REVISED CURRICULUM

M. Sc.

NEUROSCIENCES

सत्यमेव जयते

Department of Biotechnology
Ministry of Science & Technology,
Government of India

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CONTENTS

^Any two 1.5 credit courses can be taken up to make one 3 credit course.
Contents for electives are given separately.

SEMESTER - I

Cell Biology & Neuron Organization - 3 Credits

Unit I

Membrane Structure and Function

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

Unit II

Organelles

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

Unit III

Endo-membrane System and Cellular Motility

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

Unit IV

Neurons

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; Axons structure and functional aspects; Ultrastructure; Myelination and synapses.

Unit V

Glial cells

Structure and function of glial cells; Different types of glial cells: astrocytes, oligodendrocytes and Schwann cells; Types of astrocytes – type I & II astrocytes, fibrous and protoplasmic astrocytes; 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.

Texts/References

1. Siegel, Basic Neurochemistry, 7th Edition, Academic Press, 2006.
2. Alberts, Molecular Biology of the Cell, 5th Edition, Garland Science, 2008.
3. Kendel, Principles of Neural Science, 4th Edition, McGraw Hill, 2000.
4. Verkhratsky, Glial Neurobiology, A Text Book, Wiley, 2007.

Biochemistry - 3 Credits

Unit I

Chemical basis of life; Composition of living matter; Water – properties, pH, 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; Evolution of protein structure; Structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc.; Tools to characterize expressed proteins.

Unit II

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

Unit III

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

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

Unit IV

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

Unit V

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

Texts/References

1. V.Voet and J.G.Voet, Biochemistry, 3rd edition, John Wiley, New York, 2004.
2. A.L. Lehninger, Principles of Biochemistry, 4th edition, W.H Freeman and Company, 2004.
3. L. Stryer, Biochemistry, 5th edition, W.H. Freeman and Company, 2002.

Molecular Biology - 3 Credits

Unit I

Genome organization

Organization of bacterial genome; Structure of eukaryotic chromosomes; Role of nuclear matrix in

chromosome organization and function; Matrix binding proteins; Heterochromatin and Euchromatin; DNA reassociation kinetics(Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density; Nucleosome phasing; DNase I hypersensitive regions; DNA methylation & Imprinting

Unit II

DNA Structure; Replication; Repair & Recombination

Structure of DNA - A-,B-, Z- and triplex DNA; Measurement of properties-Spectrophotometric, CD, AFM and Electron microscope analysis of DNA structure; Replication initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins; Fidelity; Replication of single stranded circular DNA; Gene stability and DNA repair- enzymes; Photoreactivation; Nucleotide excision repair; Mismatch correction; SOS repair; Recombination: Homologous and non-homologous; Site specific recombination; Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLP/FRT and Cre/Lox recombination.

Unit III

Prokaryotic & Eukaryotic Transcription

Prokaryotic Transcription; Transcription unit; Promoters- Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Anti-termination; Transcriptional regulation-Positive and negative; Operon concept-lac, trp, ara, his, and gal operons; Transcriptional control in lambda phage; Transcript processing; Processing of tRNA and rRNA

Eukaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Activators and repressors; Transcriptional and post-transcriptional gene silencing

Unit IV

Post Transcriptional Modifications

Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA.

Translation & Transport

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

Unit V

Mutations; Oncogenes and Tumor suppressor genes

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

Text/References

1. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
2. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Molecular Biology of the Gene, 6th Edition, Benjamin Cummings Publishing Company Inc, 2007.
3. Alberts et al; Molecular Biology of the Cell, 4th edition, Garland, 2002.

