Meeting Educational Needs with “Course” Correction
Remodelled M.Sc. Neuroscience Curriculum
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May, 2017

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Ministry of Science & Technology
Government of India

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Department of Biotechnology initiated Integrated Human Resource Development Programme way back in 1985-86 to cater to the requirement of quality manpower for R&D, teaching and manufacturing activities. I am very proud that India is one of the first countries in the world to initiate postgraduate teaching programme in Biotechnology. M.Sc./M.Tech. programme was initiated in 5 universities and has been expanded to over 70 universities/IITs in the country to cover general, medical, agricultural, veterinary, environmental, industrial, marine, food, pharmaceutical biotech.

Students for these programmes are selected on the basis of an All India entrance test and all selected students are paid studentships. I am very happy to know that the Department has initiated major curriculum revision exercise for specialisations offered under DBT supported teaching programme. The exercise has been coordinated by Biotech Consortium India Limited. The Department invited feedback from researchers, academic community, biotech industries and past as well as present students. Feedback has been considered by the Expert groups and areas with recent developments have been included and identified gap areas which need inclusion and updation have been taken care of. I compliment the Department for taking up this major exercise for the benefit of student community and congratulate the group for bringing out this publication.
Andy Hargreaves a renowned educational expert has once remarked “Capacity building originally meant helping people to help themselves. Now it means required trainee to deliver imposed policies”. In the Indian context, Integrated Human Resource Development Programme of Department of Biotechnology is a flagship and dynamic programme which has done exceedingly well to meet the requirements of capacity building. The central idea should be to take enough care in selection of quality students and provide hands-on practical training to students.

I am extremely happy to note that Department is revising curriculum for various PG programmes in Biotechnology at regular intervals to incorporate latest developments in the field. While doing so, I am told that Biotech Consortium India Limited has obtained necessary feedback from different stakeholders viz., researchers, academia, industries and students regarding the proposed changes in curriculum. Feedback was analysed and considered by the Expert Groups vis-a-vis with curricula followed by best international universities. I am assured that the proposed curricula have incorporated papers on research methodology, scientific communication, prevailing regulations in the country etc.

I am confident that this curriculum revision exercise would be very beneficial for faculty and students of not only DBT supported programmes but also other universities involved in biotechnology teaching. I compliment the Department for undertaking this valuable exercise.
Integrated Human Resource Development Programme in biotechnology is a unique, innovative initiative taken by Department of Biotechnology way back in 1985-86. Human Resource Development programmes of the Department are highly dynamic and have evolved continuously based on need, regional aspirations and feedback from different stakeholders.

Emphasis is laid on selection of institutions based on existing expertise, infrastructure, nearby institutions engaged in research in relevant areas and students are provided hands on practical training. These programmes are continuously mentored and monitored by Advisory Committee, Expert Task Force and Course Coordinators meeting. An attempt is made to conduct curriculum revision exercise at frequent intervals to incorporate feedback from stakeholders as well as inclusion of latest developments. I am confident that revised curriculum has been framed after intense deliberations and would serve as a valuable resource to experts and student community.

I thank the Biotech Consortium India Limited for assisting DBT in this important exercise and compliment my colleague Dr. Suman Govil, Adviser, DBT for bringing out this publication.

(K. VijayRaghavan)
We need brains trained enough to understand the brain, how it works, the disorders and how to assist those suffer from a brain disorder. The M.Sc. Neuroscience with an integrated approach intends to provide training on a wide range of skills enabling the students to ask questions and motivate them to take-up a career in research towards understanding the structure and function of the nervous system.

The major and visible Institutes for neuroscience are National Brain Research Centre, National Institute of Mental Health and Neuroscience, All India Institute of Medical Sciences, Indian Institutes of Technology, Indian Institute of Science, Jawaharlal Nehru University, Indian Institute of Toxicology Research, Central Drug Research Institute, Banaras Hindu University, Jiwaji University, University of Hyderabad etc. and the list is growing. We have more than 300 PIs undertaking neuroscience research activity and several R&D and industrial setups have the subject as their priority area.

We need human resource with cross-disciplinary training in basic and clinical studies at the cutting edge enabling them for research in the forefront of neuroscience. The curriculum being presented would ensure developing hands with background covering cellular, molecular and systems neuroscience, behavior and cognitive aspects. The concept has been timely adopted in India but needs expansion. The teaching programmes have been developed and a common curriculum was projected by the Department of Biotechnology, Govt. of India. This is a revised version of the earlier one. Two centers, National Brain Research Centre and School of Studies in Neuroscience, Jiwaji University, are providing training to the next generation of neuroscientists with DBT support. The students have since been enthusiastically accepted by the neuroscience academia and industries.

Neurobiology has been a part of the Life Sciences syllabi of several University Teaching Departments. Some Institutes are expected to introduce M.Sc. Neuroscience programme soon and this document will be useful for them.

Our team has made a humble effort, trust this will be accepted by the academia.

(Ishan Patro)
Preface

Promotion of Indian Biotechnology sector is high on policy agenda of Government of India. Biotechnology has also been recognized as one of the key priority sectors under ‘Make in India’, ‘Skill India’ and ‘Startup India’ initiatives of Government of India, as it is one of sectors expected to contribute towards enterprise creation, innovation and economic growth. Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India has immensely contributed to this dynamism through various policies and initiatives, establishment of innovation clusters, academia-industry partnerships, increasing capabilities for technology development, etc. The National Biotechnology Development Strategy (2015 – 2020) released by DBT provides a strategic roadmap for India’s emergence as a global biotechnology innovation and manufacturing hub. It has also highlighted importance of human resource development and need for nurturing tailor-made human capital for advanced scientific research and entrepreneurship.

DBT has taken a number of initiatives aimed at integrated human resource development to evolve an ecosystem where scientists, innovators and future entrepreneurs can be nurtured. Keeping in mind requirement for trained manpower in various areas of Biotechnology, DBT initiated Post-Graduate Teaching Programme way back in 1985 with 5 universities which has expanded to 74 universities imparting M.Sc./M.Tech./M.V.Sc. degrees in general, agricultural, animal, food, environmental, industrial marine, medical, neuroscience and pharmaceutical biotechnology. 10 programmes are being phased out. These universities and institutes are provided liberal financial support towards strengthening of laboratory facilities, equipment, consumables, fellowships to students, dissertation grant per student etc. Post-Graduate Teaching Programme selects best students and trains them to join research or industry workforce contributing significantly to biotechnology workforce.

Taking into cognizance the changing needs of the economy and to keep abreast with latest developments in the field of biotechnology, DBT proactively initiated revision of course curricula of Post-Graduate Programmes in biotechnology. The present exercise has been undertaken by Biotech Consortium India Limited (BCIL), New Delhi. Earlier exercise was carried out in 2008. The Course Curriculum Revision Exercise has been carried out for 13 Post-Graduate programmes in Biotechnology supported by DBT.

The revision of course curriculum of M.Sc. Neuroscience aims to address mismatch between 'knowledge' gained by students and appropriate skill set required for technology development and implementation including present contemporary needs of economy.

