Curriculum (2019-21)

Semester	Course code	Title of the Paper (s)	Course type	Credits L	T	P	Total
FIRST	NS-101	Cell Biology and Neuron organization	Core	3	0	0	3
	NS-102	Neuroanatomy	Core	3	0	0	3
	NS-103	Genetics and Molecular Biology	Core	3	0	0	3
	NS-104	Laboratory Tools and Techniques	Core	3	0	0	3
	NS-105	Practical- Cell Biology and Genetics	Core	0	0	3	3
	NS-106	Practical- Neuroanatomy	Core	0	0	3	3
	NS-107	Assignment/Personality and skill development	Core	0	1	0	1
	NS-108	Seminar-I	Core	0	1	0	1
Total valid credits							**20**
	NS-109	Comprehensive viva-voce exam	Virtual credits			4	4
Total credits for First Semester (Valid Credits+ Virtual Credits)							**24**
SECOND	NS-201	Biochemistry	Core	3	0	0	3
	NS-202	Neurochemistry	Core	3	0	0	3
	NS-203	Developmental Neurobiology	Core	3	0	0	3
	NS-204	Cellular Neurophysiology and Biophysics	Core	3	0	0	3
	NS-205	Practical-Biochemistry and Molecular Biology	Core	0	0	3	3
	NS-206	Practical- Neurophysiology	Core	0	0	3	3
	NS-207	Assignment/Personality and skill development	Core	0	1	0	1
	NS-208	Seminar-II	Core	0	1	0	1
Total valid credits							**20**
	NS-209	Comprehensive viva-voce exam	Virtual credits			4	4
Total credits for Second Semester (Valid Credits+ Virtual Credits)							**24**
THIRD	NS-301	Immunology	Core	3	0	3	3
	NS-302	Systems Neuroscience-I: Sensory and Motor Systems	Core	3	0	3	3
	NS-303	Systems Neuroscience-II: Regulatory Systems	Core	3	0	3	3
	NS-304	Behaviour and Cognitive Neuroscience	Core	3	0	3	3
	NS-305	Practical- Neuropathology	Core	0	0	3	3
	NS-306	Practical- Behavior Biology	Core	0	0	3	3
	NS-307	Assignment/Personality and skill development	Core	0	1	0	1
	NS-308	Seminar-III	Core	0	1	0	1
Total valid credits							**20**
	NS-309	Comprehensive viva-voce exam	Virtual credits			4	4
Total credits for Third Semester (Valid Credits+ Virtual Credits)							**24**
FOURTH	NS-401	Clinical Neurochemistry and Neuropathology	Core	3	0	0	3
	NS-402	Practical	Core	0	0	3	3
	NS-403	Project	Core	12	0	0	12
	NS-404	Assignment/Personality and skill development	Core	0	0	1	1
	NS-405	Seminar-IV	Core	0	0	1	1
Total valid credits							20
	NS-406	Comprehensive viva-voce exam	Virtual credits				
Total credits for Fourth Semester (Valid Credits+ Virtual Credits)							**24**

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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 (2019-2021)

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

Code	Title	Credits
NS/101	Cell Biology and Neuron Organization	3
NS/102	Neuroanatomy	3
NS/103	Genetics and Molecular Biology	3
NS/104	Laboratory Tools and Techniques	3
NS/105	Practical-Cell Biology& Genetics	3
NS/106	Practical-Neuroanatomy	3
NS/107	Assignment/Personality and skill development	1
NS/108	Seminar-I	1
NS/109	Comprehensive Viva-voce exam	4
	Total=	**24**

Semester-II

Code	Title	Credits
NS/201	Biochemistry	3
NS/202	Neurochemistry	3
NS/203	Developmental Neurobiology	3
NS/204	Cellular Neurophysiology and Biophysics	3
NS/205	Practical-Biochemistry and Molecular Biology	3
NS/206	Practical-Neurophysiology	3
NS/207	Assignment/Personality and skill development	1
NS/208	Seminar-II	1
NS/209	Comprehensive Viva-voce exam	4
	Total=	**24**

Semester-III

Code	Title	Credits
NS/301	Immunology	3
NS/302	Systems Neuroscience-I: Sensory and Motor Systems	3
NS/303	Systems Neuroscience-II: Regulatory System	3
NS/304	Behaviour and Cognitive Neuroscience	3
NS/305	Practical-Neuropathology	3
NS/306	Practical-Behavior biology	3
NS/307	Assignment/Personality and skill development	1
NS/308	Seminar-III	1
NS/309	Comprehensive Viva-voce exam	4
	Total=	**24**

Semester-IV

Code	Title	Credits
NS/401	Clinical Neurochemistry and Neuropathology	3
NS/402	Practical	3
NS/403	Project	12
NS/404	Assignment/Personality and skill development	1
NS/405	Seminar-IV	1
NS/406	Comprehensive Viva-voce exam	4
	Total=	**24**

Detailed Syllabus (2019-2021)

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 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