Laboratory Tools and Techniques - 3 Credits

Unit I

Principles of fixation and staining of nervous tissue; Methods of tissue processing for microtomy, cryotomy and vibratomy; Golgi and other impregnation method

Unit II

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

Unit III

Spectroscopy Techniques

UV, Visible and Raman Spectroscopy; Theory and application of Circular Dichroism; Fluorescence; MS, NMR, PMR, ESR and Plasma Emission spectroscopy

Chromatography Techniques

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

Unit IV

Electrophoretic techniques

Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary electrophoresis; 2D Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis

Centrifugation

Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge - Microcentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods

Unit V

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

Texts/References

1. Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd edition, W.H. Freeman & Company, San Fransisco, 1982.
2. Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry, 5th Edition, Cambridge University Press, 2000.
3. D. Holme & H. Peck; Analytical Biochemistry, 3rd Edition, Longman, 1998.
4. R. Scopes, Protein Purification - Principles & Practices, 3rd Edition, Springer Verlag, 1994.
5. Selected readings from Methods in Enzymology, Academic Press.

Microscopy & Imaging Techniques - 3 Credits

Unit I

Principles and application of transmitted light and fluorescence microscopy: Basic Optics; Interaction of Light with matter; Design of a Microscope: Transmitted Light and Epifluorescence systems; Principle of Image formation and detection techniques: Real vs. virtual; Chemical vs. electronic; Improving the Image Quality by Opto-electronic Tricks and by software.

Unit II

Principles and application of scanning and transmission electron microscopy; De-Broglie Principle: Matter –wave theory; Concept of accelerated electron as a wave; Electron-matter interactions, Thomson scattering and principles of electron diffraction; Properties of accelerated electrons in a magnetic field: EM lenses, charge plates and pole pieces, and their use in electron beam focusing; Principles of image formation in TEM and SEM.

Unit III

Sample preparation of optical microscopy systems; Immunocytochemistry: Principles and applications; Immunochemical staining techniques; Sample preparations for TEM and SEM; Immunoelectron microscopy techniques

Unit IV

Confocal microscopy and immunocytochemistry; Basic concepts of stereology and image analysis; Diagnostic tools in clinical neuroscience.

Unit V

Electronic spin and nuclear spin states; Fermi and Bose principles; Principles of Nuclear Magnetic Resonance; NMR measurement techniques and its application in molecular structure determination; Imaging: Principles and applications of: MRI, PET, SPECT/FMRI

Texts/References

1. Lodish et al., Molecular Cell Biology, Chapter 5, 4th Edition, W H Freeman and Company, 2000.
2. A J Lacy, Light Microscopy for Biologists, IRL Press, Oxford, 1984.
3. D. J. Goldstein, Understanding the Light Microscope: A Computer-Aided Introduction, Pap/Cdr Edition, Academic Press, 1999.
4. Ed. L. S. B. Goldstein and E. Fyrberg, Methods in Cell Biology, Vol 44, Academic Press Inc. New York. 1994.

5. David Shotton, Electronic Light Microscopy Techniques in Modern Biomedical Microscopy, 1st Edition, Wiley-Liss Inc., New York, 1993.
6. Stephen Paddock, Confocal Microscopy: Methods and Protocols; Methods in Molecular Biology, 1st Edition, Vol. 122; Humana Press, Totowa, New Jersey, 1999.
7. www sites on Microscopy http://www.icmm.csic.es/Fagullo/w3micros.html

Lab on Biochemistry & Laboratory Techniques - 3 Credits

1. To prepare an Acetic-Na Acetate Buffer system and validate the Henderson-Hasselbach equation.
2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
3. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by TLC.
4. AN ENZYME PURIFICATION THEME (such as *E.coli* Alkaline phosphatase or any enzyme of the institutions choice).

