UNIVERSITY OF CALCUTTA

Notification No.CSR/21/2023

It is notified for information of all concerned that the Syndicate in its meeting held on 14.06.2023 (vide Item No.01) approved & confirmed by the Syndicate dated 30.03.2023 (Item No.29) the matter regarding the revised syllabus accepted and approved and the necessary CSR in M.Sc. Neuroscience for the academic year 2023-2024, under this University, as laid down in the accompanying pamphlet.

The above shall be effective from the session 2023 -2024.

31/7/2023

SENATE HOUSE
KOLKATA-700 073

Prof.(Dr.) Debasis Das
Registrar

S. N. Pradhan Center for Neurosciences

University of Calcutta

Syllabus

&

Regulations

M. Sc. in Neuroscience

2023

CONTENT

**** The course will follow the regulation frame published by the University time to time.***

ORIENTATION OF COURSES IN FOUR SEMESTERS (2 years) FOR M. SC. IN NEUROSCIENCE

Subject Code	Theory/ Practical /Project	Subject	Marks	Credit
1st SEMESTER *(CORE COURSES)*				
NS CC11-(TH)-P01	Theory	Biomolecules, Enzymology and Instrumentation	50	4
NS CC12-(TH)-P02	Theory	Cell and Molecular Biology, Neurodevelopmental Biology and Evolutionary Neurosciences	50	4
NS CC13-(TH)-P03	Theory	Neuroanatomy & Neurophysiology, Immunology & Neuroimmunology	50	4
NS CC14-(PR)-P04	Practical	(a) Biochemistry and Laboratory Techniques (b) Cell and Molecular Biology (c) Critical Analysis of Research Papers	50	4
NS CC15-(PR)-P05	Practical	(a) Neuroanatomy and Neurophysiology (b) Neurodevelopmental Biology	50	4
		Total	250	20
2nd SEMESTER *(CORE COURSES)*				
NS CC21-(TH)-P06	Theory	Metabolism and Brain Metabolism Neuroendocrinology, Redox Biology	50	4
NS CC22-(TH)-P07	Theory	Genetics and Neurogenetics RDT & Molecular Diagnostics	50	4
NS CC23-(TH)-P08	Theory	Biostatistics Neuropharmacology & Neuro-environmental Biology	50	4
NS CC24-(PR)-P09	Practical	(a) Metabolism, (b) Neuroendocrinology & (c) Seminar / Journal Club	50	4
NS CC25-(PR)-P10	Practical	(a) Neurogenetics, (b) Molecular Diagnostics	50	4
Total			250	20
Summer project: Student will opt their DSEC for their 4th Semester curriculum based on merit and will be assigned for summer projects. Students will present summer project in 4th Semester under DSEC curriculum.				
3rd SEMESTER *(CORE COURSES & GENERIC ELECTIVE COURSES)*				
NS CC31-(TH)-P11	Theory	Psychology, Behavioural and Cognitive Neuroscience	50	4
NS CC32-(TH)-P12	Theory	Genomics & Proteomics, Clinical & Molecular Neuropathology	50	4
NS CC33-(PR)-P13	Practical	(a) Neuropathology & Neurobehavioural Biology (b) Genomics & Proteomics (c) Readings in Recent Advances in Neuroscience	50	4
NS GEC31-(TH)-P14	Theory	CBCC-X or other codes Students will opt subjects offered by other Departments	50	4
NS GEC32-(TH)-P15	Theory	CBCC-Y or other codes Students will opt subjects offered by other Departments	50	4
Total			250	20
4th SEMESTER *(CORE COURSES & DISCIPLINE SPECIFIC ELECTIVE COURSES)*				
NS CC41-(TH)-P16	Theory	Computational Biology & Neuroinformatics Animal Biotechnology, Bioethics, Biosafety & IPR	50	4
NS DSEC41-(TH)-P17	Theory	Students will opt subjects offered by the Department	50	4
NS DSEC42-(TH)-P18	Theory	Students will opt subjects offered by the Department	50	4
NS DSEC43-(PR)-P19	Practical	Students will opt subjects offered by the Department	50	4
NS DSEC44-(PSV)-P20	Project	Students will opt subjects offered by the Departments	50	4
Total			250	20
		Grand Total	**1000**	**80**

"P" stands for paper

DSE Courses: Department will offer following courses for students of Neurosciences.
1. Cellular & Molecular Neuroscience
2. Systems Neuroscience

GE Course: Department will offer following course for students of other Departments.
Neurobiology: Function & Dysfunction

Detailed Syllabus for Two-year M. Sc. Course in Neuroscience
University of Calcutta
2023

First Semester

NS CC11-(TH)-P01: Biomolecules, Enzymology and Instrumentation

Biomolecules: Chemical basis of life - Chemical bonding, forces involved in biological molecules and building blocks - macromolecules; informational macromolecules. Proteins as informational macromolecules; chemistry of amino acids; primary, secondary and tertiary structure of polypeptides; peptides; peptide subunits and quaternary structure, ∝-helix, β- sheet and collagen structure, metabolism of protein and amino acids. Chemistry of Carbohydrates - mono, di- and polysaccharides. Molecular structure of DNA, alternate DNA structures, circular and superhelical DNA, Denaturation and Renaturation of DNA, the physical and chemical stability of DNA.

Enzymes and Reaction Kinetics: Definition of enzymes; active site, substrate, coenzyme, cofactor and different kinds of enzyme inhibitors; enzyme kinetics, two substrate kinetics, three substrate kinetics, deviation from linear kinetics; ligand binding studies; rapid kinetics; association and dissociation constants; use of isotopes in enzyme kinetics mechanism analysis; effect of pH, temperature and isotopically labeled substrates on enzyme activity; allosteric model of enzyme regulation; substrate induced conformational change in enzyme.

Instrumentations: Principles and application following spectroscopy in biological systems: Absorption Spectroscopy (UV-visible), Fluorescence and Phosphorescence, Circular Dichroism (CD), Infrared spectroscopy (IR), Resonance Raman spectroscopy; Electron spin resonance (ESR), Liquid Scintillation counter; pH meter; Ultracentrifuges, Optical microscopes, optical microscopy; phase, ultraviolet and interference microscope- their basic principles; optical systems and ray diagrams- their applications in cell biology; fluorescence microscope; microspectrophotometry of cells and tissues, fluorescence activated cell sorter (FACS). Electron microscopy: theory of magnetic and electrostatic lenses and their focal length; construction of electron microscope; limiting resolution and useful magnification; contrast formation; shadowing and staining technique; scanning electron microscopy; specimen preparation techniques; application of electron microscopy in cell and molecular biology; embedding and section cutting.