About the Course Curriculum Revision Exercise

A meticulous and structured approach has been adopted to accomplish the Course Curriculum Revision exercise.

BCIL had initiated the exercise with a review of literature of relevant national and international documents on curriculum design and planning for biotechnology programmes of premier national as well as international universities, guidelines by University Grants Commission, recent curricular guidelines released by Indian Council of Agricultural Research, Ministry of Health and Family Welfare and Indian Institute of Science Education & Research and other relevant research papers on curriculum development in peer-reviewed journals.

The findings of the literature review were adopted to design questionnaires for eliciting feedback from stakeholders of Biotechnology community i.e. academicians,
scientists, industry representatives and students. Feedback was received from 165 experts and 20 students belonging to academic institutions, research organizations and industry regarding addition of advanced topics, deletion of elementary, redundant and overlapping topics, updation of laboratory practicals, re-adjustment of credit load, incorporating ‘technology’ component in the curriculum, among others. It was also suggested that re-orientation of curricula should be done keeping in view the needs of the industry.

**Strategic Approach**

A Core Committee along with 9 subject specific subcommittees comprising of 63 academicians, scientists and industry representatives were constituted to revise and update the curricula. The constitution of subject specific subcommittee for M.Sc. Neuroscience is given at Annexure-1.

The salient recommendations identified from stakeholder survey were presented to the Committee. Several brainstorming discussion sessions were held for achieving the desired balance between the foundation courses, recent developments in biotechnology and updation needs identified during the stakeholder survey. Core Committee finalized broad contours for revising all the course curricula. The guidelines set by the Core Committee were taken up by the subject specific subcommittee of M.Sc. Neuroscience for updating the curriculum. The subject specific committee incorporated latest advancements in areas of Neuroscience in the curriculum. Separate meeting was held to discuss and deliberate the updations to be made in the curriculum. The revised curriculum was vetted and finalized by the Core Committee.

**Course Curriculum Revision**

The members of Committee agreed that revised course curriculum should provide skill and outcome based education and help the students to gain domain knowledge, ability to design and interpret research experiments and acquire effective communication skills. The course curriculum has been re-designed accordingly to promote skill-based and outcome-based education. The revised course curriculum totals to 96 credits comprising of theory, practical, technology-based topics, electives and dissertation. Each course includes learning objectives, student learning outcomes, course plan (number of lectures/unit) and reference textbooks/resources. Theory and practical courses include relevant examples, case scenarios and tutorials for inculcating critical thinking against rote learning. Several new courses have been included and content for existing courses has also been updated. Several areas of basic and clinical studies at the forefront of neuroscience like Development of Sensory and Motor Systems, Regeneration, Pathway Finding by Axons, Synaptic Function and Plasticity, Neurotrophin Gene Expression and Trophic Regulation, Aging, Neuron-Glia Interactions, Neural Circuits and Neural Modelling, Regulation of Neurotransmitter and Receptor Expression, Neurogenesis Neurodegenerative Disorders, Computational Neuroscience, Neuroinformatics, etc. have been introduced. With importance of students being able to execute research projects independently, separate credits have been allotted for proposal preparation and presentation before initiating dissertation and also credits for dissertation have been increased accordingly.

We hope that model course curriculum shall serve as guidelines for academicians and researchers from different parts of the country for adoption in their institutions with modifications as per availability of expertise, infrastructure and specific needs.

We wish to put on record our sincere appreciation for constant guidance and encouragement received from Dr. K. VijayRaghavan, Secretary, DBT for bringing out this publication. We wish to acknowledge whole-hearted support of Core Committee and subject specific subcommittees members. Sincere thanks are due to Dr. Manoj Singh Rohilla, Scientist- D, DBT, Ms. Shweta for creative design, Mrs. Rita Bhatla, DBT and Shri. Dilip Joy, BCIL.
# M.Sc. Neuroscience

## Recommended Electives:
1. Computational Neuroscience  
2. Neurogenetics

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<th>S.No.</th>
<th>Title</th>
<th>Credits</th>
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<td>Biochemistry</td>
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<td>2</td>
<td>Cell Biology and Neuron Organization</td>
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<td>3</td>
<td>Molecular Biology</td>
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<td>4</td>
<td>Instrumentation and Techniques</td>
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<td>5</td>
<td>Introduction to Mathematics and Statistics for Biology</td>
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<td>7</td>
<td>Laboratory II: Cell and Molecular Biology</td>
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<td>Neuroanatomy</td>
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<td>Developmental Neurobiology</td>
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<td>5</td>
<td>Neurophysiology and Biophysics</td>
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<td>7</td>
<td>Laboratory IV: Neurophysiology</td>
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<td>Readings in Recent Advances in Neuroscience/ Seminar</td>
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<td>Neurochemistry and Neuropathology</td>
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<td>2</td>
<td>Sensory and Motor Systems</td>
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<td>3</td>
<td>Neural Regulatory Systems</td>
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<td>4</td>
<td>Behavioural and Cognitive Neuroscience</td>
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<td>5</td>
<td>Project Proposal Preparation and Presentation</td>
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<tr>
<td>6</td>
<td>Critical Analysis of Research Papers</td>
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<td>7</td>
<td>Laboratory V: Neuropathology</td>
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<td>8</td>
<td>Laboratory VI: Behavioural Biology</td>
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<td><strong>SEMESTER FOUR</strong></td>
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<td>Intellectual Property Rights, Biosafety, Bioethics and Ethics</td>
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<td><strong>TOTAL CREDITS</strong></td>
<td><strong>96</strong></td>
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</table>
Biochemistry

Credits

Semester One

Course Objectives
The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways. The course shall make the students aware of various disease pathologies within the context of each topic.

Student Learning Outcomes
On completion of this course, students should be able to:
• Gain fundamental knowledge in biochemistry;
• Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.

Unit I
Protein structure
5 lectures

Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, 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, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc.; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.

Unit II
Enzyme kinetics
5 lectures

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; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.

Unit III
Glycobiology
2 lectures

Sugars - mono, di, and polysaccharides with specific reference to glycogen, amylase and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids; lipids - structure and properties of important members of storage and membrane lipids; lipoproteins.

Unit IV
Structure and functions of DNA & RNA
3 lectures

Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.

Unit V
Bio-energetics
8 lectures

Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources
Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation; target of rapamycin (TOR) & Autophagy regulation in relation to C & N metabolism, starvation responses and insulin signaling.

Recommended Textbooks and References:

Course Objectives
Neurons contain the same intracellular components, as do other cells. Understanding of brain function would absolutely need a clear understanding of cellular and molecular organization of neurons and glia as units. Thus, in this paper, student is expected to learn, in greater details, sub-cellular and molecular organization of mammalian cells in general, and that of neurons and glia cells in particular. Greater emphasis will be on cell structure of function, and to develop skill sets for reading and understanding scientific literature and to interpret experimental data in cell biology.

Student Learning Outcomes
On successful completion of this course, student should be able to:
• Gain comprehensive understanding of classical and advanced topics in cell biology;
• Design experimental models to address mechanistic question in cell biology;
• Comprehensive understanding on neuronal architecture and its interactions with glia, and underlying molecular mechanisms communication;
• Ability to understand and analyze contemporary cell biology studies reported in research papers.