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

Unit-IV

14. Glial cells: Structure and function of glial cells, Different types of glial cells: astrocytes, oligodendrocytes and Schwann cells
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:

1. Siegel, Basic Neurochemistry (8th Edition) Academic Press, 2015
2. Albertes, Molecular Biology of the Cell (6th Edition) Garland Science, 2015
3. Kandel, Principles of Neural Science (5th edition), McGraw Hill, 2013
4. Verkhratsky, Glial Neurobiology, A Text Book, Wiley, 2007

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. Constitution of CNS: Overview; Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation ofaxons

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 ofThalamus; Scheme of thalamic organization, nuclei of the thalamus
11. Functional aspects and 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 ofCerebellum: Gross anatomy, cerebellar cortex, central nuclei, cerebellar peduncles,functional anatomy of cerebellum
14. Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of Cerebral cortex: Histology, general organization, functional localization

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:

1. John A. Kierman, Barr's the Human Nervous System (10th Edition), Lippincott-Raven, 2014
2. Richard S. Snell, Clinical Neuroanatomy for the Medical Students (7th Edition) Lippincott-Williams &Wilkins, 2010
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 (5thEdition) CRC Press, 2007
5. Water, J. Hendelman, Atlas of Functional Neuroanatomy, CRC Press, 2000

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 pRB and p53tumor 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 eukaryotic chromosomes
7. Role of nuclear matrix in chromosome organization and function; Matrix binding proteins; Heterochromatin and Euchromatin
8. 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
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; FLP/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; Rho-

dependent 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, tRNA, rRNA; 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; IsoacceptingtRNA; Wobble hypothesis; Genetic code in mitochondria

Suggested Books:

1. Simmons, Principles of Genetics (7th Edition), Wiley, 2011
2. Strickberger, Genetics (3rd Edition), PHP Press, 2008
3. Albertes, Molecular Biology of the Cell (5th Edition) Garland Science, 2008
4. Lewin, Genes X, Jones & Bartlett, 2011
5. Griffiths & Miller, Introduction to Genetic Analysis (8th Edition), Freeman, 2005
6. Lodish, Molecular Cell Biology (6th Edition), Freeman, 2008
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 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

1. Principles of fixation and staining of nervous tissue; Methods of tissue processing for microtomy, cryotomy and vibratomy
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 Polyacrylamide 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, RFIP and finger printing

Unit-IV

16. Imaging techniques: MRI, PET, SPECT, MRI/FMRI
17. Principle of experimental design; Collection of data, sampling and presentation of data Statistical tables, charts and graphs
18. Centering constants and their measurements: Mean, median and mode; Measurement of variability, like deviation, standard deviation, standard error, etc.

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19. Tests of significance: Student t-test, 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. Friefelder, Physical Biochemistry (2nd Edition), Freeman, 1982
4. Bancroft, Theory and Practice of Histological Techniques (7thEdition), Churchill Livingstone, 2014
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 (8th Edition), Jaypee, 2016
9. Rubens, Science & Technical Writing (2nd Edition) Routledge, 2001
10. Renshaw, Immunohistochemistry Scion, 2007
11. P.S. Bisen, Laboratory Protocols in Applied Life Sciences, CRC 2014
12. P.S. Bisen& Anjana Sharma, Introduction to Instrumentation in Life Science, CRC 2013

NS105:PRACTICAL- *CELL BIOLOGY AND GENETICS* **Credits=3**

1. Histology: General methods: Hematoxylin & Eosin staining, Cresyl violet (Nissl) staining
2. 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. Immunocytochemistry: Tissue processing, Immunoenzymaticmethods
6. Fluorescence microscopy and immunofluorescence methods
7. Study of permanent slides and electron micrographs
8. Study of mitotic chromosomes from rat bone marrow
9. Study of polytene chromosomes in Chironomous/Blow Fly larvae etc.

NS/106:PRACTICAL-*NEUROANATOMY* **Credits=3**

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. Microtomy/Cryotomy/Vibratomy
7. Study of gross anatomy and pre-dissected human brain

NS/107: ASSIGNMENT/PERSONALITY AND SKILL DEVELOPMENT **Credits=1**

Communication Skills

Process of communication

Concept of effective communication- Setting clear goals for communication; Determining outcomes andresults; Initiating communication; Avoiding breakdowns while communicating; Creating value in Conversation; Barriers to effective communication; Non-verbal communication- Interpreting non verbal cues; Importance of body language, Power of effective listening; recognizing cultural differences

Texts/References

1. Mohan Krishna and N.P. Singh, Speaking English effectively, Macmillan, 2003.

NS/108: SEMINAR-1 **Credits=1**

NS/109: COMPREHENSIVE VIVA-VOCE EXAM **Credits=4**

Semester-II (Credits=24)

NS/201: *BIOCHEMISTRY* **Credits=3**

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 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 - mono, di, 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; Kreb'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:

1. Nelson & Cox, Principles of Biochemistry (5th Edition), Freeman, 2008
2. Voet&Voet, Biochemistry (4th edition), Wiley Press, 2006
3. Stryer, Biochemistry (6th Edition), W.H. Freeman, 2007
4. P.S. Bisen, Laboratory Protocols in Applied Life Sciences, CRC 2014
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. Catecholamine: 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 signaling; 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, docasanoids, 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