   (a) Preparation of cell-free lysates

   (b) Ammonium Sulfate precipitation

   (c) Ion-exchange Chromatography

   (d) Gel Filtration

   (e) Affinity Chromatography

   (f) Generating a Purification Table

   (g) Assessing purity by SDS-PAGE Gel Electrophoresis

   (h) Assessing purity by 2-D gel Electrophoresis

   (i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
5. Biophysical methods (Circular dichroism spectroscopy, fluorescence spectroscopy).
6. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry

Lab on Molecular Biology - 2 Credits

1. Plasmid DNA isolation and DNA quantitation: Plasmid minipreps
2. Restriction digestion
3. Preparation of competent cells.
4. Agarose gel electrophoresis
5. Restriction Enzyme digestion of DNA
6. Purification of DNA from an agarose gel
7. DNA Ligation
8. Transformation of *E.coli* with standard plasmids, Calculation of Transformation efficiency
9. Cloning of genomic DNA in standard plasmid vectors

10. Confirmation of the insert, Miniprep of recombinant plasmid DNA
11. Restriction mapping
12. Polymerase Chain reaction, using standard 16srRNA eubacterial primers
13. RFLP analysis of the PCR product
14. Transformation of yeast *Saccharomyces cerevisiae*

Lab on Microscopy & Imaging Techniques - 3 Credits

1. Demonstration of the design and operations of a Compound Epifluorescence Microscope with DIC and Phase Optics and alignment techniques.
2. Appropriate specimens to be used to demonstrate the fluorescence, DIC and phase contrast images
3. Image collection by the microscope using low and high NA objectives to demonstrate the correlation between image resolution and NA.
4. Demonstration of Abbe's theory of resolution in a transmitted light illumination system by using appropriate specimen
5. Digital Image Acquisition using CCD camera and image analysis using Image J® (www.nih.gov/ij)

Introductory Biology

Unit I

Introduction to Macromolecules

Introduction to Biology; Macromolecules; Carbon chemistry; Proteins: Structure, folding, catalysis; Nucleic acids: storage and transfer of genetic information; Lipids: membranes, energy storage; Carbohydrates: energy storage, building blocks

Unit II

Molecular genetics

Genes; Basics of DNA replication, transcription, translation, Genome organization; Mutations; Gene technology

Unit III

Cell biology and energetics

Cell structure; Membranes; Function of cell organelles; Energetics; ATP and glycolysis; Respiration; Photosynthesis

Unit IV

Reproduction, Heredity, Evolution

Reproduction and Heredity; Cell division: mitosis, meiosis, gamete formation, pollination; Mendelian genetics; Evolution; Gene variation (Hardy-Weinberg principle); Darwin's theory of evolution.

Unit V

Principles of Classification

Viruses, bacteria, protists, fungi; Physiology aspects of Plants & Animals; Regulatory systems(nervous, endocrine, immune systems); Ecology; Populations and communities; Biosphere; Conservation

Texts/References

1. W. K. Purves et al. Life, The Science of Biology, 7th Edition, W. H. Freeman and Co., 2003. http://www.whfreeman.com/thelifewirebridge2/
2. Peter H. Raven et al., Biology, 6th Edition, McGraw Hill, 2007. http://www.ravenbiology.com

Introductory Mathematics

Notation, error analysis, and probability

Scientific notation: significant digits, rounding off, scientific notation; Error analysis; Counting and Probability; Addition rules; Permutations; Combinations; Inclusion-exclusion rule; Sampling with and without replacement; Conditional probability: Bayes' theorem; Independence

Descriptive statistics and Random variables

Measures of central tendency: mean, median, mode; Expectation; Measures of spread: range, percentile, standard deviation; Higher moments: kurtosis, skew; Displaying data: Histograms, stem-and-leaf plots, box plots, frequency distributions; Discrete random variables: Bernoulli, Binomial, Poisson, Geometric distributions, Continuous random variables: Normal, Exponential distributions, Standard normal distribution

Inferential statistics and one sample hypothesis testing

Samples and populations: Random, stratified and cluster sampling. Single- and Double-blind experiments. Point and interval estimates, Sampling distributions: *t*, chi-square, F distributions, Hypothesis testing: null and alternative hypotheses, decision criteria, critical values, type I and type II errors, the meaning of statistical significance, power of a test, One sample hypothesis testing: Normally distributed data: *z*, *t* and chi-square tests. Binomial proportion testing.