Unit I
Introduction to cell biology
5 lectures
Introduction to cell biology: subcellular organelles, cell types and specialization; introduction to neurons and glial cells; tools and methods in cell biology.

Unit II
Cell membrane: structure-function
7 lectures
Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; introduction to optogenetic tools; Endo- and exocytosis; Membrane carbohydrates and their significance in cellular recognition; Cellular junctions and adhesions.
Credits

Molecular Biology

Course Objectives

Cells are fundamental units of body and this course aims at providing an introduction to experimental methods that scientists have used to discover mechanisms by which cells, at molecular level, control their specific functions, growth and differentiation into specialized tissues. Greater emphasis will be on fundamentals of molecular biology and to develop skill sets for reading and understanding scientific literature and to interpret experimental data.

Student Learning Outcomes

On successful completion of this course, students should be able to:

- Gain understanding of the genome and its regulation;
- Appreciate methodology used to decipher central dogma of molecular biology;
- Gain understanding of gene regulation – at transcriptional, post-transcriptional, translational and post-translational levels – and underlying molecular mechanisms;
- Analyse contemporary molecular biology studies reported in research papers.

Unit III

Cell organelles and functions

7 lectures

Nucleus – Structure and function of nuclear envelope, lamina and nucleolus; Macromolecular trafficking; Mitochondria – Structure; Organization of respiratory chain complexes; ATP synthase; Structure-function relationship; Mitochondrial DNA. Structure and function of microbodies, Golgi apparatus, Lysosomes and Endoplasmic Reticulum – structure and function; Cellular stress (ER, oxidative, unfolded protein stress etc.) and stress response mechanism - chaperones and ubiquitin-proteasome system; autophagy and lysosome-mediated proteolysis; mitophagy.

Unit IV

Cell organization and movement

7 lectures

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 V

Neurons

7 lectures

Introduction to neurons; The Neuron Doctrine; Components of neurons; Classification of neurons; The Nissl and Golgi stains; Types of neurons; Cytology of neurons; Dendrites structure and function; Axon structure and functional aspects; Ultrastructure; Myelination and synapses.

Unit VI

Glial cells

7 lectures

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; Function of other glial cells: oligodendrocyte and microglial cells; Overview of glial and neuronal relationship in the CNS; Importance of astrocytes in glutamate metabolism and blood brain barrier; Microglial phenotypes; Glial –neuronal interplay in the CNS.

Recommended Textbooks and References:

<table>
<thead>
<tr>
<th>Unit I</th>
<th>Molecular genetic techniques &amp; genomics</th>
<th>DNA cloning and characterization; Genome wide analyses of gene structure and gene expression; Inactivating function of specific genes in eukaryotes; Identifying and locating human disease genes.</th>
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<tbody>
<tr>
<td>Unit II</td>
<td>Molecular structure of genes &amp; chromosomes</td>
<td>Chromosomal organization genes and non-coding DNA; Mobile DNA; Structural organization of eukaryotic chromosomes; organelle DNAs.</td>
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<tr>
<td>Unit III</td>
<td>Transcriptional control of gene expression</td>
<td>Eukaryotic gene control and RNA polymerase; regulatory sequences in protein coding genes; activators and repressors of transcription; mechanism of transcription activation and repression.</td>
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<tr>
<td>Unit IV</td>
<td>Post-transcriptional gene control</td>
<td>Processing of eukaryotic pre-mRNA; transport across nuclear envelope; cytoplasmic mechanism of post-transcriptional control; processing of rRNA and tRNA.</td>
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<tr>
<td>Unit V</td>
<td>Cell signalling</td>
<td>Signalling molecules and cell surface receptors; intracellular signal transduction; G protein coupled receptors.</td>
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<td>Unit VI</td>
<td>Membrane trafficking</td>
<td>Translocation of secretory proteins across ER membrane; protein modifications, folding and quality control in the ER; export and sorting of proteins.</td>
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<tr>
<td>Unit VII</td>
<td>Eukaryotic cell cycle</td>
<td>Biochemical and genetic studies on cell cycle; mechanism regulating mitotic events; meiosis - a special type of cell division; Oncogenes and Tumor suppressor genes.</td>
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</tbody>
</table>

**Recommended Textbooks and References:**

**Course Objectives**
The course is designed to provide a broad exposure to all basic techniques (biochemical & biophysical) used in current Modern Biology research. The goal is to impart basic conceptual understanding of principles of these techniques and emphasize on Biochemical utility of the same & underlying Biophysics. At the end of the course, student is expected to have clear understanding of all analytical techniques such that the barrier to implement the same is abated to a great extent.

**Student Learning Outcomes**
Students should be able to learn how to combine previously acquired knowledge of physical chemistry and biochemistry in order to understand biochemical processes at molecular level.
<table>
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<tr>
<th>Unit I</th>
<th>Basics</th>
<th>2 lectures</th>
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<tr>
<td></td>
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<td>Units of measurement of solutes in solution. Normality, molality, molarity, millimol and ppm. Water-structure and properties; Principles of glass and reference electrodes, types of electrodes, complications of pH measurement (dependence of pH on ionic strength, pH, pOH, Hendersen-Hasselbach equations, buffers, pH of body fluids, buffers in body fluids, red blood cells and tissues. Length scales in biological systems: proteins, multiprotein complexes, organelles &amp; cells; Basic thermodynamics; Basic chemical kinetics &amp; reaction rates: Theory of chemical reactions.</td>
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<tr>
<th>Unit II</th>
<th>Hydrodynamic methods</th>
<th>2 lectures</th>
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<td>Basic principles and types of centrifugation-rotors, boundary, differential, density gradient, zonal isopycnic, equilibrium; Sedimentation - sedimentation velocity, preparative and analytical ultracentrifugation techniques: principles &amp; applications in biochemical fractionation methods.</td>
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<tr>
<th>Unit III</th>
<th>Electrophoresis</th>
<th>2 lectures</th>
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<td>Principles of electrophoretic separation, zonal and continuous electrophoresis, paper, cellulose acetate/nitrate, gel and capillary electrophoresis, use of native and denaturing gels, Protein subunit molecular weight determination using SDS-PAGE, Anamolous protein migration of some proteins in SDS-PAGE, Acid-urea PAGE and their physical basis, Isoelectric focussing and two dimensional gel electrophoresis, electroporation, pulse field gel electrophoresis, gradient gels.</td>
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<th>Unit IV</th>
<th>Chromatography and X-ray crystallography</th>
<th>2 lectures</th>
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<td>Chromatography, principles of adsorption, partition and ion-exchange chromatography, gel permeation chromatography, GC, GC-MS and HPLC; X-ray Crystallography - protein crystals, Bragg’s law, unit cell, isomorphous replacement, fiber pattern of DNA; Small-angle X-ray diffraction methods: Principles &amp; applications; Basic protein structure prediction methods.</td>
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<th>Unit V</th>
<th>Molecular and chemical biology</th>
<th>4 lectures</th>
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<td>DNA cloning; bacterial transformation; transfection; chromosome integration; screening for transformants; Polymerase Chain Reaction; PCR types; Gel electrophoresis; DNA sequencing; Molecular hybridization: Southern blot; Northern blot. Protein analyses: Western blot &amp; Immunoprecipitation; Rewriting DNA: mutations; random mutagenesis; point mutation; Site-specific mutations; Genome Editing Technology; DNA array &amp; protein array; Click-chemistry: Principles &amp; applications; Chemical sensors for in-cell biochemistry.</td>
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<th>Unit VI</th>
<th>Optical microscopy methods</th>
<th>4 lectures</th>
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<td>Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluoresence and fluorescence microscopy; Confocal microscope: confocal principle, resolution and point spread function; nonlinear microscopy: multiphoton microscopy; principles of two-photon fluorescence, advantages of two-photon excitation, tandem scanning (spinning disk) microscopes, deconvolving confocal images; image processing, three-dimensional reconstruction; Total Internal reflection microscopy, STED microscopy.</td>
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<th>Unit VII</th>
<th>Mass spectroscopy</th>
<th>3 lectures</th>
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<td>Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.</td>
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**Recommended Textbooks and References:**

