dendrodendritic synapses in Accessory Olfactory Bulb
Vision: Receptive Field: Fundamental concepts in visual physiology, eye and retina, Lateral geniculate nucleus, Visual cortex
Audition: Amplitude and frequency ranges of hearing, External & middle ear, The Cochlea, The auditory nerve, Descending systems to the periphery, Central Nervous System

Unit-IV

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
Muscle, Motor neurons and Motor neuron pools: Skeletal muscle, Motor Units, Motor neuron pools, Muscle afferents
Spinal Motor control, Reflexes and locomotion: Basic Principles, Reflexes, Interneurons associated with movements, Locomotion
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

Unit-V

Voluntary Descending Control: Cortical pathways to Motor Neurons, Organization of the Motor cortex, Control of voluntary movements by the motor cortex
Eye Movements: Gaze-stabilization mechanisms, Gaze-shifting Mechanisms, the Oculomotor Nuclei and the extraocular muscles, The Vestibulo-Ocular Reflex, The optokinetic System, The Saccadic System, Smooth pursuit, Vergeance movements
Basal Ganglia: Anatomy of the Basal Ganglia, Signaling in Basal Ganglia, Effect of damage in behaviour, Fundamental Principles of Basal Ganglia operation
Cerebellum: Anatomy and Phylogenetic Development of the cerebellum, Assessing Cerebellar Function

Suggested Text Books

1. Squire, Fundamental Neuroscience (4th Edition), Elsevier, 2013
2. Kendel, Principles of Neural Science (5th edition), McGraw Hill, 2013

NS/303: *REGULATORY SYSTEM*

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

Chemical Control of Brain and Behaviour:
Organizational Principles of the Adult Hypothalamus
Role of hypothalamus and pituitary hormones
The ANS in regulation of brain and bahaviour
ANS Pharmacology- Transmitter and Receptor Coding, Autonomic Controls of Homeostasis, Hierarchically Organized CNS Circuits

Unit-II

The diffuse modulatory systems of the brain: Locus coeruleus, raphe nucleus, substantia nigra, etc.
Neural Control of the Breathing:
Early Neuroscience and the Brainstem, Breathing & gas exchange, CNS & Breathing, Respiratory Rhythm Generation
Sensory Inputs and Altered Breathing, Modulation of Respiratory Motor Out-put, Suprapontine Structures and Breathing
Respiratory neurons and their discharge pattern

Unit-III

Cardiovascular System:
Basics of Cardiovascular physiology, Sympathetic Vasomotor Tone, Neural Control of Heart, Cardiovascular Homeostasis
The Nervous System and the Long-term control of the Cardiovascular System
Sleep and Dreaming:
The two states of sleep- slow wave and rapid eye movement
Anatomy and Physiology of the Brainstem regulatory Systems

Unit-IV

Circadian Timing:
Pineal and Circadian Rhythms, The Suprachiasmatic Nucleus, Light as the Dominant Stimulus
Circadian timings and reproduction
Heritablity of Circadian Timings
Sex and behaviour:
Neuronal basis of sexual behaviour, Sex Hormones and Brain, The Accessory Olfactory Pathway
Maternal Stimulation and Male Psychosexual Development

Why and how male and female brains differ?

Unit-V

Motivation & Reward:
Neural Mechanisms of Motivation, Dopamine and Lateral Hypothalamic Syndrome, Reinforcement System
Brain Aversion Systems
Plasticity of nervous system
Addiction

Suggested Text Books

1. Squire, Fundamental Neuroscience (4th Edition), Elsevier, 2013
2. Kendel, Principles of Neural Science (5th edition), McGraw Hill, 2013

NS/304: *BEHAVIOUR AND COGNITIVE NEUROSCIENCE*

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-1

Human Brain Evolution
Evolutionary and comparative principles, mammalian evolution
Cognitive development and aging
Brain and cognitive development
Aging and cognition
Pathological processes in cognitive development and aging

Unit-II

Visual perception of objects
Neuronal basis of object recognition
Perception and recognition of specific classes of objects
Spatial cognition
Neural system of spatial cognition: Parietal cortex, Frontal cortex, Hippocampus and adjacent cortex

Unit-III

Attention
Verities of attention and Neglect syndrome
Visual system and attention
Language and communication
Animal communication
Human language

Unit- IV

Learning and Memory: Basic Systems
Basic mechanisms of learning, key insights from invertebrate studies
Long-term potentiation
Classical conditioning in vertebrates
Mechanism of memory storage

Unit- V

Learning and memory: Brain systems
Major memory systems in mammalian brain
Multiple memory systems and behaviour
Executive brain functions
Consciousness

Suggested Text Books

1. Squire, Fundamental Neuroscience (4th Edition), Elsevier, 2013
2. Kendel, Principles of Neural Science (5th edition), McGraw Hill, 2013
3. Banich, Cognitive neuroscience (3rd Edition) Wordsworth, 2011