Multi-sample and nonparametric hypothesis testing

Two sample hypothesis testing; Nonparametric methods: signed rank test, rank sum test, Kruskal-Wallis test, Analysis of variance: One-way ANOVA. Curve fitting, Regression and correlation: simple linear regression, the least squares method, Analysis of enzyme kinetic data. Michaelis-Menten, Lineweaver-Burk and the direct linear plot, Polynomial curve fitting.

Texts/References

1. G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry, 9th Edition, ISE Reprint, Addison-Wesley, 1998.
2. E. Kreyszig, Advanced engineering mathematics, 8th Edition, John Wiley, 1999.
3. W. E. Boyce and R. DiPrima, Elementary Differential Equations, 8th Edition, John Wiley, 2005.

Communication Skills

Process of communication

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

Presentation skills

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

Technical Writing Skills

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

Computing Skills for Scientific Research

Web browsing for information search; search engines and their mechanism of searching; Hidden Web and its importance in Scientific research; Internet as a medium of interaction between scientists; Effective email strategy using the right tone and conciseness

Texts/References

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

Neuroanatomy - 3 Credits

Unit I

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

Unit II

Constitutions of CNS: Overview

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

Unit III

Cranial nerves: Functional aspects, Classification of cranial and spinal nerve components

Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of: Thalamus: Scheme of thalamic organization, nuclei of the thalamus; Basal ganglia: Corpus striatum, subthalamic nucleus, substantia nigra; Ascending sensory pathways

Unit IV

Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of Cerebellum: Gross anatomy, cerebellar cortex, central nuclei, cerebellar peduncles; Functional anatomy of cerebellum; Cerebral cortex: Histology, general organization, functional localization; Descending motor pathways

Unit V

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

Texts/References

1. John A. Kierrnan, Barr's the Human Nervous System, 7th Edition, Lippincott-Raven, 1998.
2. Richard S. Snell, Clinical Neuroanatomy for the Medical Students, 5th Edition, Lippincott-Williams & Wilkins, 2001.
3. Susan Standring (Editor-in-Chief), Gray's Neuroanatomy: The Anatomical Basis of Clinical Practice, 39th Edition, Elsevier, 2005.
4. M.J.T. Fitzgerald, Clinical Neuroanatomy & Related Neuroscience, 4th Edition, CRC Press, 2000.
5. Water, J. Hendelman, Atlas of Functional Neuroanatomy, 2nd Edition, CRC Press, 2006.

Immunology - 3 Credits

Unit I

Immunology- fundamental concepts and anatomy of the immune system

Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; Haematopoesis; Organs and cells of the immune system- primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue.(MALT&CALT); Mucosal Immunity; Antigens - immunogens, haptens; Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing

Unit II

Immune responses generated by B and T lymphocytes

Immunoglobulins-basic structure, classes and subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Immunological 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

Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques - RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, Biosenor 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

Active and passive immunization; Live, killed, attenuated, sub unit 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 and hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries.

Unit V

Clinical Immunology

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.

Texts/References:

1. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002.
2. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002.
3. Janeway et al., Immunobiology, 4th Edition, Current Biology publications., 1999.
4. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven, 1999.
5. Goding, Monoclonal antibodies, Academic Press. 1985.

Developmental Neurobiology - 3 Credits

Unit I

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

Unit II

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 the nervous system: Dorsal-ventral polarity in the neural tube; Neuronal determination and differentiation: Fate mapping of cell determination, Differentiation of nerve cells and cell lineage; Acquisition of neurotransmitter property and electrical excitability; Neurotrophic factors: Nerve growth factor (NGF), biological system of NGF; Agents analogous to NGF in functions; Role of NGF as trophic agents; Survival factors

Unit III

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

Neurogenesis in post-embryonic and adult age; Neuronal death during development: Programmed cell death, target dependent and innervation dependent neuronal death

Unit IV

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

Unit V

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

Texts/References

1. Sanes, Development of the Nervous System, 2nd Edition, Academic Press, 2006.
2. Squire, Fundamental Neuroscience, 3rd Edition, Elsevier, 2008.
3. Kendel, Principles of Neural Science, 4th Edition, McGraw Hill, 2000.
4. Guilbert, Developmental Biology, 7th Edition, Sinaur Publication, 2006.