**Course Objectives**
The objective of this course is to give conceptual exposure of essential contents of mathematics and statistics to students.

**Student Learning Outcomes**
Students should be able to:
- Gain broad understanding in mathematics and statistics;
- Recognize importance and value of mathematical and statistical thinking, training, and approach to problem solving, on a diverse variety of disciplines.

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### Unit I
**Data representation**
- Representation of Data: Histograms, Pie charts, 3D representation, Frequency distribution, Standard deviation, Skewness and Peakedness; Correlation and Regression: Correlation coefficients, Regression coefficients, Regression equation.
- Binomial formula, Probability-mutual and conditional, Gaussian and Poissonian distributions, Probability density function.

### Unit II
**Probability and uncertainty**
- Random number generation and tables, Randomization experiments, Sampling survey, Error and Standard error, Double blind approach.

### Unit III
**Random variables and sampling**
- The Null and Alternate hypothesis; Degree of significance and confidence; The Student t-test and t-distribution, Fisher’s F distribution, The Chi-square test, Goodness of fit; Analysis of variance (ANOVA) and related tools.

### Unit IV
**Inference of experimental data**
- Design and analysis of experiments: Block design, One array/muti array design, Multi-factor design, Response plotting; Nonparametric statistics: Difficult populations and uncertain parameters, Distribution free methods.

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### Recommended Textbooks and References:
Laboratory I: Biochemistry & Laboratory Techniques

Course Objectives
The objective of this laboratory course is to introduce students to experiments in biochemistry. The course is designed to teach students the utility of set of experimental methods in biochemistry in a problem oriented manner.

Student Learning Outcomes
On completion of this course, students should be able to:

1. Preparing various stock solutions and working solutions that will be needed for the course.
2. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation.
3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer-Lambert's Law.
4. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.
5. Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of the institution's choice).
   a) Preparation of cell-free lysates
   b) Ammonium Sulfate precipitation
   c) Ion-exchange Chromatography
   d) Gel Filtration
   e) Affinity Chromatography
   f) Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method
   g) Generating a Purification Table (protein concentration, amount of total protein; Computing specific activity of the enzyme preparation at each stage of purification)
   h) Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis
   i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
6. Experimental verification that absorption at OD_{260} is more for denatured DNA as compared to native double stranded DNA. reversal of the same following DNA renaturation. Kinetics of DNA renaturation as a function of DNA size.
7. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy; UV-visible absorption specturm for proteins, Dynamic Light scattering analyses of native particle sizes in protein mixture and pure proteins; Assessing the sub-unit composition of an oligomeric protein).

Laboratory II: Cell and Molecular Biology

Course Objectives
The objective of this laboratory course is to introduce students to experiments in cell biology & molecular biology. The course is designed to teach students utility of set of experimental methods in cell biology & molecular biology in a problem oriented manner.

Student Learning Outcomes
On completion of this course, students should be able:

- To elaborate concepts of cell biology & molecular biology with easy to run experiments;
- To familiarize with basic laboratory instruments and understand principle
Credits
3

Syllabus

Cell Biology
1. Introduction to anatomy and functioning of upright and inverted microscope.
2. Handling and maintenance of microscopes.
3. Preparation of temporary and permanent slides of given samples.
4. Observation of suitable specimen under bright field, phase contrast, dark field and differential interference contrast (DIC) microscope.
5. Measurement of cell size by oculometer and stage micrometre.
6. To quantify number of cells present in given sample and assessment of cell viability.
7. Identification of Barr body by preparing buccal smear.
8. Low speed separation of cells from animal blood.
9. Isolation of lysosome from given samples (i.e. chicken liver) in isotonic sucrose method.
10. To study process of cellular osmosis in guard cells from plant leaves or animal blood.
11. To study cellular distribution of mitochondria by janus green staining.
12. Isolation of mitochondria from given tissue samples.
14. To assay activity of acid phosphatase enzyme in extract of wheat germ/moong dal and to determine its specific activity.

Syllabus

Molecular Biology
Isolation of Genomic DNA from Chicken blood or mouse tissues
1. Genomic DNA isolation, purification and quantification of DNA by DNA agarose gel, UV-visible spectrophotometer and NanoDrop method
2. EcoRI, BamH1 and HindIII digestion of total DNA, calculation of restriction endonuclease units, DNA ligation, Purification of His-tag protein on Ni-NTA columns

Analysis of RNA
1. Isolation of total RNA from mouse liver/blood using guanidine isothiocyanate method
2. Quantitation of RNA by spectrophotometer
3. Reverse transcriptase-PCR.

Polymerase chain reaction and its applications
1. cDNA synthesis from the total RNA using oligo dT primers
2. Quantitative PCR using real-time PCR machine
3. Nested-PCR, Multiplex PCR
4. RFLP, RAPD, DNA fingerprinting.

Conditional expression of genes
1. In Drosophila using the Gal4-UAS system (e.g crossing Dpp-Gal4 and UAS-eyeless flies for induction of ectopic eyes in legs and wings in progeny or crossing HS-Gal4 and UAS-GFP flies and examining GFP expression in progeny following heat shock).
Course Objectives
The primary objective of course is to provide strong fundamentals, and to broaden knowledge and understanding of genetics and genetic principles and their applications in genomics with an aim to develop skill sets required for independent and critical thinking.

Student Learning Outcomes
On successful completion of this course, student is expected to have:
- Detailed understanding of molecular basis of heredity and genome;
- Comprehensive understanding of methodology used to decipher genetic process;
- Comprehensive understanding on quantification of heritable traits and underlying molecular mechanism;
- Ability to understand and analyze contemporary genetic studies reported in research papers.

Unit I
Principle of segregation
8 lectures
Introduction to genetics and its history, Structure of DNA, DNA as genetic material, Mechanism of DNA Replication, Cell Division, Mitosis and Meiosis, Recombination, DNA repair mechanism, Allele, Traits, Dominant and recessive.