NS CC12-(TH)-P02: Cell and Molecular Biology, Neurodevelopmental Biology and Evolutionary Neurosciences

Cell Biology: Evolution of cells (from prokaryotes to eukaryotes; from single cells to multicultural organisms), Cell-structure and function. Internal Organization of the cell: Membrane structure – Lipid Bilayer, membrane protein; Membrane transport of small molecules and the electrical properties of membrane; Principles of membrane transport,carrier protein and active membrane transport, ion channel and the electrical properties of membranes; Roles of ion transport in human genetic disease Intracellular compartments & protein sorting; Intracellular vesicular traffic; Energy conversion and Mitochondria; Cell communication - General principles of cell communication signaling through G-protein linked cell surface receptor. Shape and structure of protein and protein function. Cytoskeleton- Self assembly & dynamic structure of cytoskeletal filaments, regulation of cytoskeletalfilaments, Molecular motor, Cytoskeleton and cell behaviour. Cell Cycle and programmed cell death. Components of cell cycle control system, intracellular control of cell cycle events; Apoptosis, extracellular control of cell division, cell growth and apoptosis. Cell Division -Mitosis and Meiosis, Genetic diversity).

Concept of extracellular matrix and adhesion molecules. The cytoskeleton, myofibrils and their function in cell shape. Isolating cells and growing them; fractionation of cell, Methods of studying the cell surface, re-constitutional studies; fluorescence assisted methods e.g. flow cytometry.

Molecular Biology: Gene Concept: Fine structure analysis of the gene, one gene-one enzyme hypothesis; organization of eukaryotic genes: Basic Genetic Mechanisms - DNA & Chromosome – structure and function of DNA, chromosomal DNA & packaging, DNA replication, repair & recombination, transcription, RNA synthesis and processing in eukaryotes, translation, the Genetic Code, deciphering the code, codon usage; protein synthesis: structure of ribosome, role of tRNA and rRNA, translation and its control, control of gene expression, post transcription control; evolution of genome.

Neurodevelopmental Biology and Evolutionary Neurosciences: Principles in stem cell biology, totipotency, pluripotency, multipotency; Brain stem cells – Embryonic & adult stem cells. The evolution of nervous systems development – Invertebrates and vertebrates, Introduction to brain development – evolution and complexity of human brain, Nature vs nurture: role of epigenetics – brain cells and functions, Brain morphogenesis – mechanisms involving neural tube formation, neurogenesis, neuronal migration etc. Neuronal differentiation – mechanisms involving axonal growth, dendritic spine formation – Growth cones in axonal path finding – Synaptogenesis, Myelinogenesis – Pruning of brain: apoptotic mechanisms involved, Nerve growth factor: discovery – mode of action – signaling pathway – role in the various stages of brain development, BDNF and other growth factors – importance in brain development**,** Repair and regeneration in the nervous System – Types, Cellular & molecular basis of repair and regeneration in central and peripheral and central nervous system, Cellular and molecular mechanisms of adult neurogenesis, Adult neurogenesis in non-mammalian vertebrates and mammalian Brain.

NS CC13-(TH)-P03: Neuroanatomy and Neurophysiology, Immunology and Neuroimmunology

Neuroanatomy: Gross anatomy of adult brain, organization of the nervous system, subdivision of the nervous system, concept of CNS, ANS & PNS, meninges. The scalp, skull, meninges and cerebrospinal fluid, anatomy of the pituitary (normal & enlarged), vertebral column, cutaneous nerve supply of head and neck limb and trunk. Brain, spinal cord, cranial nerve, spinal nerve, autonomic nervous system.

Neurophysiology: Neurons and glial cells, Resting membrane potential & Action potential, Propagation of Nerve Impulses, Degeneration & regeneration /repair of nerve fibers, Nerve growth factors. Synaptic & neuro-muscular transmission, Muscle tone, posture, Equilibrium & their regulation. Pain production, pathways and analgesics, head ach & referred pain. Vestibular apparatus & motion sickness. Integrative functions of thalamus, cerebellum, basal ganglia & Cerebral cortex. Blood brain barrier, Blood CSF barrier, Spit Brain, EEG.

Immunology**:** Immunoglobins, organization and expressions of Ig genes; B cell maturation, activation and differentiation; MHC/ HLA; antigen processing and presentation; T-cells, T-cell receptors, T-cell maturation, activation and differentiation; cytokines; cellmediated and humoral effector responses, auto immunity, immunodeficiency diseases, transplantation immunology. Monoclonal and polyclonal antibodies, monoclonal antibody technique. Lymphocytes that respond to individual antigens,Immunogenetics - immunoglobulin genes, diversity of germline information, somatic mutations and diversity; Stem cell differentiation – embryonic/fetal/adult cell transplantation; Immune Diversity.

Neuroimmunology: Microglia as immune cells in CNS, role of astrocytes in microglia activation, Neural cell immunology, Immune interaction between Neurons-Microglia-Astrocytes; Interaction between peripheral immunity and central nervous system; Neuro-immunomodulation**;** Basic concepts of Psychoneuroimmunology.

NS CC14-(PR)-P04: Practical

Biochemistry and Laboratory Techniques: pH meter – buffer preparation, Absorption Spectroscopy (UV-visible), DNA, and protein measurement, Enzyme kinetics, effects of pH and temperature on enzyme activity, use of inhibitors for active site determination, Michaelis-Menten equation:determination K_M and $V_{max,}$ Fluorescence microscopy, FACS etc.

Cell and Molecular Biology: Isolation of cells from human and animal tissues, preparation of single cell suspension and do primary culture; Methods of studying in-vitro cell viability, cell counting and imaging by microscopy; Isolation and quantification of DNA, RNA, and protein from cells / tissues.