1. Siegel, Basic Neurochemistry (8th Edition) Academic Press, 2015
2. Friefelder: Practical Biochemistry
3. Kandel, Principles of Neural Science (5th edition), McGraw Hill, 2013
4. Squire, Fundamental Neuroscience (4th Edition), Elsevier, 2013

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
3. Neural Induction: Interactions with neighboring tissues in making neural tissue and the organizer concept, Molecular nature of the Neural inducer, Conservation of neural induction, Interactions among the ectodermal cells in controlling neuroblast segregation
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
7. Dorsal-ventral polarity in the neural tube, Patterning of the cerebral cortex, Dorsal Neural tube and neural crest
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. Histogenesis 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
12. Neuronal determination and differentiation: Transcriptional hierarchies in invariant lineages in C. elegans; Spatial and temporal coordinates of determination and Drosophila CNS neuroblast segregation
13. Asymmetric cell division and asymmetric fate, Specification and differentiation of vertebrate neural crests
14. Naturally occurring Neuronal death during development: target dependent and innervation dependent neuronal death, Intracellular-signaling pathways that mediate death
15. Neurotrophic factors: Neurotrophins and their receptors, Intracellular-signaling pathways that mediate cell 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:

1. Sanes, Development of the Nervous System (3rd Edition), Academic Press, 2012
2. Squire, Fundamental Neuroscience (4th Edition), Elsevier, 2013
3. Kandel, Principles of Neural Science (5th edition), McGraw Hill, 2013
4. Gilbert, Developmental Biology (11th edition) Sinauer Publication, 2016

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 in a concise enough manners so that the fundamentals are 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 is 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

14. Synthesis and trafficking of neuronal proteins
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;

1. Squire, Fundamental Neuroscience (4th Edition), Elsevier, 2013
2. Kandel, 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

NS/205: PRACTICAL-*BIOCHEMISTRY AND MOLECULAR BIOLOGY* **Credits=3**

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

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10. Gene cloning methods

NS /206: PRACTICAL-*NEUROPHYSIOLOGY* **Credits=3**

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 Stereotaxic instrument for neuroscience research
4. Demonstration of basal metabolic rate
5. Effect of various neurotransmitters on fish melanophores
6. Pharmacological experiments on melanophores

NS/207: ASSIGNMENT/PERSONALITY AND SKILL DEVELOPMENT **Credits=1**

Presentation skills

Formal presentation skills; Preparing and presenting using Over Head Projector, Power Point; DefendingInterrogation; Scientific poster preparation & presentation; Participating in group discussions

NS/208 SEMINAR-II **Credits=1**

NS/209 COMPREHENSIVE VIVA-VOCE EXAM **Credits=4**

Semester-III (Credits=24)

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 an 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:

1. Kuby Immunology (7th Edition), W.H. Freeman, 2013
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/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 venfrobasal 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, Turning of peripheral taste fibers

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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
18. Eye Movements: Gaze-stabilization mechanisms, Gaze-shifting Mechanisms, the Oculomotor Nuclei and the extra ocular muscles, The Vestibulo-Ocular Reflex, The optokinetic System, The Saccadic System, Smooth pursuit, Vergeance movements
19. Basal Ganglia: Anatomy of the Basal Ganglia, Signaling 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

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

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 Out-put
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:Pineal 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?

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

Suggested Text Books

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

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
9. Visual perception of objects: Neuronal basis of object recognition, Perception and recognition of specific classes of objects
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

1. Squire, Fundamental Neuroscience (4th Edition), Elsevier, 2013
2. Kandel, Principles of Neural Science (5th edition), McGraw Hill, 2013
3. Banich, Cognitive neuroscience (3rd Edition) Wordsworth, 2011
4. Gazzaniga, Cognitive Neuroscience (4th Edition) Norton, 2014

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/PERSONALITY AND SKILL DEVELOPMENT **Credits=1**

Computing Skills for Scientific Research
Web browsing for information search; search engines and their mechanism of searching; Hidden Web andits importance in scientific research; Internet as a medium of interaction between scientists; Effective emailstrategy using the right tone and conciseness

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:

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

NS/402: *RESEARCH METHODS, BIOSTATISTICSAND COMPUTER APPLICATIONS* **Credits=3**

1. Collection of data for statistical analysis
2. Chi square test
3. Student 't' test
4. ANOVA-one way and two way
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

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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**

Technical Writing Skills

Types of reports; Layout of a formal report; Scientific writing skills: Importance of communicating Science;Problems while writing a scientific document; Plagiarism; Scientific Publication Writing: Elements of a Scientificpaper including Abstract, Introduction, Materials & Methods, Results, Discussion, References; Drafting titlesand framing abstracts

NS/405: SEMINAR-IV **Credits=1**

NS/405: COMPREHENSIVE VIVA-VOCE EXAM **Credits=4**

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