Unit II
Mendelian and non-mendelian genetics
8 lectures
Mendelian Genetics: Introduction to human genetics; Background and history; Types of genetic diseases; Role of genetics in medicine; Human pedigrees; Patterns of single gene inheritance - autosomal recessive; autosomal dominant; X linked inheritance; Complicating factors - incomplete penetrance; variable expression; Multiple alleles; Codominance; Sex influenced expression; Hemoglobinopathies - Genetic disorders of hemoglobin and their diseases. Non-Mendelian inheritance patterns: Mitochondrial inheritance; genomic imprinting; Lyon hypothesis; isodisomy. Complex inheritance - genetic and environmental variation; Heritability; Twin studies; Behavioral traits; Analysis of quantitative and qualitative traits.

Unit III
Cytogenetics and developmental genetics
8 lectures
Cytogenetics: Cell division and errors in cell division; Non disjunction; Structural and numerical chromosomal abnormalities – deletion; duplication; translocation; Sex determination; Role of Y chromosome; Genetic recombination; Disorders of sex chromosomes and autosomes; Molecular cytogenetics – Fluorescence In Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH). Developmental genetics: Genes in early development; Maternal effect genes; Pattern formation genes; Homeotic genes and Signalling and adhesion molecules.

Unit IV
Genetic variation and population genetics
8 lectures
Genetic variation: Mutations; kinds of mutation; agents of mutation; genome polymorphism; uses of polymorphism; Gene mapping and human genome project; Physical mapping; linkage and association. Population genetics and evolution: Phenotype; genotype; gene frequency; Hardy Weinberg law; Factors distinguishing Hardy Weinberg equilibrium; Mutation selection; Migration; Gene flow; Genetic drift; Human genetic diversity; Origin of major human groups.

Unit V
Genetic linkage, chromosome mapping and inheritance
8 lectures
Genetic linkage and chromosome mapping: Genetic recombination, Principle and mechanism of genetic recombination, homologous recombination and its application in research, Map units, Markers, LOD values. Genetics of complex inheritance: Introduction to complex trait inheritance, establish inheritance pattern, Model population for studying complex inheritance, Multifactorial inheritance, Genetic Heterogeneity, Heritability, Mapping complex trait genes, Introduction to statistical methods.
Recommended Textbooks and References:
2. *An Introduction to Genetic Analysis* by Griffiths, Wessler, Carroll and Doebley, (11th Edition), Macmillan Learning

Course Objectives
The objectives of this course are to learn about structural features of components of immune system as well as their function. The major emphasis of this course will be on development of immune system and mechanisms by which our body elicits immune response. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.

Student Learning Outcomes
On completion of this course, students should be able to:
- Evaluate usefulness of immunology in different pharmaceutical companies;
- Identify proper research lab working in area of their own interests;
- Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in the setting of infection (viral or bacterial).

Unit I
**Immunology: fundamental concepts and anatomy of the immune system**
6 lectures
- Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, hapten; Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing.

Unit II
**Immune responses generated by B and T lymphocytes**
7 lectures
- Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor;
- Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system.

Unit III
**Antigen-antibody interactions**
6 lectures
- Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay; immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand – receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.

Unit IV
**Vaccinology**
6 lectures
- Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering:chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.
Neuroanatomy

Credits

3

Course Objectives
The objectives of this course are to inculcate understanding of anatomical organization of nervous system so that student is able to correlate functional aspects in subsequent stages of learning. Comparative approaches across species may be integrated to demonstrate homology and diversification.

Student Learning Outcomes
On completion of this course, students should be able to demonstrate a solid understanding of basic neuroanatomy and nervous system function on a molecular, cellular and systems level.

Unit I
Structure of brain and CNS-I
6 lectures

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

Unit II
Structure of brain and CNS-II
6 lectures

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

Unit V
Clinical immunology
7 lectures

Immunity to infection: bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology; tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmunity disorder, anaphylactic shock, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.

Unit VI
Immunogenetics
5 lectures

Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex.

Recommended Textbooks and References:
Thalamus: Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of thalamus: Scheme of thalamic organization, nuclei of thalamus; Functional aspects, classification of cranial and spinal nerve components; Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of Basal ganglia: Corpus striatum, subthalamic nucleus, substantia nigra; 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; Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of Cerebral cortex: Histology, general organization, functional localization.

Ascending sensory pathways; Descending motor pathways; Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of Auditory system; Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of Visual system; Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of olfactory system and Limbic system.


Recommended Textbooks and References:

Course Objectives
Neural development is a complex process starting with specification of neurons from undifferentiated ectoderm. This course is designed to explore early events shaping the birth of neurons and signals necessary for the neurons to differentiate from one another to become brain.

Student Learning Outcomes
On completion of course, students should:
- Be conversant with basic areas of developmental neurobiology including neurogenesis, cell fate assignment, cell death, axon pathfinding and synaptogenesis;
- Understand techniques in developmental biology and neurobiology research.
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; Compensatory phenomenon in embryonic forms; 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; Neural stem cells, Induced pluripotent stem cells (iPSCs) and stem cell therapies for neuroregenerative medicine.

Patterning; Polarity and regionalization of the nervous system: The anterior-posterior axis and Hox genes; Forebrain development; prosomeres and Pax genes; Patterning; Polarity and regionalization of nervous system: Dorsal-ventral polarity in 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; Neurotrophic factors: Nerve growth factor (NGF), biological system of NGF; Agents analogous to NGF in functions; Role of NGF as trophic agents; Survival factors.

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.

Axon growth, path finding and nerve patterns: Axonal navigation, 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.

Rearrangement of developing neuronal connections: Synaptic rearrangement in different parts of nervous system; Refinement of synaptic connections; Maintenance of synapses; Denervation and regeneration of synaptic connections; Effects of Denervation on postsynaptic cell; Denervation super-sensitivity, susceptibility to innervation, and axonal sprouting; Regeneration in lower vertebrates and mammalian nervous system.

Recommended Text books and References:
Course Objectives
This course deals with study of electrical properties of neurons and signal processing at electrical and chemical synapses.

Student Learning Outcomes
At end of this course, students should be able to be familiar with neurophysiological basis of sensory, motor and higher functions in humans.

Unit I
Neural signals
7 lectures
Overview of neurons, synapses and networks; Stimulus to sensory perception to motor action / higher brain function; Chemical and electrical signalling within a circuit; Methods to record electrical activity of a neuron.

Unit II
Membrane potential and electrical activities of neurons
8 lectures
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 III
Ion channels and action potential generation
8 lectures
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; Methods to record action potential.

Unit IV
Synaptic transmission
8 lectures
Principles of synaptic transmission: Electrical and chemical synapses; Calcium hypothesis; Synaptic vesicles; Control of transmitter release; Synaptic transmission at central synapses; Transmission at nerve-muscle junction; Ligand gated channels, their structures and major types; Second messengers and synaptic transmission; Methods for quantifying channels; Methods to study channel structure.

Recommended Textbooks and References:

Course Objectives
This course will give hands on experience of various techniques and procedures used to carry out dissection and analysis of nervous system related organs.