Critical Analysis of Research Papers: *Selected by the students / teachers.*

NS CC15-(PR)-P05: Practical

Neuroanatomy and Neurophysiology: Gross anatomy of Human brain and its different parts, Histological identification of CNS and PNS structures. Electrophysiological studies of the brain in animals (EEG), Patch clumping, Measurement of ECG and BP.

Neurodevelopmental Biology: Studying early, mid and late developmental stages of CNS in animal models (Zebrafish, Chick, Mouse).

Second Semester

NS CC21-(TH)-P06: Metabolism, Redox Biology & Neuroendocrinology

Metabolism: Chemical component of cell, catalysis and use of energy by cells. Intracellular metabolism of glucose - glycolysis. HMP Shunt. Citric acid cycle; Glycogenolysis. Glycogen synthesis. Carbon cycle, bioenergetics and metabolism, the ATP cycle and glycolysis, the citric acid cycle, electron transport, oxidative phosphorylation and regulation of ATP production, membranes – its structure and role in ATP generation oxidative degradation of fatty acids and amino acids in animal tissues correlation between carbohydrate, amino acids and fatty and degradation, Metabolism of nitrogen compounds protein turnover, metabolic regulation of enzymes, nitrogen fixation - mechanisms and control he nitrogen cycle as the source of cellular biosynthetic intermediates.

Brain metabolism: Brain metabolism of carbohydrate, lipids & amino acids, Brain energy metabolism, Metabolism of neurotransmitters and Brain amines, Neuro-glial interaction on brain metabolism, Calorie restriction and ketogenic diet in brain function, Effect of malnutrition on brain metabolism; Metabolic brain diseases.

Redox Biology*:* Introduction to reactive oxygen and nitrogen species (ROS/RNS)**,** Important cellular redox couples (Glutathione and Thioredoxin couple), Methods of monitoring cellular redox homeostasis, Real-time monitoring of redox homeostasis in live cells by ratiometric imaging, Changes in redox homeostasis as part of normal physiology. Implications in neuronal differentiation, Perturbations of redox homeostasis - relevance to diseases. e.g redox homeostasis changes in neurodegeneration.

Neuroendocrinology: Structure and function of hypothalamus, pituitary, median eminence, circumventricular organs, characteristics of blood brain barrier; Hypophysiotrophic hormones; Posterior Pituitary & Neurohormones; Feedback loops & neuroendocrine control of pituitary hormones; Neuron as target cells for hormone action; pineal gland & neuroendocrine regulation of biological rhythms; Chronobiology & regulation of circadian rhythms, Metabolic regulation of hypothalamic function and role of tanycytes; Neuroendocrine-immune interaction Neuroendocrine regulation of energy metabolism Neuroendocrine disorders.

NS CC22-(TH)-P07: Genetics, Neurogenetics, RDT & Molecular Diagnostics

***Basic genetics*:** Concepts of gene: Allele, multiple alleles, pseudoallele, complementation tests. Mendelian principles - Inheritance, sex linked inheritance, co-dominance and incomplete dominance; Epistasis and pleiotropism; lethals and sub-lethals; Multiple alleles-ABO blood groups in humans, Rh blood group incompatibility. Mutations - Types, causes and detection, germline versus somaticmutations, Mutant types – lethal, conditional, biochemical, loss of function, gain of function,point/deletion/insertional mutations, DNA repair. Chromosomal segregations and mapping – Linkage, recombination and Crossing over Chromosomal Variations - Structural and numerical abnormalities: Aneuploidy, Euploidy, Polyploidy, Trisomy, monosomy, nullisomy; Non-mendelian inheritance – Maternal effect, Cytoplasmic inheritance (mitochondria & chloroplast), Imprinting; Cytogenetic mapping in Drosophila, detection of linked loci by pedigree analysis in humans, the chi square test for linkage, coincidence and interference; Epigenetic mechanisms of inheritance; Complex patterns of inheritance, quantitative traits, Inbreeding and resemblance between relatives; Genes and environment.

Neurogenetic diseases: Autosomal (recessive and dominant) and X-linked neurological diseases –Neurodegenerative diseases, unstable mutation (repeat expansion) causing spinocerebellar ataxias, Huntington's disease, Friedreich's ataxia, Fragile-X syndrome, etc., and molecular pathology**.** Complex genetic diseases, gene environment interactions – epilepsy, autism, and schizophrenia.

Recombinant DNA Technology & Molecular Diagnostics: Manipulating proteins, DNA, RNA – Cell culture, fractionation of cell, DNA-isolation, cloning and sequencing, analysis of protein structure and function,studying gene expression & function, visualizing cells, molecules in cells. Gene function evaluation and mutation detections using techniques, such as, DNA microarray, knock out in mice, transgenic mice, Southern blot, northern blots, DNA sequencing, RFLPs, single nucleotide polymorphisms, methods for identification of mutations. PCR based diagnostics, DNA fingerprinting, DNA chip.

NS CC23-(TH)-P08: Biostatistics, Neuropharmacology & Neuro-Environmental Biology.

Biostatistics: Probability and statistics; population, variables, collection, tabulation and graphical representation of data, frequency distribution, central tendency and skewness, binomial, poisson and Gaussian distributions, additive and multiplicative laws of probability, concept and correlation; regression; methods of least squares; chi-square tests, randomnumber generation- testing and use; probability density and cumulative distribution function; systematic and random sampling. Principles and applications of statistical methods in Genetics.

Neuropharmacology: Cellular foundation of Neuropharmacology - the chemical approach; Molecular foundation of Neuropharmacology, Modulation of Synaptic transmission, transmission, amino acid transmitters – GABA / GABA receptors, Pharmacology of GABAergic Neurons, excitatory amino acid receptors; Acetylcholine / Cholinergic pathways / Cholinergic receptors, ACTH in disease states, Norepinephrine and Epinephrine, Pharmacology of Central Catecholamine containing neurons, Catecholamine. Theory of Affective Disorder; Dopamine / Dopaminergic systems, Postsynaptic dopamine receptors, Parkinson's disease, Dopamine hypothesis or Schizophrenia; Serotonin and Histamine - biosynthesis and metabolism, Pineal Body, localization of Brain Serotonin to Nerve Cells, 5-HT Receptors, Neuroactive peptides.