LABORATORY COURSE- V: NS/305: *NEUROPATHOLOGY*

1. Neurotoxicological studies using animal models
2. Study of developing rat nervous system: Normative and under exposure to toxic agents
3. Study of pathological tissue from different pathological conditions
4. Study of permanent slides
5. Visits to neurology and neurosurgery clinics
6. Histopathological methods for analysis of pathological tissues
7. Study of neurodegenerative models, e.g., nerve injury models

LABORATORY COURSE-VI: NS/306: *BEHAVIOUR BIOLOGY*

1. Automated exploratory behaviour recording using activity monitor
2. Assessment of neuromuscular function/performance using Grip Strength Meter
3. Studies on locomotory behaviour in rats
4. Studies on learning behaviour using T-maze
5. Studies on learning behaviour using Y-maze
6. Studies on locomotory development like: pivoting, traversing, homing, etc.
7. Exploratory behavior of young and old rats
8. Maternal behaviour in rats and mice
9. Nesting behavour in birds
10. Study of museum specimens for adaptations

SEMESTER-IV

NS/401: *CLINICAL NEUROCHEMISTRY AND NEUROPATHOLOGY*

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

Neurochemical and molecular mechanisms of peripheral Neuropathy; Diseases involving myelin; Multiple sclerosis and other demyelinated disorders; Genetic disorders of Lipid, glycoprotein, and Mucopolysaccharide metabolism; Duchenne Muscular dystrophy: Molecular, genetic aspects and diagnostic characteristics

Unit-II

Nutritional and metabolic Diseases: Disorders of amino acid metabolism
Wernicke-Korsakoft syndrome; Pellagra; Alcoholic Cerebellar Degeneration; Metabolic Encephalopathies and Coma

Unit-III

Neurotransmiters and disorders of basal ganglia; Molecular targets of abused drugs; Ischemia and hypoxia; Epileptic seizures; Genetics and diagnosis of Huntington disease and other triplet repeat disorders; Alzheimer's disease: Molecular, genetic, immunological aspects and diagnostics

Unit-IV

Theories of aging; Neurobiology of aging: cellular and molecular aspects of neuronal aging; Aging and neurodegeneration; Parkinson's disease

Unit-V

Motor Neuron Diseases; Prion's Disease; Biochemical aspects of the psychotic disorders; Biochemical basis of mental illness: Anxiety disorders; Mood disorders; Attention disorders; Schizophrenia

Suggested Books:

1. Brady, Basic Neurochemistry (8th Edition) Academic Press, 2012
2. Squire, Fundamental Neuroscience (4th Edition), Elsevier, 2013
3. Kendel, Principles of Neural Science (5th edition), McGraw Hill, 2013
4. Duchene E. Haines, Fundamental Neuroscience for Basic & Clinical Applications (3rd Edition), Churchill Livingstone, 2006
5. Bear, Neuroscience-Exploring the Brain (3rd Edition), Lippincott, 2007

NS/402: *NANOTECHNOLOGY AND BIOINFORMATICS FOR NEUROSCIENCE*

Note: This paper aims at illustrating the basics and possible applications of nanotechnology as well as bioinformatics in neuroscience. Both the aspects shall be just introduced to the students who are expected to make use of these tools in future. However, extensive details with wide range of examples shall be avoided.

NANOTECHNOLOGY

Unit- I

Introduction to nanotechnology; Molecular nanotechnology; Atoms by inference
Atomic force microscope; Nanopowders and nanomaterials; Sol-gels and their use; Use of natural nanoparticles

Unit-II

Nanobiometrics; Lipids as nano-bricks; Proteins as nanomolecules; DNA in nanotechnology;
Present and future of nanotechnology applications in:
Molecular biology and Medicine

Unit-III

Neuroscience nanotechnology: Progress, opportunities and challenges; Nanotechnology tools for probing neurons and glia; Nanoengineered materials for neuroregeneration; Nanoparticles for effective drug delivery to the CNS; Ethical issues in nanotechnology

BIOINFORMATICS

Unit-IV

Bioinformatics: History, scope and importance; Computers, internet, WWW, and NCBI;
Neuroinformatics: Concept and applications; DNA sequencing and analysis; Protein sequencing and analysis

Unit-V

Databases, tools and their uses; Sequence alignment; Predictive methods using DNA sequences; Predictive methods using protein sequences; Pharmainformatics and drug discovery

Suggested Text Books

1. Wilson: Nanotechnology: Basic Science and Emerging Technologies, CRC Press, 2002
2. Timp: Nanotechnology, Springer, 1999
3. Ignacimuthu: Basic BioinformaticsAlpha Science, 2004
4. Koslow: Neuroinformatics, Mahwah, 1997
5. Lesk: Introduction to Bioinformatics (3rd Edition), OUP, 2008

LABORATORY COURSE-VII: NS/403: *RESEARCH METHODS, BIOSTATISTICS AND COMPUTER APPLICATIONS*

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/404: *DISSERTATION*

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/405: *VIVA-VOCE ON THE DISSERTATION*