Student Learning Outcomes
On completion of this course, students should be able to:
- Dissect nervous system of model organisms;
- Study anatomy of dissected organs;
- Perform analysis of nervous system.
Syllabus

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

Laboratory IV: Neurophysiology

Course Objectives
This course will give hands on experience of various neuronal data analysis. It will also give brief overview to students on various techniques used for determination of different physiological parameters in neuroscience.

Student Learning Outcomes
On completion of this course, students should be able to:
• Acquire data from various sources;
• Determine and analyze various physiological parameters;
• Study different model organisms.

Credits
4

Syllabus

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 use of Stereotoxic instrument for neuroscience research
4. Effect of various neurotransmitters on fish melanophores
5. Pharmacological experiments on melanophores
6. Study of Physiology models related to neurophysiology.

Recommended Textbooks and References:
1. Practicals using low cost kits provided by Backyard Brains (https://backyardbrains.com/). Detailed experimental protocols are available at this website which may be modified to suit local needs
2. Simulation exercises using the free online Nerve programme (http://nerve.bsd.uchicago.edu/). Pre-developed exercises are available at this website.
Semester Three

Neurochemistry and Neuro-pathology

Credits 3

Course Objectives
The goal is to introduce the basics of neurochemistry and relate it to neurochemical bases of brain disorders and neuropathology.

Student Learning Outcomes
On completion of course, students should be able to:

- Familiarize with current literature related to functions and diseases associated with neurotransmitter/neuromodulator;
- Formulate a hypothesis about structure-activity relationships between endogenous neurotransmitter, agonists and antagonists.

Unit I

Biosynthesis release and action of neurotransmitters
9 lectures

Biosynthesis, storage, release, distribution and action of excitatory amino acid neurotransmitters; Biosynthesis, storage, release and action of inhibitory neurotransmitters; Biosynthesis, storage, release and action of acetylcholine, dopamine, histamine and serotonin; Biosynthesis, storage, release and action of peptidergic neurotransmitters; Neurotransmitter receptor diversity, distribution, signalling mechanisms; G protein coupled receptors (GPCRs) and intracellular signalling and Neurotransmitter systems and behaviour.

Unit II

Brain metabolism
10 lectures

Cerebrospinal fluid; Microcirculation and blood brain and CSF barriers; Metabolism: Energy metabolism of brain.

Unit III

Neurochemistry of neurological disorders
11 lectures

Ischaemia and hypoxia; Epileptic seizure; Diseases involving myelin and demyelination; Nutritional and metabolic diseases; Neurotransmitters and disorders of basal ganglia; Biochemical aspects of psychotic disorders; Biochemical basis of mental illness: Anxiety disorders; Mood disorders; Schizophrenia; Drug addiction, drug abuse and adverse drug reaction; Genetic disorders of lipid, glycoprotein, mucopolysaccharide metabolism; Repeat expansion diseases; Proteinopathies; Disorders of RNA metabolism and Prion disease.

Recommended Textbooks and References:

Sensory and Motor Systems

Credits 3

Course Objectives
Sensory and motor systems are two important subfield of neuroscience that deals with anatomy and physiology of neuron that are part of different sensory and motor system. Understanding function of sensory and motor system will allow students to understand brain function in general.

Student Learning Outcomes
On completion of this course, students should be able to have a comprehensive understanding of sensory and motor systems including prevailing concepts on systems-level organization and neural signal mechanisms.
<table>
<thead>
<tr>
<th>Unit I</th>
<th><strong>Somatosensory system</strong> 6 lectures</th>
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<tbody>
<tr>
<td></td>
<td>Introduction to systems approach to understand brain function; Peripheral receptors and sensory coding, Modality specific spinal pathways; Medullary, thalamic and cortical somatosensory structures and pathways; Somatosensory areas in cortex and their connection.</td>
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<table>
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<tr>
<th>Unit II</th>
<th><strong>Visual system</strong> 6 lectures</th>
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<tbody>
<tr>
<td></td>
<td>Eye; Retina; Organization and connections of thalamic and midbrain visual areas; Cortical visual areas; Dorsal vs. ventral stream.</td>
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<tr>
<th>Unit III</th>
<th><strong>Auditory system</strong> 6 lectures</th>
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<tbody>
<tr>
<td></td>
<td>Tonotopy in the cochlea; Brainstem auditory nuclei; Delay lines; Thalamic nuclei and cortical auditory areas.</td>
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<tr>
<th>Unit IV</th>
<th><strong>Olfactory and gustatory systems</strong> 7 lectures</th>
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<tbody>
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<td></td>
<td>Peripheral receptors for each of chemical senses; Pathways to brain.</td>
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<tr>
<th>Unit V</th>
<th><strong>Motor system</strong> 7 lectures</th>
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<tbody>
<tr>
<td></td>
<td>Spinal, cerebellar and cortical motor pathways; Role of basal ganglion; Oculomotor pathways; Plasticity of nervous system.</td>
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</table>

**Recommended Textbooks and References:**


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**Neural Regulatory Systems**

**Course Objectives**

This subfield of neuroscience focuses on how different parts of our brain regulate function of important organs and some of our complex behaviour.

**Student Learning Outcomes**

On completion of this course, students are expected to have a comprehensive understanding of chemical and electrical signal mechanisms of regulatory systems.

<table>
<thead>
<tr>
<th>Unit I</th>
<th><strong>Chemical control of brain and behaviour</strong> 7 lectures</th>
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<tr>
<td></td>
<td>Organizational Principles of Adult Hypothalamus; Role of hypothalamus and pituitary hormones; Diffuse modulatory systems of brain: Locus coeruleus, Raphe nucleus, substantia nigra, etc.; ANS in regulation of brain and behaviour; ANS Pharmacology-Transmitter and Receptor Coding; Autonomic Controls of Homeostasis; Hierarchically Organized CNS Circuits.</td>
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<tr>
<th>Unit II</th>
<th><strong>Cardiovascular system</strong> 6 lectures</th>
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<tbody>
<tr>
<td></td>
<td>Basics of cardiovascular physiology; Sympathetic vasomotor tone; Neural control of heart; Cardiovascular homeostasis; Nervous system and long-term control of cardiovascular system.</td>
</tr>
</tbody>
</table>
Unit III
Neural control of breathing
7 lectures
Early neuroscience and brainstem; Breathing & gas exchange; CNS & breathing; Respiratory rhythm generation; Sensory inputs and altered breathing; Modulation of respiratory motor output; Suprapontine structures and breathing; Respiratory neurons and their discharge pattern.

Unit IV
Circadian timing, sleep and dreaming
6 lectures
Pineal and circadian rhythms; Suprachiasmatic nucleus; Light as dominant stimulus; Circadian timings and reproduction; Heritability of circadian timings; Two states of sleep- slow wave and rapid eye movement; Anatomy and physiology of brainstem regulatory systems.

Unit V
Sex and behaviour, motivation & reward
5 lectures
Neuronal basis of sexual behaviour; Sex hormones and brain; Basis and mechanism of differences between male and female brains; Neural mechanisms of motivation; Reinforcement system; Brain aversion systems; Neurobiological basis of anger and violence.