Neuro-Environmental Biology: Introductory concepts of Man and Environment, Causes of environmental hazards, Environmental awareness and safety measures, Environmental factors - physical and chemical, microbial and physiological changes. Physical factors - Electromagnetic Radiations, UV, X-rays; Environmental heat, cellular and metabolic changes, heat disorders and stroke; Atmospheric Composition and Physiology; environmental chemical stress, genotoxic agents and physiology, principles of toxicology; mutagenicity, environmental pollutants: Metals and other chemical and their impact on human health, Microbial environments on health and disease. Bioremediation & Phytoremediation; Environmental factors affecting neural system, Neurological disturbances due to altered environment - Hypobaric and Hyperbaric Physiology, Neurological Disorder, Neuroendocrine disruptors, Environmental toxins, pathogens causing neurodegenerative diseases.

NS CC24-(PR)-P09: Practical

Metabolism and Neuroendocrinology: Measurement of blood glucose, SGOT, SGPT; Determination of activity of different metabolically active enzymes; Fatty acid analysis; Isolation and analysis of neurotransmitters from animal brain; Histological detection of dopaminergic and glutaminergic synapses.

Seminar / Journal Club: *Topics would be selected by the students / teachers.*

NS CC25-(PR)-P10: Practical

Neurogenetics and Molecular Diagnostics: DNA isolation, Restriction enzyme digestion, gel electrophoresis, Polymerase chain reaction (PCR), Analysis of PCR products by Agarose and polyacrylamide gel electrophoresis; primer designing for PCR; cDNA synthesis and RT-PCR, Isolation of Plasmid DNA, Transformation of plasmid DNA; Human Pedigree analysis; Genetics in Drosophila and Zebrafish model – analysis of Mutants & Transgenics.

[Summer Project: At end of the session of 2nd Semester, Student will opt their DSEC and will be assigned for summer projects. *The project performance report based on the summer research training in a reputed laboratory of excellence will have to be submitted in the 4th semester. A presentation of the accomplishments willbe required before a panel of experts. Evaluation will be based on both the project report and presentation.]*

Third Semester

NS CC31-(TH)-P11: Psychology, Neurobehaviour & Cognition

Introductory Psychology: Definition of Psychology, application of Psychology, methods in Psychology, Principles of Learning, Behaviour, memory, thinking and language, emotion and stress, social perceptions, influences and relationships, attitudes, Psychological assessment and testing, Abnormal Psychology, Therapy for Psychological distress.

Sensory principles

Sensory processing, Weber-Fechner law & Power law, Muller's specific nerve energy, basic attribute of special senses.

Special Senses:

Vision: Photochemistry of vision, Neural pathways of vision, accommodation, light & accommodation reflexes, modern concept of color vision, Molecular mechanisms of Biological Clocks.

Audition: organ of corti, auditory transduction, Pathways of audition, auditory coding, auditory localization.

Olfaction: Olfactory organ, olfactory transduction, pathways, coding.

Gustation: Gustatory organ, pathways, transduction, coding.

Pathophysiological conditions related to vision, audition, olfaction & gastation.

NS CC32-(TH)-P12: Genomics and Proteomics, Molecular Neuropathology

Genomics: Introduction to genomics and first generation sequencing strategies; Overview of new sequencing strategies; Study of variants: SNP in genomics; Study of gene expression: Microarray miRNA in Genomics. Genetic and physical maps, physical mapping and map-based cloning, choice of mapping population, simple sequence repeat loci, southern and fluorescence in situ hybridization for genome analysis, chromosome microdisection, molecular markers in genome analysis; RAPD and AFLP analysis, molecular markers linked to disease resistant genes, application of RFLP in forensic, disease prognosis, genetic counseling, pedigree, varietal etc. Genome sequencing: genome sizes, organelle genomes, genomic libraries, YAC, BAC libraries, strategies for genome sequencing, packaging, transfection and recovery of clones, application of sequence information for identification of defective genes. Pharmacogenetics, genetics of globin triplet repeat disorders, cancer genetics; immunogenetics; mapping of human genome; somatic cell genetics; DNA polymorphism in mapping; structure and function; biochemical genetics; polygenic inheritance.

History and development of Human genetics- hereditary traits, genetics and disease; Organization of the Human genome; Repetitive DNA in human genome; Methods of' genetic study in man Pedigree analysis, Chromosomal analysis; Biochemical analysis; Somatic cell genetics; Human Genome Project. Human genome and its impact on medicine-Genome mapping and sequencing, implications of human genome sequence information, molecular medicine, pharmacogenomics and personalized medicine, Databases for disease and mutation information.

Proteomics: Introduction and techniques applicable to macromolecule / proteomics: Standard technologies to identify and characterize protein-protein interactions, Biophysical approaches, computation and functional approach, Characterization of the proteome by ORF analysis, Gene disruption Knockouts; study of gene interaction by yeast two-hybrid system, Study of gene interaction by yeast two-hybrid system, Study of developmental regulation by using DNA chips. Physical techniques (absorption and fluorescence spectroscopy, IR, NMR techniques);

Chromatography: TLC, GLC, HPLC, FPLC, gel filtration, ion-exchange and affinity chromatography; CD, ORD, X-RayDiffraction and crystallography and its application in protein structure determination, 2D gel electrophoresis. Mass spectroscopy, basic principle, MALDI-TOF, ESI; 2-D Gel electrophoresis, Nuclear magnetic resonance spectroscopy (NMR), basic principles, chemical shift, spin-spin interaction, NOE, 2D-NMR**,** NOESY, COSEY. X-ray Crystallography: Principle of X-ray diffraction, scattering vector, structure factor, phase problem, reciprocal lattice and Ewald sphere, Miller indices, Zone axes, crystal lattice, Lane Equations, Bragg's law, special properties of protein crystals, model building, refinement and R-factor.

Molecular Neuropathology: Molecular basis of Neuropathology in Epilepsies and Convulsive diseases, Cerebrovascular diseases, Dementia, Parkinson's Disease, Torsion dystonia, Progressive Supranuclear Palsy (PSP), Motor neuron Diseases [Amyotropic Lateral Sclerosis (ALS)]; Viral diseases – Encephalitis, etc.**;** Prions (Proteinaceous infectious particles) – Transmissible Neurodegenerative diseases; Nutritional and Metabolic Diseases (Lysosomal storage disease e. g. TaySach's, Gaucher's, etc); Neurodegenerative movement disorder: Parkinson's Disease, Wilson & Menkes Disease, Huntington's chorea; Multiple Sclerosis, Spinomuscular atrophy, Encephalomyelities, Encephalitis, Prions Disease, Dementia, Epilepsies (Mitochondrial and others), cerebral infarction, stroke, etc.