Cellular Neurophysiology and Biophysics - 3 Credits

Unit I

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

Unit II

Neural Signals

Overview of Neurons, Synapses and Networks

Stimulus à Sensory Perception à Motor Action / Higher Brain Function

Chemical and Electrical Signaling Within a Circuit; Methods to Record Electrical Activity of a Neuron.

Unit III

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

Unit IV

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

Unit V

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

Texts/References

1. Squire, Fundamental Neuroscience, 3rd Edition, Elsevier, 2008.
2. Kendel, Principles of Neural Science, 4th Edition, McGraw Hill, 2000.
3. Mishra, Clinical Neurophysiology, 2nd Edition, Elsevier, 2006.
4. Duchene E. Haines, Fundamental Neuroscience for Basic & Clinical Applications, 3rd Edition, Churchill Livingstone, 2006.
5. Bear, Neuroscience-Exploring the Brain, Lippincott, 2007.

Genetics - 3 Credits

Unit I

The Principle of segregation

Structure of DNA, DNA as genetic material, Mechanism of Replication, difference between prokaryotes and eukaryotes, Cell Division, Mitosis and Meiosis, Allele, Traits, Dominant and recessive

Unit II

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; Co dominance; 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

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 Signaling and adhesion molecules.

Unit IV

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 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 - 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.

Texts/References

1. Simmons, Principles of Genetics, 4th Edition, Wiley, 2006.
2. Strickberger, Genetics, 3rd Edition, PHP Press, 2004.
3. Griffiths & Miller, Introduction to Genetic Analysis, 7th Edition, Freeman, 2005.

Lab on Neuroanatomy - 4 Credits

1. Dissection of nervous system in invertebrates and vertebrates
2. Dissection of nervous system of rat as experimental model
3. Procedure for removal of various parts of brain in rat and other experimental animals for further study
4. Perfusion techniques
5. Processing and handling of tissue for microanatomy of brain: Nissl/Silver techniques
6. Study of gross anatomy and pre-dissected human brain

Lab on Genetics, Neurophysiology & Biophysics - 4 Credits

1. Acquisition of data for various physiological parameters using Biopac
2. Electrophysiological recording setup (EEG, ECG, EMG, EOG, Heart rate, respiration, pulse rate, heart sound, etc.)
3. To determine pain sensitivity in rat/mice using Tail-Flick Analgesia meter
4. To learn the use of Stereotaxic instrument for neuroscience research
5. Demonstration of basal metabolic rate
6. Effect of various neurotransmitters on fish melanophores
7. Pharmacological experiments on melanophores
8. Study of Physiology models related to neurophysiology
9. Study of monohybrid and dihybrid cross in *Drosophila*
10. Preparation of mitotic chromosomes from rat bone marrow
11. Preparation of meiotic chromosomes from grasshopper testis
12. Preparation of polytene chromosomes from *Drosophila* and *Chironomous* larvae

Neurochemistry - 3 Credits

Unit I

Carbohydrates, protein and fat Metabolism

Glycogenesis; Glycolysis, Gluconeogenesis; TCA cycle; Glycerophosphate shuttle; Mitochondrial Electron Transport Chain; Inhibitors of ETC; Oxidative phosphorylation; Diabetes mellitus; Lipids and their functions; Adipose tissue lipolysis; Beta, alpha and omega oxidation of fatty acids; Synthesis of cholesterol, bile acids and steroids; Ketone bodies; Myelin structure; Transmination and Transdeamination; Urea cycle; Synthesis of glutathione; Synthesis and catabolism of histamine, GABA, serotonin, melatonin, catecholamines, melanin.