Recommended Textbooks and References:

Course Objectives
Students will be exposed to basic understanding of evolution of human brain and behaviour, cognitive development, neural control of attention, sensory-motor integration, language acquisition and language processing, neural basis of learning and memory, and cognitive functions like thought, cognitive dysfunctions in aging & neurodegenerative disorders, and consciousness. These biological models of brain function will be linked with behavioural, affective and cognitive function and dysfunction. While this is the front line of neuroscience research today, students will be given basic elementary exposure to subject to stimulate them to undertake further research in this challenging area. It is essential to repeat that only introductory aspects of subject shall be dealt.

Student Learning Outcomes
On completion of this course, students should be able to:
- Develop an awareness in learning and memory, control of movement, language, visual processing;
- Apply psychological concepts, theories, and research findings to solve problems in everyday life and in society;
- Understand major areas of applied psychology and neuroscience;
- Understand how basic research in psychopharmacology and neuroscience gives rise to treatment for addictions, movement and memory disorders and other neurological disorders;
- Develop capacity for independent learning that will sustain personal and professional development in rapidly changing field of neuroscience;
- Self-assess performance accurately; incorporates feedback for improved performance.

Unit I
Evolution and brain development
8 lectures
A brief history of cognitive neuroscience and human uniqueness; Evolutionary and comparative principles, mammalian evolution; Human brain evolution; Brain and cognitive development/ Brain changes underlying development of cognitive control & reasoning.
Physical aspects of aging and cognition, lifestyles, habits and actions; Pathological processes in cognitive dysfunction like AD, PD and aging; Cognitive functions of motor system: understand how different parts of nervous system interact in higher cognitive functions, how neurological disturbances and illnesses can influence sensory, motor, cognitive and executive functions; Motor control and movements; Visual perception of objects: Neuronal basis of object recognition, Perception and recognition of specific classes of objects’ Visual recognition disorders; Spatial cognition: Neural system of spatial cognition; Parietal cortex, Frontal cortex, Hippocampus and adjacent cortex.

Theories of learning and memory: Animals models system to study memory and mechanisms of short-term and long-term memory, episodic and semantic memory; Learning and Memory: Basic Systems: Basic mechanisms of learning, key insights from invertebrate studies, Classical / operant conditioning in vertebrates; Long-term potentiation (NMDAR dependent and NMDAR independent LTP, LTP between CA3-CA1 synapse, Different phases of LTP, properties of LTP) and long-term depression (NMDAR and Ca2+ dependence, LTD at CA3-CA1 synapse); Learning and memory: Brain systems, Major memory systems in mammalian brain, Multiple memory systems and behavior; Spatial memory; Memory consolidation, reconsolidation, extinction; Dynamic interplay between cognitive control & memory.

Attention: Varieties of attention and Neurosensory neglect syndrome, Visual system and attention; Language and communication: Animal communication, Human language, Neuronal organization for language; Decision making executive brain functions: Role of prefrontal cortex, Neurophysiology of prefrontal cortex, Theories of prefrontal cortex function; Neurobiology of consciousness and unconsciousness; Emotion of consciousness.

Recommended Text Books and References:

Course Objectives
The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

Student Learning Outcomes
Students should be able to demonstrate the following abilities:
- Formulate a scientific question;
- Present scientific approach to solve the problem;
- Interpret, discuss and communicate scientific results in written form;
- Gain experience in writing a scientific proposal;
- Learn how to present and explain their research findings to the audience effectively.
Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven.

Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources.

Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, etc. Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.

Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic.

At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

Course Objectives
This course will provide a collaborative learning experience, through a critical discussion of journal papers and writing assignments. This will develop understanding of what “neural systems” are, and value of this kind of analysis.

Student Learning Outcomes
Upon successful completion of this course, students should be able to:

1. Identify “general systems properties” of neural mechanisms described in text form and formulate flow diagram descriptions of their processes;
2. Relate concepts from systems theory and applied mathematics to analysis of models of neural function.

1. The instructor will assign papers from scientific literature on topic, unless otherwise stated.
2. Everyone is expected to complete reading before class for which it is assigned, assuming it has been assigned at least three days in advance.

Course Objectives
This course will give practical overview of the neuronal histochemistry of various model organisms.

Student Learning Outcomes
On completion of this course, students should be able to:

1. Study and understand the basis of various neurodegenerative diseases;
2. Stain various neurodegenerative diseases;
3. Understand the histochemistry of various model organisms.
1. Study of brain pathology (using permanent slides) from different neurodegenerative disorders (Alzheimer's, Huntington's, Parkinson's disease, ALS, Lafora disease)
2. Immunohistochemical staining of neurodegenerative disease brain using ubiquitin/other markers
3. Cellular model of neurodegeneration: Rotenone or paraquat model of cell death; study of apoptosis, Immunoblot analysis of important apoptotic markers.
4. *Drosophila* as a model organism to study neurodegeneration: Maintenance of transgenic fly for any neurodegenerative disorders (AD, PD or HD), Fly eye to study the process of neurodegeneration, genetic screening.

**Syllabus**

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 help of any Maze software
5. Studies on spatial learning behaviour using Y-maze with help of any Maze software
6. Elevated Plus maze for anxiety like behaviour with help of any Maze software
7. Morris water maze for learning and memory with help of any Maze software
8. Studies on locomotory development like: pivoting, traversing, homing, etc.
9. Behavioral studies using *Drosophila* or *C. elegans* (courtship, olfactory conditioning or aggression is easily demonstrable and quantifiable)
10. Optogenetic control of behaviour using *Drosophila* larvae or *C. elegans*.

**Course Objectives**

This course will give brief information on experiment design, controls, analysis and interpretation of data rather than demonstrations.

**Student Learning Outcomes**

On completion of this course, students should be able to:

- Study various neurons associated with behavioural changes;
- Analyse the changes using various techniques on model organisms.

**Recommended Textbooks and References:**

**Course Objectives**

The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.

**Student Learning Outcomes**

Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:

- In-depth knowledge of the chosen area of research.
- Capability to critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis.
- Competence in research design and planning.
- Capability to create, analyse and critically evaluate different technical solutions.
- Ability to conduct research independently.
- Ability to perform analytical techniques/experimental methods.
- Project management skills.
- Report writing skills.
- Problem solving skills.
- Communication and interpersonal skills.

**Syllabus**

**Planning & performing experiments**

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.

**Syllabus**

**Thesis writing**

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.
Course Objectives
The course concentrates on technology, knowledge and business management aspect of intellectual property, including patenting aspect so as to:

- Focuses on use of IP to drive business models and value propositions;
- Provides insights to align IP strategies with overall corporate strategies;
- Shares best practice models for IP valuation.
- Learn biosafety and risk assessment of products derived from biotechnology and regulation of such products.
- Understand ethical issues in biological research.

Student Learning Outcomes
Students should be able to:

- Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents;
- Understand policy of companies and other technology-intensive organizations to build, manage and govern technology-based business;
- Understand systemic and cross-functional identification, control and governance of IP assets in sourcing, collaboration and exploitation.
- Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environment release of genetically modified organisms, national and international regulations.
- Understand ethical aspects related to biological, biomedical, health care and biotechnology research.