NS CC33-(PR)-P13: Practical

Neuropathology & Neurobehavioural Biology: Identification of analysis of brain pathology of neurodegenerative and neurological diseases using histological sections; Behavioural studies using animal model (Zebrafish, Mouse),Testing motor functions, Testing Cognitive Functions – Learning and memory related test (Any-arm Maze, Water Maze, etc.).

Genomics & Proteomics: Techniques for mutation detection by RFLP, ARMS-PCR; Analysis of DNA sequencing data by BLAST and primer designing. Gel Filtration, Protein analysis by SDS-PAGE, 2D Gel, Western Blot and Protein estimation by ELISA.

NS GEC31-(TH)-P14: ---- Students will opt course offered by Other Department -----

NS GEC32-(TH)-P15: **----** Students will opt course offered by Other Department-----

Fourth Semester

NS CC41-(TH)-P16: Computer applications, Bioinformatics & Neuro-informatics; Animal Biotechnology, Gene therapy, and Bioethics.

Computer applications & Bioinformatics: Basics of Computer applications-introduction to structural organization and types of digital computers, operating systems, word processing, Computer programs in the analysis of statistical methods and preparation of graphs. Application of Programs to solve - Algebric and matrix equations - Differential equations -Dynamical systems Models – Linear Regression, Handling Files - Containing Numerical and /or character da-Files from sequence and structural data banks.

Neuro-informatics: MRI & other image database (NIH); Digital reconstructions of neuronal morphology (NeuroMorpho.Org.); Overview of active neuroinformatics initiatives: Allen Brain Atlas, Human Connectome Project, SenseLab, CramTest.Info, NeuroElectro, BigNeuron, EU HBP, HHMI news, etc. Other tools and meta-reviews (Scholarpedia review); Neuron types of the mammalian hippocampus. Anatomical patterns, biophysical properties, and molecular markers: Hippocampome.org. Neuronal reconstructions: from image stacks to digital vector trees. NeuTube, Vaa3D, and other tracing tools;

Animal Biotechnology, Gene therapy and Bioethics: Structure and organization of animal cell. Equipment and materials for animal cell culture technology, Primary and established cell line cultures, Introduction to the balanced salt solution and simple growth medium. Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium. Role of carbon dioxide, role of serum and supplements. Serum & protein free defined media and their application. Measurement of viability and cytotoxicity. Biology and characterization of the cultured cells, measuring growth parameters. Basic techniques of mammalian cell culture *in vitro*, disaggregation of tissue and primary culture, maintenance of cell culture; cell separation, Scaling-up of animal cell culture, cell synchronization, cell cloning and micromanipulation, cell transformation. Application of animal cell culture. Stem cell culture, embryonic stem cells and their applications. Cell culture based vaccine, somatic cell genetics, Organ and histotypic cultures, measurement of cell death, Apoptosis of three dimensional culture. General idea on animal growth and development, Mammalian (including human) reproduction, endocrine control and hormone-cascade. Comparison with Birds (Chicken) and Fish reproduction. Animal genes and their regulation, some specific promoters for tissue specific expression. Improvements of animal/fish by biotechnology by transgenic approach with specific examples, embryo splitting and animal cloning. Genetically engineered animals for pharmacological research. Basic techniques of mammalian cell culture *in vitro*; desegregation of tissue andprimary culture, maintenance of cell culture, cell separation. Scaling up of animal cellculture. Cell synchronization. Cell cloning and micromanipulation. Cell transformation.Gene therapy : Introduction, Understanding vectors used in Gene therapy, Genome Editing by CRISPR cas-9 approach, Methodologies for successful RNAi and expression of non-codingRNAs to regulate genes and treat disease - discussion of concepts, current advances, Current progress intherapeutic gene editing for monogenic diseases, Gene therapy in the treatment of diseases. Biosafety, Intellectual property right: patents, Biohazards, human safety,environmental and ecological hazards.

NS DSEC41-(TH)-P17: (Theory) Students will opt Discipline Specific Elective course offered by the Parent Department

NS DSEC42-(TH)-P18: (Theory) Students will opt Discipline Specific Elective course offered by the Parent Department

NS DSEC43-(PR)-P19: (Practical) Based on DSEC opted by the students

NS DSEC44-(PSV)-P20: (**P**roject work & **S**eminar, **V**iva) –Based on DSEC opted by the students

(Detailed syllabus of DSEC are in page 13-14)

[Project work (Summer Project) & Seminar: *Students will submit and present performance report of their summer project opted at end of the session of 2nd Semester, for their specific DSE course assigned during 4th Semester curriculum. A project will be performed during the summer research training in a reputed laboratory of excellence. A presentation of the accomplishments will be required before a panel of experts. Evaluation will be based on both the project report and presentation.]*

[Viva: *Students will be evaluated on all the topics discussed in the two years programme by a panel of experts.]*

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSEC)

Offered by the Parent Department
for the Students of Neurosciences

Assigned for 4th Semester Curriculum

Detailed Syllabus for theory and practical classes under DSEC curriculum during 4th Semester.

Students will opt any one of the following subjects offered by the Centre. Selection will be made on merit basis during 2nd Semester curriculum. Each paper carry 50 marks equivalent to 4 credits.

1. Cellular & Molecular Neuroscience
2. Systems Neuroscience

Cellular & Molecular Neuroscience

NS DSEC41-(TH)-P17: Advance studies of cellular and molecular basis of Neurosciences

Regulation of Neuronal Gene Expression
Molecular Properties of Ion Channels & receptors
Release of Neurotransmitter: Stimulus/ Secretion Coupling (direct & indirect)
Neurotransmitter Receptors: Ionotropic vs. metabotropic
Intracellular Signaling Pathways (pre & post synaptic signaling)
Synaptic plasticity and Memory consolidations – Short-term and Long-term.
Neuro-glia molecular interaction in development, homeostasis and diseases.
Higher brain functions: Learning and Memory - Neural Circuits, Hippocampal Memory and Engram, Neurophysiological basis of sleep and Neural circuits governing Sleep, Sleep disorders, Mood Disorders, Depression, Anxiety, and Stress management. Effect of Ageing on the brain function.