Unit II

Synaptic Transmission

Electrical and chemical synapses; Structure and their properties; Transmission; Synaptic vesicles; Vesicle release mechanism; EPSP and IPSP; Temporal and spatial summation; Presynaptic modulation; Voltage dependent calcium channel and their blockers; Drug effects on synapse, Channelopathies; Classification of neurotransmitters and neurotransmitter receptors; Receptor binding assays; Determination of affinity and binding capacity of receptor; Scatchard plot; Receptor agonists and antagonists.

Unit III

Acetylcholine

History; Neuromuscular transmission; End plate potential; Nicotinic and muscarinic acetylcholine receptors and their classification; Structure; Agonist and antagonists; Clinical chemistry; NMJ diseases; anti-ChE agents and their applications; Cholinergic projections in the brain; Cholinergic neurons and Alzheimer's disease.

Unit IV

Amino acids neurotransmitters

Excitatory and inhibitory neurotransmitters: GABA glycine and glutamate and their receptors, GABA receptor agonists and antagonists, AMPA, Kainate and NMDA receptors; Glutamate mediated synaptic transmission; Glutamate excitotoxicity; NMDA receptor and LTP; Neurolathyrism.

Unit V

Catecholamines, Opiate and Peptide Neurotransmitters

Dopamine receptors structure; Function; Agonist and antagonists; Dopaminergic pathways; Dopamine transpoters; MPTP; Parkinson's disease; Schizophrenia; Amphetamine cocaine and their mode of action; Opiate and their receptors; Agonist and antagonists; Drug addiction tolerance and withdrawal; Morphine and pain relief; Neuropeptides: precursors' structure, common features, synthesis, processing and regulation; Catecholamines and serotonin: structures, classifications and their receptors.

Texts/References

1. Siegel et al., Basic Neurochemistry, 6th Edition, Lippincott -Williams-Wilkins, 1999
2. Kandel et al., Principles of Neural science, 4 Edition, McGraw-Hill Medical, 2000.
3. Zegmond, Fundamentals of Neuroscience, 1st Edition, Academic Press, 1999
4. Bear: Neuroscience: Exploring the Brain, 2nd edition, Lippincott Williams & Wilkins, 2001

Systems Neuroscience I - 3 Credits

Unit I

Somatosensory System

Introduction to the systems approach to understand brain function; Peripheral receptors; Spinal pathways; Medullary, thalamic and cortical somatosensory structures and pathways; Somatosensory areas in the cortex and their connection.

Unit II

Visual System

Eye; Retina; Organization and connections of thalamic and midbrain visual areas; Cortical visual areas; Dorsal vs. ventral stream.

Unit III

Auditory System

Tonotopy in the cochlea; Brainstem auditory nuclei; Delay lines; Thalamic nuclei and cortical auditory areas.

Unit IV

Olfactory and Gustatory Systems

Peripheral receptors for each of the chemical senses; Pathways to the brain.

Unit V

Motor System

Spinal, cerebellar and cortical motor pathways; Role of basal ganglion; Oculomotor pathways; Plasticity of Nervous System

Texts/References

1. Shepherd: Neurobiology, 3rd Edition, Oxford University Press, 1994
2. Kandel et al., Principles of Neural science, 4 Edition, McGraw-Hill Medical, 2000.
3. Zegmond, Fundamentals of Neuroscience, 1st Edition, Academic Press, 1999
4. Bear, Neuroscience: Exploring the Brain, 2nd edition, Lippincott Williams & Wilkins, 2001

Systems Neuroscience II - 3 Credits

Unit I

Chemical Control of Brain and Behaviour

Organizational Principles of the Adult Hypothalamus; Role of hypothalamus and pituitary hormones; Diffuse

modulatory systems of the brain: Locus coeruleus, rafe nucleus, substantia nigra, etc.; ANS in regulation of brain and bahaviour; ANS Pharmacology- Transmitter and Receptor Coding; Autonomic Controls of Homeostasis; Hierarchically Organized CNS Circuits