Unit I
Introduction to intellectual property rights
8 lectures
Concepts of IPR; Types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, plant variety protection and farmers rights act, International framework for the protection of IP (Introduction to history of GATT, WTO, WIPO and TRIPS), The economics behind development of IPR: Company perspective, IP as a factor in R&D and of relevance to biotechnology.

Unit II
Patenting
8 lectures
Basics of Patents, Indian Patent Act 1970 with Patent Rules 2003 (including recent amendments and Budapest Treaty), Patent application - forms and guidelines including those of National Biodiversity Authority (NBA) and other regulatory bodies, fee structure, time frames; provisional and complete specifications, filing of a patent application; precautions before patenting - disclosure/non-disclosure, concept of “prior art”, patent databases including patent search, analysis and report formation., Patent Cooperation Treaty (PCT) and procedure for filing a PCT application and costs (PCT and conventional patent applications), Patent infringement- meaning, scope, litigation, case studies and examples.

Unit III
Business of intellectual property
8 lectures
Concept of using intellectual property and identifying intellectual assets and link them to business strategy to maximize value generation, commercialization of patented innovations; licensing – outright sale, licensing, royalty; collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives; Aligning of IP strategies with overall corporate strategies; Development of organizational capabilities to strengthen IP management as a core business activity; Addressing issues such as R&D collaboration, strategic partnering, standards, patent pools, licensing and open business models; Value creation in knowledge-based business with valuation of intellectual property.
Risks common to most everyday work places such as electrical and fire hazards, specific hazards associated with handling and manipulating human or animal cells and tissues, as well as toxic, corrosive or mutagenic solvents and reagents, accidental punctures with syringe needles or other contaminated sharps, spills and splashes onto skin and mucous membranes, ingestion through mouth pipetting, and inhalation exposures to infectious aerosols.

Regulations and recommendations for biosafety, ascending levels of containment, Defining microbiological practices, safety equipment and facility safeguards for corresponding level of risk associated with handling a particular agent.

Safety Data Sheet (SDS), also referred to as Material Safety Data Sheet (MSDS), physical data such as melting point, boiling point, and flash point, information on substance’s toxicity, reactivity, health effects, storage, and disposal, as well as recommended protective equipment and procedures for handling spills. Introduction to Safety equipment in a laboratory includes primary barriers personal protective equipment (PPE).

Guidelines for safe laboratory practices, role of institution’s safety committee and rules and regulations pertaining to laboratory safety.

History and philosophy of bioethics, clinical ethics, research ethics, law and bioethics, neuroethics; Practical issues of bioethics, awareness about ethical guidelines and regulations to be followed when human participants are involved in biomedical research etc.

Recommended Textbooks and References:
5. J. M. Davis, Basic Cell Culture (Practical Approach Series).

Recommended Electives

Course Objectives
The objective of this course is to study information processing in brain using mathematical modelling.

Student Learning Outcomes
On completion of this course, students should understand key concepts concerning electrical properties underlying information processing in nervous system, how networks of individual neurons can together perform computations, and how systems of such networks operate together to solve tasks such as visual perception and motor behaviour.
**Unit I**

**Dynamical system**
5 lectures

Introduction to dynamical system; Spiking neuron as a dynamic system; Phase portraits, why is it useful to study ion channel dynamics in phase space; Bifurcations, resting, spiking, periodic spiking, bursting.

**Unit II**

**Linear systems**
6 lectures

Linear systems, Differential equations, Hodgkin-Huxley model, Fitzhugh-Nagumo model.

**Unit III**

**Neuronal coding**
6 lectures


**Unit IV**

**Methods for neural signal recoding**
6 lectures

Neuronal populations, macroscopic recording, pulse to wave conversion, basics of EEG and MEG, neuro-electromagnetism, Field theoretical approaches.

**Unit V**

**Neuronal decoding**
6 lectures

Introduction to neuronal decoding and information theory, entropy, mutual information.

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**Recommended Textbooks and References:**


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**Course Objectives**

The aim of this course is to provide a comprehensive overview of exciting developments in neurogenetics research and molecular and cellular mechanisms that are disrupted in disorders that affect nervous system.

**Student Learning Outcomes**

After completion of this course, students should be able to:

- Describe complete range of monogenetic defects that result in neurodevelopmental disorders;
- Describe epigenetic modifications that affect learning, memory, behavior and discuss trans-generational epigenetic inheritance;
- Apply principles of neurophysiology to study synaptic plasticity in rodent models for neurodevelopmental disorders.

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**Neurogenetics**

**Credits**

3

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**Unit I**

**Neuronal assembly**
6 lectures

Major regions of human brain; Cellular components of nervous tissue; Subcellular organization of nervous system; Membrane potential and action potential; neurotransmitters.

**Unit II**

**Genetic aspect of learning and memory**
5 lectures

Genetics of learning and memory; Genetic approaches to circadian rhythms.
Modern sequencing technique: applications in neuroscience; Transgenics and their application in neurogenetic analysis; Gene targeting technologies and their application in neuroscience; Optogenetics and Pharmacogenetics in neuroscience.

Nature-nurse and behaviour; Genetic experiments to investigate animal behaviour: Selection Studies, Inbred strain studies, studies in genetic model organisms; Identifying genes for controlling behavior: Induced mutations, Quantitative trait loci; Synteny/orthology; Investigating genetics of human behaviour; Twin and adoption study designs, interpreting heritability; Linkage and association studies; Environmental influence-shared and non-shared environment.

Genetics of psychopathology: Schizophrenia, mood disorders, disorders of childhood neurogenetic disorders; Spinomuscular atrophy; Syndromes due to triplet nucleotide expansion; Alzheimer's disease; Parkinson’s disease.

Recommended Textbooks and References:
DBT Supported Teaching Programme

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<tr>
<th>S.No.</th>
<th>Name of University</th>
<th>Contact Details of Course Coordinator</th>
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Annexure I

Subject Specific Subcommittee of M.Sc. Neuroscience

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3. Dr. Nihar Ranjan Jana, Professor and Scientist-VI, National Brain Research Centre, Manesar
4. Dr. Aurnab Ghose, Associate Professor, Department of Biology, Indian Institute of Science Education and Research, Pune
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As on May, 2017

M.Sc. GENERAL BIOTECHNOLOGY
M.V.Sc. ANIMAL BIO TECHNOLOGY
M.Sc. MARINE BIO TECHNOLOGY
M.Sc. NEUROSCIENCE
M.TECH. FOOD BIO TECHNOLOGY
M.Sc. ENVIRONMENTAL BIOTECHNOLOGY
M.TECH. PHARMACEUTICAL BIOTECHNOLOGY
M.Sc. BIOLICAL SCIENCE
M.Sc. AGRICULTURAL BIOTECHNOLOGY
M.Sc. MEDICAL BIOTECHNOLOGY
M.Sc. MOLECULAR & HUMAN GENETICS
M.Sc. INDUSTRIAL BIOTECHNOLOGY
M.TECH. BIO TECHNOLOGY
M.Sc. BIORESOURCE BIOTECHNOLOGY