NS DSEC42-(TH)-P18: Techniques in Cellular & Molecular Neurosciences for health and diseases

Application of Qualitative and Quantitative approach in Neurosciences for health and diseases; *In-vivo* and *in-vitro* models in neuroscience research.
Functional genomics, proteomics, transcriptomics, metabolomics in clinical neurosciences; *In-vitro* Cell, tissue & organ culture in Neurosciences, cell & tissue specific therapy; *In-vivo* therapeutic approach for Neuro-diseases;
In-silico methods for biomarker based evaluation of drug therapy for Neuro-diseases.
Brain imaging Technologies
Neuroimaging – Neuroradiology: CT, MRI, Myelography; Interventional Radiology - PET (Positron Emission Tomography), Single - Photon Emission Computed Tomography, MR Spectroscopy, Magnetic Source imaging. Optogenetics and its applications in neuroscience
EEG of single, dual and multi-functional aspects of cognition & Artificial Intelligence.

NS DSEC43-(PR)-P19: Practical

Molecular Genetic tools for neurodegenerative diseases: Investigation of Single Nucleotide Polymorphisms (SNP) using PCR amplification by ARMS-PCR and RFLP. Analysis of Genotype and allele frequency and assessment of risk towards disease predisposition using statistical analysis.

Histology & Cell Culture: Dissection, embedding, sectioning of animal brain and identification of neuronal & glial cells using immunohistochemistry. Culturing, maintenance and differentiation into neurons, analysis of differentiation by investigating differentiation marker using Real-time PCR and Confocal Microscopy. Isolation and maintenance of primary cortical neurons.

Identification of analysis of brain pathology of neurodegenerative and neurological diseases using MRI, CT scan images

NS DSEC44-(PSV)-P20: Laboratory project work & **S**eminar, Grand **V**iva.

Systems Neuroscience

NS DSEC41-(TH)-P17: Brian maps and loops for health & Diseases
Concepts of Micro-structure of brain circuits and their interconnections during health and diseases.
Active & Passive sensing.
Involvement of different brain regions for Sleep-awaking systems, Motor systems, Somato-Sensory systems.
Learning-memory systems.
Disinhibition Circuits & Planning for voluntary movements, motor learning and cognition,
Closing motor-sensory loops.
Spatial navigation and memory consolidation
Emotion-motivation
Eating & Drinking
Language & Sex
Artificial Intelligence, Man-Machine interaction.

NS DSEC42-(TH)-P18: Methodologies used to study brain systems for health and diseases
Basic assumptions and approaches.
Measuring neural activity (electrophysiology and imaging);
Shutting down neural activity (lesions, pharmacological inactivation, optogenetics)
Perturbing of neural activity (microstimulation and opto-stimulation)
Opening the loop at the behavioral and neural levels.

NS DSEC43-(TH)-P19: Practical
Development of paradigm for cognitive task,
EEG recording of single, dual and multi-functional aspects of cognition & data analysis,
Artificial Intelligence

NS DSEC44-(PSV)-P20: Project work & **S**eminar, Grand **V**iva

GENERIC ELECTIVE COURSE (GEC)

Offered by S. N. Pradhan Centre for Neurosciences

For Students of Other Departments

Assigned for 3rd Semester Curriculum

Detailed Syllabus for classes (Theory) under GEC curriculum during 3rd Semester.

The students will have to choose two courses offered by the University. No student is allowed to choose the course offered by his/her parent Department. Each course is of 50 marks and carries 4 credits.

GEC syllabus offered by S N Pradhan Centre for Neurosciences

(The course was mentioned in previous syllabus as CBCC-A1)

Topic- Neurobiology: Function & Dysfunction

1. Nervous System Anatomy

Different Lobes/ Cortex
Brain Organisation – CNS, PNS, ANS
Structure of Cerebellum and Basal Ganglia
Histology of Brain Sections (Coronal/sagittal) – Normal vs. Diseased
Neuro-developmental Biology (Briefly)
Blood Brain Barrier

2. Nervous System Cell Biology & Physiology

Neurons and Glial Cells
Detection of different neuronal cells (by IHC/ICC)
Neuronal Transmission

i. Electrical Impulse – Action Potential, Excitatory and Inhibitory Postsynaptic Potentials (EPSP and IPSP)
ii. Chemical Impulse
iii. Synapse
iv. Neurotransmitters and their metabolism
v. Different Pathways (Dopaminergic, Adrenergic, Serotonergic, etc.)
vi. Examples of malfunctions of pathways

Neuronal study in Cell/Organ

a. Isolation and culturing of primary neurons and means of manipulation
b. Culturing and methods of differentiation of cultured neuronal cells
c. Organotypic brain cultures

3. Neural Sensation and Sensory Processing

i. The Somatic Sensory System: Touch and Proprioception
ii. Pain
iii. Vision – The Eye and Central Visual Pathways
iv. The Auditory System
v. Olfactory System
vi. Gustatory System
vii. Learning & Memory
viii. Sleep and higher order functions

4. Neuropathology & Neurobiology Tools

Clinical, Cellular and Molecular Mechanisms of the Neurological Diseases:
Alzheimer's Disease, Parkinson's Disease, Huntington Disease, Dystonia, Wilson Disease, Epilepsy, Autism, Multiple Sclerosis, Amyotrophic Lateral Sclerosis (ALS), Attention Deficit Hyperactivity Disorder (ADHD), Schizophrenia, Depression, Dementia, Cerebro-vascular Disease (Stroke).
Techniques and tools applicable in neuroscience: MRI, PET, Fluorescence microscopy, FACS, Electron Microscopy, Patch Clamp, etc., Database sequence information and mutation information on specific neurodegenerative diseases.