Unit II

Cardiovascular System

Basics of Cardiovascular physiology; Sympathetic Vasomotor Tone; Neural Control of Heart; Cardiovascular Homeostasis; The Nervous System and the Long-term control of the Cardiovascular System

Unit III

Neural Control of the Breathing

Early Neuroscience and the Brainstem; Breathing & gas exchange; CNS & Breathing; Respiratory Rhythm Generation; Sensory Inputs and Altered Breathing; Modulation of Respiratory Motor Output; Suprapontine Structures and Breathing; Respiratory neurons and their discharge pattern

Unit IV

Circadian Timing Sleep and Dreaming

Pineal and Circadian Rhythms; Suprachiasmatic Nucleus; Light as the Dominant Stimulus; Circadian timings and Reproduction; Heritability of Circadian Timings; Two states of sleep- slow wave and rapid eye movement; Anatomy and Physiology of the Brainstem regulatory Systems.

Unit V

Sex and behaviour, Motivation & Reward

Neuronal basis of sexual behaviour; Sex Hormones and Brain; Accessory Olfactory Pathway; Maternal Stimulation and Male Psychosexual Development; Basis and mechanism of differences between male and female brains; Neural Mechanisms of Motivation; Dopamine and Lateral Hypothalamic Syndrome; Reinforcement System; Brain Aversion Systems.

Texts/References

1. Shepherd: Neurobiology, 3rd Edition, Oxford University Press, 1994
2. Kandel et al., Principles of Neural science, 4 Edition, McGraw-Hill Medical, 2000.
3. Zegmond, Fundamentals of Neuroscience, 1st Edition, Academic Press, 1999
4. Bear, Neuroscience: Exploring the Brain, 2nd edition, Lippincott Williams & Wilkins, 2001.

Clinical Neurochemistry & Neuropathology - 3 Credits

Unit I

Biochemistry of peripheral Neuropathy; Diseases involving myelin; Multiple sclerosis and other demyelinated disorders; Genetic disorders of lipid, glycoprotein; Mucopolysaccharide metabolism; Duchenne Muscular Dystrophy: Molecular, genetic aspects and diagnostic characteristics

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Texts/References

1. Siegel, Basic Neurochemistry, 7th Edition, Academic Press, 2006.
2. Squire, Fundamental Neuroscience, 3rd Edition, Elsevier, 2008.
3. Kendel, Principles of Neural Science, 4th Edition, McGraw Hill, 2000.
4. Duchene E. Haines, Fundamental Neuroscience for Basic & Clinical Applications, 3rd Edition, Churchill Livingstone, 2006.
5. Bear, Neuroscience: Exploring the Brain, 2nd edition, Lippincott Williams & Wilkins, 2001.

Behavioural & Cognitive Neuroscience - 3 Credits

Unit I

The Methods of Cognitive Neuroscience

Brief History of Cognitive Neuroscience; Mental representations and transformations; Characterizing mental operations; Constraints on information processing; Computer Modeling; Experimental Techniques Used with Animals; Single-cell recording; Lesions; Genetic manipulations; Neurology; Structural imaging of neurological damage Causes of neurological disorders; Converging Methods; Cognitive deficits following brain damage; Virtual lesions: Transcranial magnetic stimulation Functional imaging

Unit II

Perception and Encoding, Higher Perceptual Functions

Disorders of Perception; Overview of visual pathways; Deficits in Feature Perception; Deficits in color perception: Achromatopsia; Deficits in motion perception: Akinetopsia; Deficits in other aspects of visual perception; Agnosia: A Case Study; Two Cortical Pathways for Visual Perception; Representational differences between the dorsal and ventral pathways; Perception for identification versus perception for action; Computational Problems in Object Recognition; View-dependent or view-invariant recognition; Shape encoding; Grandmother cells and ensemble coding; Failures of Object Recognition; Subtypes of agnosia; Integrating parts into wholes; Category specificity in agnosia; prosopagnosia; Neural mechanisms for face perception; Dissociations of face and object perception; Two systems for object recognition; Relationship Between Visual Perception, Imagery, and Memory

Unit III

Selective Attention and Orienting, Learning and Memory

Theoretical Models of Attention; Cocktail party effect, Early- versus late-selection theories; Quantifying attention in perception; Neural Systems in Attention and Selective Perception; Neurophysiology of human attention; Animal studies of attentional mechanisms; Neurology and Neuropsychology of Attention; Extinction and neglect; Theories of Memory; Sensory and short-term memory mechanisms; Models of short-term memory; Models of long-term memory; Memory and Brain; Human memory, Brain damage, and amnesia; Animal models of memory; Imaging the human brain and memory

Unit IV

Language and the Brain

Theories of Language; Storage of words and concepts; Mental lexicon; Perceptual analyses of the linguistic input; Recognition of words and integration of words in sentences; Speech production; Neuropsychology of Language and Language Disorders: Aphasia; Neurophysiology of Language; Functional neuroimaging of language; Electrophysiology of language

Unit V

Executive Functions and Frontal Lobes

Lateral Prefrontal Cortex and Working Memory; Distinguishing between stored knowledge and activated information; Working memory versus associative memory; Frontal lobes and the temporal organization of memory; Source memory; Component Analysis of Prefrontal Cortex; Content-based accounts of functional specialization within lateral prefrontal function; Process-based accounts of functional specialization within lateral prefrontal function; Selection of task-relevant information; Goal-oriented behaviour; Planning and selecting an action; Anterior cingulate as a monitoring system

Texts/References

1. Gazziniga M.S et al., The New Cognitive Neuroscience: The Biology of Mind, 2nd Edition, W. Norton, 2002.

Lab on Neurochemistry - 3 Credits

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

Lab on Behaviour Biology - 3 Credits

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

IPR & Bioethics

Unit I

Introduction to Intellectual Property

Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs; International framework for the protection of IP

IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO and TRIPS

Unit II

Concept of 'prior art'

Invention in context of "prior art"; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, India etc.); Analysis and report formation

Unit III

Basics of Patents

Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Procedure for filing a PCT application

Unit IV

Patent filing and Infringement

Patent application- forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention patent applications; International patenting-requirement, procedures and costs; Financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US; Patenting by research students, lecturers and scientists-University/organizational rules in India and abroad, credit sharing by workers, financial incentives

Patent infringement- meaning, scope, litigation, case studies and examples

Unit V

Bioethics

Concepts; Philosophical considerations; Epistemology of Science; Ethical Terms; Principles & Theories; Relevance to Biotechnology; Ethics and the Law Issues: Genetic Engineering, Stem Cells, Cloning, Medical techniques, Transhumanism, Bioweapons; Research concerns - Animal Rights, Ethics of Human Cloning, Reproduction and Stem Cell Research; Emerging issues: Biotechnology's Impact on Society; DNA on the Witness Stand - Use of genetic evidence in civil and criminal court cases; Challenges to Public Policy - To Regulate or Not to Regulate; Improving public understanding of biotechnology products to correct misconceptions

Text/References

http://www.w3.org/IPR/

http://www.wipo.int/portal/index.html.en

http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html

www.patentoffice.nic.in

www.iprlawindia.org/ - 31k - Cached - Similar page

Bioethics - by Ellen Frankel Paul , Fred D. Miller, Jeffrey Paul , Fred Dycus Miller

http://www.accessexcellence.org/RC/AB/IE/#Anchor-Bioethics-6296

www.bioethics.net

Bioethics & Science

http://www.americanprogress.org/issues/domestic/science?_kk=bioethics&_kt=21a1e10d-48e4-44bc-8b39-21c695383746

The Stem cell debate

http://www.billmuehlenberg.com/2005/09/02/the-stem-cell-debate/