Recommended Readings:

1. Biochemistry 4th Ed., Voet and Voet;
2. Lehninger Principles of Biochemistry 5th Ed., Nelson and Cox;
3. Biochemistry 7th Ed., Stryer
4. Principles & Techniques of Biochemistry & Molecular Biology, Wilson and Walker;
5. Physical Biochemistry, Freifelder;
6. Fundamental Enzymology 3rd Ed. Nicholas C. Price, Lenis Steven;
7. Biochemical Calculations 2nd Ed. I. H. Segel
8. Molecular Cell Biology 6th Ed. Lodish;
9. Molecular Biology of the Cell 6th Ed., Alberts;
10. Cell Biology, Karp; The Cell – A molecular Approach, Cooper
11. Molecular Biology 4th Ed. R. F. Weaver; Molecular Biology, Clark;
12. Molecular Biology of the Gene, 7th Watson;
13. Principles of Molecular Biology, Burton E. Tropp
14. Gray's Anatomy; Gray's Anatomy for Students, Drake, Vogl, Mitchell;
15. Text Book of Medical Physiology, Guyton and Hall;
16. Ganong's Reviews of Medical Physiology, Barrett, Barman;
17. Principles of Anatomy and Physiology, G. J. Tortotora, B. Derrickson;
18. Principles of Neural Science, Eric R. Kandel;
19. Neuroscience, Dale Purves;
20. The Human Nervous System, Mai Paxinos
21. Handbook of Neuroendocrinology, George Fink;
22. William's Textbook of Endocrinology, Krorenberg, Meaund;
23. Basic and Clinical Pharmacology, Katzung;
24. Essentials of Medical Pharmacology, K. D. Tripathi
25. Introduction to Genetic Analysis, J. F. Griffiths;
26. Human Molecular Genetics, Strachan and Read;
27. Principles of Genetics, Snustad and Simmons;
28. Gene Cloning and DNA Analysis: An Introduction, T. A. Brown;
29. Immunology, Kuby ;
30. Neuroimmunology in Clinical Practice, Kindt, Goldsby, Osborne;
31. Neuroimmune Biology, Vol:6, Richard M. Ransohoff;
32. Cytokines and the Brain, IstvanBerczi, AndorSzentivanyi
33. Fundamentals of Statistics, A.M. Goon, M.K. Gupta, B. Dasgupta;
34. Statistical Method, N. G. Das;
35. Biostatistics, A Foundation for Analysis in the Health Sciences, Daniel & Cross
36. Strickberger's evolution, Brian K. Hall;
37. Evolutionary Biology, Futuyma
38. Principle of Cognitive Neuroscience, Dale Purves;
39. Cognitive Neuroscience-The Biology of the Mind, Gazzaniga, Ivry, Mangun;
40. Cognitive Neuroscience, Marie T. Banich, Rebecca J. Compton;
41. Principles of Behavioural& Cognitive Neurology, M. MarselMesulam
42. Principles of Gene Manipulation and Genomics, Primrose & R. M. Twyman;
43. Genomes 3, T. A. Brown;
44. Introduction to Genomics - Arthur M. Lesk,
45. From Genes to Genomes: Concepts and Applications of DNA Technology, Jeremy W. Dale and Malcolm von Schantz;
46. Next Generation DNA Sequencing Informatics, Stuart M. Brown;
47. Proteins Biochemistry & Biotechnology, Gary Walsh;

48. Principles of Protein X-ray Crystallography, Jan Drenth;
49. Organic Spectroscopy, William Kemp
50. Developmental Biology, Scott F. Gilbert;
51. Development of the Nervous System, Dan Sanes, Thomas *Reh*, William *Harris*;
52. Developmental Neurobiology, Greg Lemke
53. Introduction to Psychology, Hilgard, Atkinson, Atkinson;
54. Introduction to Psychology, C. T. Morgan & R. K. King;
55. Brain & Behavior: An Introduction to Biological Psychology, Bob Garrett
56. Neuromuscular Disorders, Amato & Russell;
57. Clinical Neurology, Simon, Greenberg, Aminoff;
58. Neuroanatomy through Clinical Cases, Hal Blumenfeld
59. Environmental Science 7th Ed., Botkin, Keller;
60. Environmental Science, Richard T. Wright
61. Animal Biotechnology, M. M. Ranga;
62. Animal Cell Culture-A Practical Approach, John R. W. Masters
63. Bioinformatics Sequence & Genome Analysis, David W. Mount;
64. Discovering Genomics, Proteomics and Bioinformatics, Campbell;
65. Bioinformatics & Functional Genomics 3rd Edition, Jonathan Pevsner
66. Theoretical Neuroscience – Computational and Mathematical Modeling of Neural System by Dayan and Abbot, 1st Edition, The MIT Press, 2001.
67. Neuroinformatics for Neuropsychology by VinothJagaroo, Springer, 2009.
68. Neuroinformatics by ChiquitoJoaquimCrasto, Humana Press, 2007.
69. Neuroinformatics: an overview of the Human Brain Project by Stephen H. Koslow, Michael F. Huerta, Routledge, 1997.
70. Further reading: Conventional Mathematics, Statistics, Computer Science, Database Management System (DBMS), Network Theory, Bioinformatics Books.
71. Principles of Neural Science, Eric R. Kendel;

The regulations for Two-year M. Sc. Course in Neuroscience, University of Calcutta

ADMISSION CRITERIA

1. The University of Calcutta shall provide instructions leading towards two year M.Sc. degree.
2. **Eligibility for admission in M.Sc. Neuroscience:** B.Sc. Hons. in any Life Science Subjects / Chemistry / Biochemistry / Anthropology / Environmental Science / Physics / Mathematics / Computer Science / Informatics. All the above candidates should have Chemistry as one of the General Subjects except the candidates with Hons. in Chemistry/Biochemistry. M.B.B.S, Graduates from Pharmacy / Pharmacology are also eligible. All the candidates should have At least 55% marks in B.Sc. (Hons.) and at least 60% marks on average in best three subjects in Science Group at -(10+2) level. Reservation of seats will be governed by the rules of Govt. of West Bengal at present.
3. Applicants from University of Calcutta will get admission to the sixty percent of seats (Category-A). Forty percent of the seats (Category-B) will be filled up from candidates from both CU and non CU from a common merit list prepared on the basis of a Common Entrance Test. The criteria for the preparation of the merit list will be determined by individual departments. Non-CU students, however, will have to satisfy the same eligibility criteria applicable to the students of the University of Calcutta. A **Common Entrance Test** will be conducted for the 7 (seven) courses including i) Biophysics & Molecular Biology (BMB), ii) Genetics (GN), iii) Biochemistry (BC), iv) Biotechnology (BT), v) Environmental Science (ENV1, ENV2), vi) Marine Science (MS) and vii) Neuroscience (NS). The Common Entrance Test will be MCQ type covering the fields of Physics, Chemistry, Mathematics, and Biology of (10+2) level.
4. The duration of the course shall be two academic years and the examination for the M.Sc. degree shall be held over four semesters over a total of 1000 marks and 80 credits. The duration of the semesters shall be as follows:

1st Semester	**July - December**
2nd Semester	**January - June**
3rd Semester	**July – December**
4th Semester	**January - June**

5. The course curriculum includes **Core courses** (offered by the Department), **Discipline Specific Elective Courses** (offered by the Department) and **Generic Elective Courses** (offered by the other Department).
6. A student will have to take **two courses** from **Generic Elective Courses (GEC) offered by the other Departments in 3rd Semester curriculum** in addition to courses offered by the Parent Department. Each course will carry credits according to the number of theoretical classes required, study hours and laboratory hours.
7. A student will have to take **one course** from **Discipline Specific Elective Courses (DESC)** offered by the **Parent Department in 4th Semester curriculum** in addition to **Core Courses** offered by the Parent Department. The course will carry credits according to the number of theoretical classes required, study hours and laboratory hours.

8. A candidate shall be eligible for appearing at the examination provided he/she prosecutes a regular course of studies maintaining percentage of attendance as specified by the University.

9. Examinations would be held after the completion of curriculum at the end of each semester. However, evaluation of the practical will be based on continuous assessment as well as on the final Viva-Voce examination of the students on the experiments. The examination time allotted for each paper carrying 50 marks is 2 hours.

PASSING CRITERIA

10. A candidate is required to appear at the examination in each and every paper/course/module/part/group of the respective syllabus. A candidate in order to be declared to have passed an examination, must obtain at least 40% marks in each paper/course/module/part/group. In case of a paper/course/module/part/group containing both theoretical and practical portions, a candidate is required to secure at least 35% marks separately in the theoretical and practical portions and at least 40% marks in aggregate in that paper.

11. If a student gets 'F' in a particular course, he/she shall be deemed to have failed in that course only and shall be required to write a supplementary examination to be offered within six months.

12. The students will get a maximum of three academic years to complete the M.Sc. course.

CRITERIA FOR RE-APPEARING AT SUPPLEMENTARY EXAMINATION

13. All supplementary examinations shall be held after six months of the original examination. Having **failed** or **absent** in maximum two papers/courses a candidate shall be eligible to appear at the supplementary examination. A candidate who has **failed** in more than two papers will have to appear at the same semester without appearing at the higher semester and without attending the classes. Candidate who fails in one or two papers can clear the paper/s in two more consecutive chances **(excluding the main examination)** along with higher semester examination. If the candidate is unable to clear the same within two consecutive chances, he shallbe dropped from the concerned course. A failed candidate, intending to re-appear in a subsequent semester has to take permission from the concerned Faculty Secretary through the Head of the Department immediately after publication of result.

ABSENT CRITERIA

14. Failure to fill up the examination form shall be considered as missing a chance and such candidates who have not filed up the examination form shall have to appear atthe same semester examination. A candidate who has filled up the examination form but remains absent in the entire examination or more than two courses will be considered to have lost a chance and shall be required to re-appear at the same semester examination. A candidate remaining absent in one or two papers/courses but clearing the other papers/courses shall be considered to have failed in those papers/courses in which he remains absent and shall be eligible to clear those as statedabove.

15. If all the chances of a candidate (Main + 2) has been exhausted, he has to drop or leave the course. He may apply for re-admission in the same course of study in the 1st Semester of the next academic session along with the fresh applicants.

Results Determination criteria

CALCULATION OF GRADE POINTS, SGPA AND CGPA

Credit-weighted grade point system will be followed and therefore only the grade points but not the overall percentage of marks either in individual paper or in aggregate marks will be provided. The grade points will be given according to the following computation.

Grading of students' performance:
Grade scores will be calculated in a scale of 6 (six) as per the following table:

Marks (%)	Grade Score Brackets	Grade Score added per each additional mark to minimum grade score in the bracket
80-100	5.00 - 6.00	0.05
70-79	4.50 – 4.99	0.05
60-69	4.00 – 4.49	0.05
55-59	3.75 – 3.99	0.05
50-54	3.50 – 3.74	0.05
40-49	3.00 – 3.49	0.05
00-39	Below 3.00	0.075

Award of Grade Points:
For example, if a student scores 53% in theory and 68% in practical in a 3-credit course (2+1), his/her grade point for the course will be as follows:

$$\text{Grade point} = \frac{2x(3.5+0.05x3)+1x(4.0+0.05x8)}{2+1} = 3.90$$

For a credit course with no practical component, for example a 2-credit course, if a student scores say, 56%, then the grade point will be:

$$\text{Grade point} = \frac{2x(3.75+0.05x1)}{2} = 3.80$$

Semester Grade Point Average (SGPA):
The computation of average grade point of a student in a semester will be worked out as follows:

N^{th} Semester

Course	Credits	Grade Scored
1	3+1	5.65
2	3+1	5.33
3	2+0	3.99
4	2+0	5.05
5	3+1	4.22
6	3+1	4.46

Semester Grade Point Average (SGPA) = 4.836

$$\text{SGPA} = \frac{(5.65x4)+(5.33x4)+(3.99x2)+(5.05x2)+(4.22x4)+(4.46x4)}{20} = 4.836$$

Cumulative Grade Point Average (CGPA) over four semesters:
Working out simple average of SGPA obtained over four semesters, cumulative grade point average will be given after four semesters.

Significance of grades:
On the basis of the cumulative results of the student's performance, the following grades will be given in each semester as well as over four semesters.

Grade points	**Grades**	**Class**
5.00 - 6.00	Outstanding (O)	First (I)
4.50 – 4.99	Excellent (A+)	First (I)
4.00 – 4.49	Very good (A)	First (I)
3.75 – 3.99	Good (B+)	Second (II)
3.50 – 3.74	Fair (B)	Second (II)
3.00 – 3.49	Satisfactory(C)	Second (II)
Below 3.00	Fail (F)	Fail